ISAR-7

Seventh International Symposium on Arctic Research

March 6-10, 2023

Tachikawa, Japan

Transdisciplinary studies on a rapidly changing Arctic toward a sustainable society

Welcome Words

Hajime Yamaguchi
Chair, ISAR-7 Symposium Organizing Committee

On behalf of the Symposium Organizing Committee, it is our great pleasure to welcome you to the Seventh International Symposium on Arctic Research (ISAR-7) held in Tachikawa, Tokyo on March 6-10, 2023, in a hybrid manner (partly in-person and partly online). The symposium is organized by Japan Consortium for Arctic Research (JCAR) and National Institute of Polar Research (NIPR) with cordial supports from Japan Agency of Marine/Earth Science and Technology, Hokkaido University, Institute for Space-Earth Environmental Research of Nagoya University and many other institutions. The theme of this symposium is *Transdisciplinary Studies on a Rapidly Changing Arctic toward a Sustainable Society*.

The previous symposia have mainly focused on the effects of global warming, which is progressing several times faster in the Arctic than in the other regions, as well as related interdisciplinary discussions on the rapidly changing Arctic such as the Arctic shipping routes which require natural science, economics, international law and other perspectives. However, the COVID-19 pandemic and the new international problem that have occurred in the last three years since ISAR-6 were unexpected and devastating changes for humanity. Thus, we have extended the sessions for ISAR-7 to broader areas such as security and geopolitics. I believe that research in the Arctic region should lead to contribute for sustainable development of all humankind.

The expected number of participants is around 430 from 26 countries and regions, which are comparable with those of the previous symposia. We sincerely thank all the colleagues who have gathered at this symposium under the current difficult situation. We hope you would have fruitful discussions in ISAR-7 and take a successful step toward your goal.

Takuji Nakamura
Professor, Director-General, National Institute of Polar Research, Japan

Dear friends of Arctic research,

National Institute of Polar Research sincerely welcomes all of you to ISAR-7, the 7th International Symposium on Arctic Research, as a co-organizer of the symposium and the host institute of its venue. I also would like to express my special appreciation to each and every one of you who came from oversea. This year, ISAR is going to be held in-person and virtually, and will bring Arctic researchers together in-person after five years since ISAR-5 was held in-person in January 2018.

The rapid warming in the Arctic region in recent years has significantly increased the importance of the Arctic observation and researches. In the mean time, both the global pandemic of COVID-19 and on-going conflict between the countries in European region have constrained our activities in such an urgency where acceleration of Arctic research is strongly demanded for us mankind. However, we shall stay united and engaged in moving forward with our common goal under any circumstances.

March 6 of this year, which happened to be the first day of the symposium, is called 'Keichitsu' in Japan (in Chinese, Jing-zhe), meaning it is the day when insects come out of hibernation after a long winter. I do wish that the symposium becomes a great opportunity for Arctic scientists from all around the world to come out and actively interact again towards our challenge to the surging global climate change. I hope everyone enjoys the ISAR-7 symposium held first time in Tachikawa, the city in west Tokyo.

Organizations

Organizers

Japan Consortium for Arctic Environmental Research (JCAR)
National Institute of Polar Research (NIPR)

Co-Organizers

Hokkaido University

Institute for Space-Earth Environmental Research (ISEE), Nagoya University

Japan Agency for Marine-Earth Science and Technology (JAMSTEC)

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National Institute for Environmental Studies (NIES)

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The Japan Association of Siberian Studies
The Japan Society of Naval Architects and Ocean Engineers (JASNAOE)
The Japanese Association for Canadian Studies (JACS)
The Japanese Society of Cultural Anthropology (JASCA)
The Japanese Society of Snow and Ice (JSSI)
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Nozomu Takeuchi (Cryobiology) Chiba University
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Atsushi Yamaguchi (Marine ecology) Hokkaido University
Masakazu Yoshimori (Climate modeling) The University of Tokyo

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Takashi Yamanouchi (Atmosphere) National Institute of Polar Research, Japan
Huigen Yang (Upper atmosphere) Polar Research Institute of China, China

Session Titles

R1………… Atmosphere
R2………… Ocean and Sea Ice
R3………… Rivers, Lakes, Permafrost and Snow Cover
R4………… Ice Sheets, Glaciers and Ice Cores
R5-S8……… Terrestrial Ecosystems
Biogeochemical and hydrological responses to climate and environmental changes in the Arctic
R6………… Marine Ecosystems
R7………… Geospace
R8………… Laws, Politics and Economy
R9………… Culture, Language, and Environment
R10………… Engineering for Sustainable Development
S1………… High-latitude Fires, Arctic Climate, Environment and health (HiFACE)
S2………… Extratropical teleconnections and predictability of weather and climate related with the Arctic environmental changes
S3………… Atmospheric composition and Arctic environment/climate: New assessment reports and original studies
S4………… Synoptic Arctic Survey – international collaboration for Arctic Ocean transdisciplinary studies
S7………… Arctic hydrology in the context of warming climate
S9………… Sustainable, responsible, and resilient Arctic tourism: lip service or concrete actions
S10………… Changing Arctic strategic and geopolitical landscapes: the impact of the war in Ukraine
S11………… After the Ukraine: The Arctic, International Law, and International Scientific Cooperation
S12-S22…… International Governance of the Central Arctic Ocean: Science Indigenous Knowledge, and the Rule of Law
Indigenous Co-Production of Arctic Knowledge: Toward a More Inclusive Arctic Scientific Research
S13………… Building a region: Arctic identities and identity politics
S15………… Redefining the well-being of Arctic communities in the context of global environmental and societal change
S16………… Making of Arctic exhibition and material study: the potential of collaboration study with local people
S17………… Arctic Shipping: Economic Feasibility and Challenges
S18………… Arctic Sea Route and Coastal Protection: environmental, engineering, and economic assessment
S20………… Toward sustainable Arctic -developing a network of Arctic researchers and other Arctic stakeholders-
S21………… Funding International Arctic Science
S23………… Multidisciplinary observing systems in Arctic, potential and challenges

Plenary

【Keynote Speech ➤Venue1 (B201) 】

7-Mar **Keynote Speech 1**

Rapid Arctic Warming and its Impact on Indigenous Peoples and Other Communities (Online Presentation)

Dalee Sambo Dorough

Senior Scholar and Special Advisor / Arctic Indigenous Peoples University of Alaska Anchorage, Former chair / Inuit Circumpolar Council, 2022 IASC Medalist

8-Mar **Keynote Speech 2**

Collaborating towards a pan-Arctic Observing System of System: perspectives from the Arctic PASSION project

Michael Karcher

Senior scientist / Alfred Wegener Institute, Coordinator / Arctic PASSION project, Chair / Arctic-Subarctic Ocean Flux study (ASOF), Advisory Board member / Nansen LEGACY, Member / SAON Board

9-Mar **Keynote Speech 3**

Transdisciplinary research on environmental issues

Juichi Yamagiwa

Director-General / Research Institute for Humanity and Nature (RIHN)

10-Mar **Keynote Speech 4**

Environmental (in-)Security in the Arctic: Expanding Interdisciplinary Approaches

Marc Lanteigne

Associate Professor / The Arctic University of Norway

Program

As of February 22, 2023

The Entire Program

			Room						
			Venue1 (B201)	Venue2 (C301)	Venue3 (D305)	Venue4 (D304)	Venue5 (K301)	Venue6 (NINJAL244)	Venue7 (NINJAL201)
Mar. 6 (Mon)	13:00-14:30	Breakout Sessions 1	R2		S3	R7		R5&S8	
	14:45-16:15	Breakout Sessions 2	R2	S13	S3	R7	S7	R5&S8	
	16:30-18:00	Breakout Sessions 3	R2	S10	S2-Part1		S7		
Mar. 7 (Tue)	10:00-10:50	Opening Ceremony/ Photo Session	Opening/ Photo Session						
	11:00-11:45	Keynote Speech 1	Keynote Speech 1						
	13:00-15:00	Session Presentations 1	R7, R2, S3, S2, S8, S7						
	15:15-16:45	Breakout Sessions 4	S2-Part2	S11	S9	S16		R10	
Mar. 8 (Wed)	8:20-9:20	Poster Session Core Time 1 (Online)							
	9:30-10:15	Keynote Speech 2	Keynote Speech 2						
	10:30-12:30	Session Presentations 2	R4, S4, S15, S17, S18, S21						
	13:30-15:00	Breakout Sessions 5	R4			S4	S17	S21	S15
	15:15-16:45	Breakout Sessions 6	R4			S4	S17	S21	S15
	17:00-18:00	Poster Session Core Time 2 (Online)							
Mar. 9 (Thu)	9:30-10:50	Session Presentations 3	R1, R3, R6, S1						
	11:00-11:45	Keynote Speech 3	Keynote Speech 3						
	13:00-14:30	Breakout Sessions 7	R3	S1	S18	R8	R6	S23	S20
	14:45-16:15	Breakout Sessions 8	R3	S1	S18	R9	R6		S20
	16:30-18:00	Breakout Sessions 9	R3	S12&S22	R1				
Mar. 10 (Fri)	9:30-10:15	Keynote Speech 4	Keynote Speech 4						
	10:30-12:00	Plenary Session/ Closing Ceremony	Plenary Session/ Closing						

7-Mar Opening Ceremony ➤Venue: 1 (B201)

10:00 Declaration of Opening: Hajime Yamaguchi (Chair of ISAR-7 Symposium Organizing Committee)

Welcome Speech: Takuji Nakamura (Professor, Director General, National Institute of Polar Research)

Guest Speeches: TBC

10:30 Photo session

10-Mar Closing Ceremony ➤Venue: 1 (B201)

10:30 Closing Remarks: Henry Burgess/ President of the International Arctic Science Committee (IASC), Head of the Arctic Office, Natural Environment Research Council (NERC) UK

11:00 Closing Remarks: Larry Hinzman/ Executive Director of Interagency Arctic Research Policy Committee (IARPC), Assistant Director for Polar Sciences, Office of Science and Technology Policy (OSTP), Executive Office of the President

11:30 Poster Award announcement: Kazuyuki Saito (Chair of the Poster Award Committee of SOC)

Closing Address : Hajime Yamaguchi (Chair of SOC)

Keynote Speech 1 / March 7, 2023

Venue: 1 (B201)

11:00-11:45 Rapid Arctic Warming and its Impact on Indigenous Peoples and Other Communities (Online Presentation)

Speaker: Delee Sambo Dorough
Senior Scholar and Special Advisor / Arctic Indigenous Peoples University of Alaska Anchorage, Former chair / Inuit Circumpolar Council, 2022 IASC Medalist

Profile:
Dr. Dalee Sambo Dorough is the former Chairperson of the Inuit Circumpolar Council [2018- 2022]. She received a Ph.D. in Law from the University of British Columbia, Faculty of Law (2002) and a Master of Arts in Law & Diplomacy, from The Fletcher School, Tufts University (1991). Presently, she is a Senior Scholar and Special Advisor on Arctic Indigenous Peoples, the University of Alaska Anchorage, where she was an Assistant Professor of International Relations. Dr. Dorough was Chairperson (2014) and an Expert Member of the UN Permanent Forum on Indigenous Issues (2010-2016). She is past co-Chair of the International Law Association (ILA) Committee on Implementation of the Rights of Indigenous Peoples and has published contributions in the field of Indigenous human rights as well as Arctic Indigenous peoples, including a forthcoming co-authored chapter on The World Heritage Convention and the Rights of Indigenous Peoples for Oxford University Press manuscript on the occasion of the 50th Anniversary of the World Heritage Convention.

Keynote Speech 2 / March 8, 2023

Venue: 1 (B201)

9:30-10:15 Collaborating towards a pan-Arctic Observing System of System: perspectives from the Arctic PASSION project

Speaker: Michael Karcher
Senior scientist / Alfred Wegener Institute, Coordinator / Arctic PASSION project, Chair / Arctic-Subarctic Ocean Flux study (ASOF), Advisory Board member / Nansen LEGACY, Member / SAON Board

Profile:
Dr. Michael Karcher is a senior scientist at the Alfred Wegener Institute - Helmholtz Centre for Polar and Marine Research in Germany. He is a physical oceanographer by education and has been active in numerous interdisciplinary and inter-sectoral international projects dealing with the Arctic. He is currently acting as the scientific coordinator of the EU funded H2020 project 'Arctic PASSION' (Pan-Arctic Observing System of Systems - Implementing Observations for Societal Needs), a 4 year program meant to support the improvement of the Arctic environmental observing system with 35 partners from the EU, Canada, India, Japan, Korea and the US and 6 Arctic Indigenous Communities.

Keynote Speech 3 / March 9, 2023

Venue: 1 (B201)

11:00-11:45 Transdisciplinary research on environmental issues

Speaker: Juichi Yamagiwa
Director-General / Research Institute for Humanity and Nature (RIHN)

Profile:
Dr. Juichi Yamagiwa, Director-General of RIHN, is a world-renowned researcher and expert in the study of primatology and human evolution. Awarded Doctor of Science from Kyoto University in 1987. After holding positions at the Karisoke Research Center, Japan Monkey Center, and Primate Research Institute Kyoto University, he has been Professor of Graduate School of Science at Kyoto University since 2002. Dean of Graduate School and Faculty of Science, 2011-2013. 26th President of Kyoto University, 2014-2020. Served as President of International Primatological Society, 2008-2012, also as Editor in Chief of Primates, a quarterly peer-reviewed scientific journal of primatology published by Springer Science+Business Media, 2010-2014. Domestically, he served as the president of JANU, the president of Science Council of Japan, and the ongoing member of Environmental Policy Committee of Ministry of Environment. His passion for fieldwork research frequently made him travel to some countries of Africa, where he discovered an abundance of new findings related to gorillas, through his unique viewpoint of evolution.

Keynote Speech 4 / March 10, 2023

Venue: 1 (B201)

9:30-10:15 Environmental (in-)Security in the Arctic: Expanding Interdisciplinary Approaches

Speaker: Marc Lanteigne
Associate Professor / The Arctic University of Norway

Profile:
Dr. Marc Lanteigne is an Associate Professor of Political Science at UIT: The Arctic University of Norway, Tromsø, teaching information relations and Polar politics. He has previously taught in Britain, Canada, China and New Zealand. His research focusses on China, East Asia, and Polar Regional politics and international relations. He is chief editor of the Arctic news blog Over the Circle, and his current work includes the comparative politics of non-Arctic states, including in the Asia-Pacific, within the Arctic policy sphere. He is the author of Chinese Foreign Policy: An Introduction, co-editor of the Routledge Handbook of Arctic Security, and has also published numerous articles on Chinese and East Asian politics and foreign policy, including Asia-Arctic diplomacy.

Session Presentations 1/March 7, 2023

Venue 1 (B201)

Chair: Hiroyuki Enomoto			
SP1-R7	13:00-13:20	Coordinated observations between the Arase satellite and ground-based observations over Arctic	*Y. Miyoshi, I. Shinohara, K. Shiokawa, K. Hosokawa, Y. Ogawa, S. Oyama, S. Kurita, M. Ozaki, Y. Kazama, S-Y. Wang, K. Asamura, S. Kasahara, S. Yokota, T. Mitani, N. Higashio, Y. Kasahara, S. Matsuda, H. Kojima, Y. Katoh, A. Matsuoka, S. Imajo, T. Takashima, ERG-project team
SP1-R2	13:20-13:40	Planning for a Future Arctic Oil Spill: New Model Insights and Regional Security Implications	*K. Frazier, M. Richards, R. Kee
SP1-S3	13:40-14:00	Evaluation of black carbon simulations in CMIP6 with long term observations in East Asia during 2009–2020	*K. Ikeda, H. Tanimoto, Y. Kanaya, F. Taketani, A. Matsuki
SP1-S2	14:00-14:20	Contribution of the decline in Chukchi and Bering sea ice to cold East Asian winter	*Y. Tachibana, U. Ando
SP1-S8	14:20-14:40	Effect of the extreme wet event on temporal variations in NDVI and ecosystem parameters of larch forest in northeastern Siberia	*A. Nogovitcyn, R. Shakhmatov, T. Morozumi, S. Tei, Y. Miyamoto, S. Nagai, T. C. Maximov, A. Sugimoto
SP1-S7	14:40-15:00	Role of Snow for Hydrological Change in Lena River Basin	*D. Gustafsson, J. Musuuza, K. Klemeth, L. Lebedeva, T. Hiyama

Session Presentations 2/March 8, 2023

Venue 1 (B201)

Chair: Takashi Kikuchi			
SP2-S23	10:30-10:50	TBC *Initially planned presentation (SP2-R4) has been cancelled.	TBC
SP2-S4	10:50-11:10	Taking the Pulse of the Arctic Ocean System, from the Shelves to the Pole – A US Contribution to the International Synoptic Arctic Survey Program	*C. Ashjian, J. Grebmeier, N. Bates, R. Campbell, L. Cooper, S. Danielson, L. Juranek, E. Labunski, C. Magen, S. Moore, C. Pilskaln, M-L. Timmermans
SP2-S15	11:10-11:30	Climate change, community development, and consumption in North Greenland: Redesigning food sovereignty research.	*N. Hayashi, *A. Delaney
SP2-S17	11:30-11:50	The economic impacts of opening the Northern Sea Route under political uncertainty	*T. Tran, R. Shibasaki, W. Ding
SP2-S18	11:50-12:10	Experimental Study on Wave-ice Interaction for Small Ice Floes and Plate Ice in Regular Wave	*J. Sawamura, H. Mizushima, I. Hamamoto, M. Zen
SP2-S21	12:10-12:30	The need for International Arctic Science Funding to answer the “Big Questions”	*V. Rachold

Session Presentations 3/March 9, 2023

Venue 1 (B201)

Chair: Tetsuya Hiyama			
SP3-R1	9:30-9:50	Revision of global fossil fuel methane emissions based on trends and meridional gradients of CH_4 and $^{13}CH_4$ during 1990-2020	*N. Chandra, P. K. Patra, R. Fujita, T. Umezawa, D. Goto, S. Morimoto, B. H. Vaughn, T. Röckmann
SP3-R3	9:50-10:10	Consequences of wildfires in boreal forests underlain by ice-rich permafrost near Batagay, NE Siberia	*G. Iwahana, K. Yanagiya, M. Furuya, P. Danilov, N. Fedorov, A. Desyatkin, A. Fedorov
SP3-R6	10:10-10:30	The Pelagic Ecosystem in the Central Arctic Ocean with Increased Pressures as Future Prospect	*H. Hop, O. A. Misund
SP3-S1	10:30-10:50	Variability and evolution of fire weather conditions in boreal regions under levels of global warming	*M. T. Lund, K. Nordling, A. B. Gjelsvik, B. H. Samset

Breakout Sessions

R1
Atmosphere

Breakout Session/March 9, 2023
Venue 3 (D305)

Chair: Toshinobu Machida, Toru Nozawa			
R1-O01	16:30-16:45	Trend of N_2O isotope ratios in the Arctic atmosphere	*S. Toyoda, D. Goto, S. Morimoto, M. Sasakawa, T. Machida, Y. Tohjima, D. Worthy, N. Yoshida
R1-O02	16:45-17:00	Preliminary results of the atmospheric particulate matter variations in the summer of 2022 in Qaanaaq, Greenland	*T. J. Yasunari, T. Kajikawa, Y. Matsumi
~~R1-O03~~	17:00-17:15	**Cancel** ~~Simulating The Effect Of Leads In Sea Ice Using Global Climate Models~~	~~*R. Davy, P. Griewank, L. Suo, Y. Gao~~
R1-O04	17:15-17:30	Slow-down in summer warming over Greenland in the past decade linked to central Pacific El Niño	*K. Suzuki, S. Matsumura, K. Yamazaki
R1-O05	17:30-17:45	Regional ensemble of global climate models for Sakha (Yakutia) Republic, Northern Eurasia	*N. Tananaev, K. Kirillina, K. Olenov

R2
Ocean and Sea Ice

Breakout Session/March 6, 2023
Venue 1 (B201)

Chair: Amane Fujiwara, Satoshi Kimura, Yasushi Fujiwara			
R2-O01	13:00-13:15	Development of a high latitudinal SST and sea ice dataset derived from GCOM-C/SGLI	*Y. Kurihara, R. Shimada
R2-O02	13:15-13:30	Retrieving sea ice strength in the Beaufort Sea using variational data assimilation	*G. Panteleev, M. Yaremchuk
R2-O03	13:30-13:45	Automatic Sea Ice Concentration Segmentation of Sentinel-1 Imagery using a Convolutional Neural Network	*T. Akiyoshi, Y. Toyonaga, Y. Matsuo
R2-O04	13:45-14:00	The arctic summer sea ice prediction based on sea-ice histories	*M. Oyama, H. Yamaguch, N. Kimura
R2-O05	14:00-14:15	Estimation of sea ice thickness based on the ice histories	*N. Kimura, H. Hasumi
R2-O06	14:15-14:30	Estimation of sea ice thickness using UAV-SfM in Utoro, Hokkaido on the shores of the Sea of Okhotsk	*Y. Ouchi, K. Tateyama, T. Watanabe, K. Sato, T. Waseda, T. Kodaira, R. Uchiyama
	14:30-14:45	Break	
R2-O07	14:45-15:00	Seasonal variations of sea-ice thickness in the Northwind Abyssal Plain of the Arctic Ocean: Data analysis of moored ice-profiling sonar	*T. Ueno, H. Ueno, M. Itoh, E. Watanabe, J. Onodera, Y. Kawaguchi, S. Fujio, E. Moriya, Y. Fukamachi, N. Harada
R2-O08	15:00-15:15	Energy Cascade in Eurasian Basin of the Central Arctic Ocean: interpretation of horizontal wavenumber spectra of density derived from an autonomous buoy and the FESOM2 Model	*W-C. Wu, Y-C. Fang, B. Rabe, V. Müller
R2-O09	15:15-15:30	Impact of the sea ice divergence on the sea ice thickness distribution in the Beaufort Gyre	O. Francis,*G. Panteleev, M. Yaremchuk, D. Hebert, R. Allard, R. Krishfield, A. Proshutinsky,
R2-O10	15:30-15:45	Best practice: How we reconciled biologists' and physicists' ice coring methodology for the MOSAiC expedition	*M. Oggier, R. Rember, A. A. Fong , A. Aguilar-Islas, H. Eicken, L. Whitmore, M. A. Granskog
R2-O11	15:45-16:00	Biogeochemical Evolution of Sea Ice During the Spring Melt	*L. Whitmore, M. Oggier, M. Kaufman, K. Dilliplaine, C. Bolt, H. Eicken, R. Rember, A. Aguilar-Islas
R2-O12	16:00-16:15	Future Projection of Ice-Algal Production in the Arctic Ocean: Model Intercomparison	*Y. Zhang, E. Watanabe, H. Hayashida
	16:15-16:30	Break	
R2-O13	16:30-16:45	Interannual dynamics of particle transportation in shelf slope area of the western Arctic Ocean from 2010 to 2021	*J. Onodera, E. Watanabe, K. Mizobata, M. Muramatsu, M. Itoh, Y. Tanaka, E. J. Yang, N. Harada, T. Kikuchi
R2-O14	16:45-17:00	Multidecadal decreasing trend of sea ice production and melt in the Bering Sea revealed by ocean observations	*V. Mensah, Y-C. Chen, K. I. Ohshima
R2-O15	17:00-17:15	Development and validation of a sea ice melt estimation method based on T-S analysis in the Pacific Arctic Region	*Y-C. Chen, V. Mensah
R2-O16	17:15-17:30	Enhancement of turbulent mixing by the eddy-wave interaction in the Canada Basin: Results from autonomous observations using ITP-V	*E. Y. Son, Y. Kawaguchi, S. T. Cole, J. M. Toole, H. K. Ha
R2-O17	17:30-17:45	Sea ice timing feedback in observed freeze-up and melt dates across the Arctic	*A. Bradley, A. Flatland, W. Downs
~~R2-O18~~	17:45-18:00	**Cancel** ~~Turbulent Mixing during Late Summer in Ice–Ocean Boundary Layer in Central Arctic Ocean: Results from MOSAiC Expedition~~	~~*Y. Kawaguchi, Z. Koenig, D. Nomura, M. Hoppman, J. Inoue, Y-C. Fang, K. Schulz, M. Gallagher, C. Katlein, M. Nicolaus, B. Rabe~~

R3
Rivers, Lakes, Permafrost and Snow Cover

Breakout Session/March 9, 2023

Venue 1 (B201)

Chair: Tetsuo Sueyoshi, Daqing Yang, Kazuyuki Saito, Masahiro Hori			
R3-O01	13:00-13:18	Landslides and Hydrological Environment of Sedimentary Rock Slope in northwest Greenland	*T. Watanabe, S. Yamasaki
R3-O02	13:18-13:36	Supraglacial lake evolution on Tracy and Heilprin Glaciers in northwestern Greenland from 2014 to 2021	*Y. Wang, S. Sugiyama
~~R3-O03~~	13:36-13:54	**Cancel** ~~Freshwater ice and safety of people: input of multi-satellite observations~~	~~E. Zakharova, *A. Kouraev, C. Duguay, S. Agafonova, N. Frolova~~
R3-O04	13:54-14:12	25 years of high-frequency ground penetrating radar measurements for snow studies in Svalbard	*D. Ignatiuk, T. Dunse, J-C. Gallet, L. Girod, M. Grabiec, D. Kępski, J. Kohler, M. Laska, B. Luks, W. Pelt, R. Pettersson, V. Pohjola, T. V. Schuler
R3-O05	14:12-14:30	Bottom-tracking ADCP measurements of river ice floes during collisions with a concrete structure	*T. Abe, H. Yokoyama, H. Ogushi
	14:30-14:45	Break	
R3-O06	14:45-15:03	Deep learning-based satellite image classification using the chopped picture method for thermokarst detection	*K. Takaya, N. Kurata, T. Ise, Y. Iijima
R3-O07	15:03-15:21	Spatial and temporal change patterns of CO2 and CH4 concentrations in Mongolian permafrost regions	*A. Saruulzaya, M. Ishikawa, T. Hiyama
R3-O08	15:21-15:39	Thermokarst development in the Lena-Aldan interfluve, eastern Siberia, observed by satellite remote sensing	*T. Abe, Y. Iijima
R3-O09	15:39-15:57	Oxygen-18 Content in Natural Waters of the Upper Kolyma River Basin	*V. Khomiakova, A. Zemlianskova, A. Ekaykin, O. Makarieva, N. Nesterova, A. Ostashov, K. Suzuki
R3-O10	15:57-16:15	Taliks and streamflow generation at the small watershed in continuous permafrost	*L. Lebedeva
	16:15-16:30	Break	
R3-O11	16:30-16:48	Betula nana growth rings as indicators of permafrost degradation in subarctic Sweden	*H. W. Linderholm, C. Leifsson, M. Björkman, M. Fuentes
R3-O12	16:48-17:06	Assessment of the effects of short-term warming on permafrost by meta-omics analysis	*L. C. Nguyen, G. Iwahana, S. Fukuda, J. Galipon
R3-O13	17:06-17:24	A mobile Suitcase Lab for onsite genome-wide analysis of DNA and RNA in remote locations	*J. Galipon, M. Usui, S. U Dagva, B. Erdenetsetseg, L. C. Nguyen, S. Fukuda, M. Tomita, B. Boldgiv, G. Iwahana, M. Watanabe, K. Tadakuma
R3-O14	17:24-17:42	New Data on Ground Temperature in the Upper Kolyma Basin	*D. Abramov, O. Makarieva, A. Zemlianskova, A. Ostashov, N. Nesterova, K. Suzuki
R3-O15	17:42-18:00	Modelling of Heat Transfer Processes in Subaerial Taliks of Central Yakutia, Russia	*S.V. Popov, A.S. Boronina, L.S. Lebedeva

R4
Ice Sheets, Glaciers and Ice Cores

Breakout Session/March 8, 2023

Venue 1 (B201)

Chair: Tomotaka Saruya			
~~R4-O01~~	13:30-13:50	**Cancel** ~~Organophosphorus Esters in a Firn Core from Austfonna, Svalbard~~	~~*M. H. Hermanson, R. Hann, E. Isaksson, G. W. Gabrielsen~~
R4-O02	13:50-14:10	Accumulation rate at a semiannual accuracy and melting history of an ice core from southeastern Greenland (SE- Dome Ⅱ) dating back to preindustrial	*K. Kawakami, Y. Iizuka, M. Sasage, M. Matsumoto, T. Saito, A. Hori, S. Ishino, S. Fujita, K. Fujita, K. Takasugi, T. Hatakeyama, S. Hamamoto, A. Watari, N. Esashi, M. Otsuka, R. Uemura, K. Horiuchi, M. Minowa, S. Hattori, T. Aoki, M. Hirabayashi, K. Kawamura, S. Matoba
R4-O03	14:10-14:30	MODIS-derived snow/ice physical parameters and their relationships to albedo over the Greenland ice sheet	*T. Aoki, R. Shimada, S. Matoba, M. Niwano, H. Ishimoto, T. Tanikawa, M. Hori, K. Stamnes, S. Yamaguchi, T. Yamasaki, K. Fujita, I. Yoshinori, M. Schneebeli, C. Carmagnola
R4-O04	14:30-14:50	Study of water circulation by water stable isotope and crystal shape of snow fall in northwestern Greenland	Y. Kurosaki, *S. Matoba
	14:50-15:15	Break	
Chair: Masahiro Minowa			
R4-O05	15:15-15:35	Reduced mass loss from the Greenland ice sheet under stratospheric aerosol injection	*R. Greve, J. C. Moore, T. Zwinger, F. Gillet-Chaulet, C. Yue, L. Zhao
R4-O06	15:35-15:55	The Impact of Climate Change on the Transformation of Aufeis in the North-East of Russia	*A. Zemlianskova, O. Makarieva, N. Nesterova, A. Ostashov, V.R. Alexeev, K. Suzuki
R4-O07	15:55-16:15	New Arctic Straits and Islands Appeared due to Glacial Recession from the 1960s to 2021	*W. Ziaja, K. Ostafin, W. Haska
R4-O08	16:15-16:35	Spatiotemporal changes in communities of snow-ice microbes living on Gulkana Glacier, Alaska	*M. Ono, J. Uetake, A. Tsushima, Y. Onuma, K. Kobayashi, D. Seto, S. Usuba, F. Konishi, N. Takeuchi

R5
Terrestrial Ecosystems
S8
Biogeochemical and hydrological responses to climate and environmental changes in the Arctic

Breakout Session/March 6, 2023

Venue 6 (NINJAL244)

Chair: Hideki Kobayashi, Tomoaki Morishita, Yongwon Kim			
R5-S8-O01	13:00-13:15	Preliminary result of creating continental-scale, daily water and vegetation maps over Pan-Arctic area using optical and microwave satellite data	*H. Mizuochi, T. Sasagawa
R5-S8-O02	13:15-13:30	Inclusion of a Site Specific, Variable Aerodynamic Roughness Length (z_0) in the SNOWPACK Model	*J. E. Sanow, S. R. Fassnacht, K. Suzuki
R5-S8-O03	13:30-13:45	Long-term degradation of petroleum in Arctic tundra soils	*Z. Bikmullina
R5-S8-O04	13:45-14:00	Groundwater inputs of mercury to Arctic coastal lagoons	*E. Bullock, I. Schaal, C. Demir, M. B. Cardenas, E. Bristol, J. McClelland, W. Huffman, H. Inman, R. Mason, M. Charette
R5-S8-O05	14:00-14:15	Long-term insight into the changes of plant populations in Arctic Alaska over the last 2000 years.	*M. Gałka, A.-C. Diaconu, A. Feurdean, L. Hedenäs, K.-H. Knorr, E. Łokas, M. Obremska
R5-S8-O06	14:15-14:30	Winter extreme precipitation event in interior Alaska in December 2021	*K. Suzuki, H. Hirashima, S. Matsumura, B. Busey, G. Iwahana, H. Park, H. Kobayashi
	14:30-14:45	Break	
R5-S8-O07	14:45-15:00	Carbon cycle of permafrost transects: representative terrestrial and hydrological ecosystems of Eastern Siberia	*T. Maximov, A. J. Dolman, A. Kotani, T. Hiyama
R5-S8-O08	15:00-15:15	Permafrost landscapes as cultural landscapes? On the interaction of pastoral and agricultural life-ways in different permafrost regions of North and Inner Asia	*J. O. Habeck
R5-S8-O09	15:15-15:30	Successional development of soil fungal community on a glacier foreland in The high Arctic	*M. Naka, K. Nishizawa, S. Masumoto, S. Matsuoka, M. E. Adaime, M. Uchida, A. S. Mori

R6
Marine Ecosystems

Breakout Session/March 9, 2023

Venue 5 (K301)

Chair: Atsushi Yamaguchi, Jacqueline Grebmeier, Russell Hopcroft, Yoko Mitani, Franz Mueter, Jean-Baptiste Thiebot			
R6-O01	13:00-13:15	Diatoms Contributing to New Production in Surface Waters of the Northern Bering and Chukchi Seas During Summer with Reference to Water Column Stratification	*K. Suzuki, Y. Yoshino, Y. Nosaka, J. Nishoka, S. B. Hooker, T. Hirawake
R6-O02	13:15-13:30	Characteristics of autumn diatom communities in the Chukchi Sea unraveled by combined DNA metabarcoding and scanning electron microscope techniques	*Y. Fukai, K. Matsuno, A. Fujiwara, K. Suzuki
R6-O03	13:30-13:45	Long-term changes in Arctic Zooplankton communities	*R. R Hopcroft
R6-O04	13:45-14:00	Distribution of Polar cod, Boreogadus saida, in the Chukchi Sea inferred from environmental DNA analysis	*T. Kawakami, A. Yamazaki, H. Jiang, H. Ueno, A. Kasai
R6-O05	14:00-14:15	Balance between human economic activities and the impacts on ecosystem by Atlantic salmon escape into the Pacific Ocean and Pacific salmon invasion of the Atlantic Ocean	*I. Shimizu
R6-O06	14:15-14:30	International regulation of fur sealing in the North Pacific : The role of non-state actors in marine living resource management and conservation	*M. Lomaeva, Y. Mitani, J. Saunavaara
	14:30-14:45	Break	
R6-O07	14:45-15:00	Seasonal movement and habitat use of ringed seals in northwestern Greenland	*Y. Sakuragi, A. Rosing-Asvid, S. Sugiyama, Y. Mitani
R6-O08	15:00-15:15	Diet of seals in northwest Greenland determined by stomach contents analysis	*M. Ogawa, Y. Sakuragi, M. Otsuki, S. Sugiyama, A. Rosing-Asvid, Y. Mitani
R6-O09	15:15-15:30	Seabird community response to contrasting levels of subglacial meltwater plume activity in NW Greenland	*J.B. Thiebot, M. Otsuki, A. Yamaguchi, Y. Watanuki, S. Sugiyama
R6-O10	15:30-15:45	Bird-colony dynamics revealed by sound monitoring (Siorapaluk, Greenland)	*E.A. Podolskiy, M. Ogawa, J.-B. Thiebot
R6-O11	15:45:16:00	Assessing Vulnerability of the Arctic Marine Ecosystems Under the Multiple Environmental and Anthropogenic Stressors	*T. Hirata, K. Sato, I. Alabia, J. García-Molinos, H. Ueno, E. Watanabe
R6-O12	16:00-16:15	Activities of the ICES-PICES-PAME working group on Integrated Ecosystem Assessment for the Central Arctic Ocean (WGICA)	L. Jørgensen , *S. Saitoh , M. Heuvel-Greve

R7
Geospace

Breakout Session/March 6, 2023

Venue 4 (D304)

Chair: Yasunobu Ogawa, Takuo Tsuda, Takanori Nishiyama, William Ward			
R7-O01	13:00-13:22	Abrupt Change in the Lower Thermospheric Mean Meridional Circulation during Sudden Stratospheric Warmings and its Impact on Trace Species	*Y. Orsolini, J. Zhang, V. Limpasuvan
R7-O02	13:22-13:44	Progress in high latitude ionospheric specification through diverse data integration	*D.R. Themens, B. Reid, P.T. Jayachandran, S. Elvidge, A.M. McCaffrey, J. Bernard, N. Rogers, F. Honary, J. Ruck
R7-O03	13:44-13:59	Localised three-dimensional current systems at auroral and sub-auroral latitudes and their potential impacts on the arctic upper atmosphere	*H. Opgenoorth, A. Schillings, A. N. Willer
R7-O04	13:59-14:14	Climatology of HF propagation at very high latitudes	*P. Ponomarenko, K. McWilliams
R7-O05	14:14-14:29	SuperDARN Hokkaido Pair of (HOP) radars – studying the ionosphere, thermosphere and upper atmosphere in the Antarctic region	*N. Nishitani
	14:29-14:45	Break	
R7-O06	14:45-15:00	Thermospheric Radiative Cooling during Northward Interplanetary Magnetic Fields：A case study	*T. Bag, D. Rout, Y. Ogawa
R7-O07	15:00-15:15	Insights into the Dynamics of the Polar Mesopause Region	*W. Ward, S. Kristoffersen, D. Fraser, D. Gamblin, C. Meek, A. Manson
R7-O08	15:15-15:30	Energetics of Arctic Stratospheric and Mesospheric Coupling Due to Small-scale Gravity Waves	*K. Nielsen, T. Tsuda, S. Nozawa
R7-O09	15:30-15:45	AGW-TID detection with EISCAT and meteor radar and application for background neutral wind measurements	*F. Günzkofer, D. Pokhotelov, G. Stober, I. Mann, S. L. Vadas, E. Becker, A. Tjulin, C. Borries
R7-O10	15:45-16:00	Effect of Arctic Stratospheric Warming Events on the Antarctic Middle Atmosphere	*P. Espy, K. Yamase-Skarvang
R7-O11	16:00-16:15	First Campaign Results of LODEWAVE (LOng-Duration balloon Experiment of gravity WAVE over Antarctica)	*Y. Tomikawa, K. Sato, Y. Saito, I. Murata, N. Hirasawa, M. Kohma, K. Nakashino, D. Akita, T. Matuso, M. Fujiwara, T. Kaho, L. Yoshida

R8
Laws, Politics and Economy

Breakout Session/March 9, 2023
Venue 4 (D304)

Chair: Fujio Ohnishi, Kentaro Nishimoto, Daiju Narita			
R8-O01	13:00-13:15	Arctic law is an academic discipline	*K. Hossain
~~R8-O02~~	13:15-13:30	**Cancel** ~~Human rights and security of non-Arctic people in the Arctic: policies and practices~~	~~*N. Yeasmin~~
R8-O03	13:30-13:45	The Regulation of Black Carbon Emissions in Arctic Shipping: the Role of Actors	*A. S. Ebbersmeyer
R8-O04	13:45-14:00	Toward Reducing the Arctic Black Carbon Emissions: Comparative Assessment of Policy Instruments across Arctic and non-Arctic States	K. Motohashi, *D. Narita
R8-O05	14:00-14:15	Why Do Non-Arctic States Develop Governmental Arctic Policies? : Motivations and Self-Justifications	*J. Jeong
R8-O06	14:15-14:30	The Analysis on Korean Arctic Policy based on the Policy Model and Policy Priorities	*H. SEO

R9
Culture, Language, and Environment

Breakout Session/March 9, 2023
Venue 4 (D304)

Chair: Megumi Kurebito, Nobuhiro Kishigami			
R9-O01	14:45-15:00	Arctic Silences: Avoiding Speech in Siberia	*L. Vallikivi
R9-O02	15:00-15:15	Naming of meadowlands and their identities in Sakha (Yakutia)	*M. Goto
R9-O03	15:15-15:30	Religious Resurgence among Sakha (Yakuts) in the Context of Muslim Immigration from Central Asia	*Z. Tarasova
R9-O05	15:30-15:45	Being Komi in the city: identities and belonging	*M. Fedina
R9-O06	15:45-16:00	Indigenous Well-Being in the Arctic Region of North America: A Theoretical Consideration	*N. Kishigami
	16:00-16:15	Q&A	

R10
Engineering for Sustainable Development

Breakout Session/March 7, 2023
Venue 6 (NINJAL244)

Chair: Shotaro Uto			
R10-O01	15:15-15:33	Examination of urban ZEB envelope performance under sub-Arctic climate condition	*T. Mori, H. Osawa, T. Yamauchi, H. Itsumiya
R10-O02	15:33-15:51	Challenges of sustainable regional development in arctic remote villages	*S. Oike, T. Mori, A. Delaney
R10-O03	15:51-16:09	Prediction of daily leachate generation at dumpsites located in Greenland	*Y. Tojo, T. Yasukouchi
R10-O04	16:09-16:27	Icing process hazards related to the “Lena” highway sustainability for the last 100 years	*L. Gagarin, N. Baishev, V. Ogonerov, D. Kuzmin
R10-O05	16:27-16:45	Engineering Challenge toward Sustainable Use of Arctic Sea Route	*S. Uto

S1
High-latitude Fires, Arctic Climate, Environment and health (HiFACE)

Breakout Session/March9, 2023

Venue 2 (C301)

Chair: Adriana Ford			
S1-O01	13:00-13:10	Community Vulnerability to Wildfire Risk in the Robson Valley region of British Columbia, Canada	*J. Whitehead, T. Pearce, J. Ford, G. Halseth
S1-O02	13:10-13:20	Community Risk and Resilience to High-latitude Wildfires	*I.V. Canosa, J. Ford, J. Paavola
S1-O03	13:20-13:30	Health Impacts of Wildfire smoke in Arctic Council Nations	*B. Silver, S. Arnold, L. Emmons, C. Reddington, L. Conibear
S1-O04	13:30-13:40	Fire Regimes in the Arctic Region	*H. Hayasaka
S1-O05	13:40-13:50	Develop an INtegrated Fire Risk mAnagement (INFRA) Pilot Service for Arctic Wildfires	*V. Vitale, E. Brugnoli , G. Bernardi, O. Drofa, O. Gavrichkova, M. Sarti, E. Nestola, A. Tiesi, L. Giandomenico, N. Tramarin, M. Mazzola, A. Lupi, F. Becherini, D. Mastrangelo
S1-O06	13:50-14:00	Predicting seasonal wildfire patterns with machine learning for the circumpolar and Alaska boreal and Arctic regions	*C. Waigl, E. Fischer, T. Ballinger, P. Bieniek, C. B. Strigle, M. Burgard, J. Hostler, R. Lader, E. Stevens, H. Strader, A. York, U. Bhatt
S1-O07	14:00-14:10	Arctic fire representations in the latest-generation Earth System Models	*M. Kasoar, K. Blackford, C. Burton, S. Hantson, A. Voulgarakis
S1-O08	14:10-14:20	INFERNO-peat: A Representation of High Latitude Peat Fires in the JULES-INFERNO Fire Model	*K. Blackford, A. Voulgarakis, C. Prentice, C. Burton, M. Kasoar
	14:20-14:45	Break	
	14:45-15:45	Discussion	

S2
Extratropical teleconnections and predictability of weather and climate related with the Arctic environmental changes

Part-1
Breakout Session/March 6, 2023
Venue 3 (D305)

Chair: Meiji Honda, Bunmei Taguchi, Masakazu Yoshimori, Tomonori Sato			
S2-O01	16:30-16:45	A new proposed scheme for seamless detection of cutoff lows and preexisting troughs	*M. Honda, S. Kasuga, J. Ukita, S. Yamane, H. Kawase, A. Yamazaki
S2-O02	16:45-17:00	Cutoff Low Approaching Routes to the Japan Islands	*S. Kasuga, M. Honda, J. Ukita, S. Yamane, H. Kawase, A. Yamazaki
S2-O03	17:00-17:15	Distinct seasonality in the frequency of migratory cyclones and anticyclones over the North Pacific	*S. Okajima, H. Nakamura, Y. Kaspi
S2-O04	17:15-17:30	Remote influence of the interannual variability of the Australian summer monsoon on wintertime climate in East Asia and the western North Pacific	*S. Sekizawa, H. Nakamura, Y. Kosaka
S2-O05	17:30-17:45	Reconciling conflicting evidence for the cause of the observed early 21st century Eurasian Cooling	*S. Outten, C. Li, M. King, L. Suo, P. F. Siew, H. Cheung, R. Davy, E. Dunn-Sigouin, T. Furevik, S. He, E. Madonna, S. Sobolowski, T. Spengler, T. Woollings
S2-O06	17:45-18:00	Barents-Kara sea-ice decline attributed to surface warming in the Gulf Stream	*Y. Yamagami, M. Watanabe, M. Mori, J. Ono

Part-2
Breakout Session / March 7, 2023
Venue 1 (B201)

Chair: Meiji Honda, Bunmei Taguchi, Masakazu Yoshimori, Tomonori Sato			
S2-O07	15:15-15:30	Atmospheric circulation-constrained model sensitivity delays timing of ice-free Arctic	*D. Topál, Q. Ding
S2-O08	15:30-15:45	Energetics of Atmospheric Meridional Teleconnections of Internal/ External Variability over the North Pacific in Winter	*R. Satoh, Y. Kosaka
S2-O09	15:45-16:00	Changing Role of Atmospheric Temperature Advection and Water Vapor Advection under Arctic Amplification using a Large-scale Ensemble Model Dataset	*M. Hori, M. Yoshimori
S2-O10	16:00-16:15	Exchange of atmospheric moisture between Arctic Ocean and Eurasian continent investigated by moisture transport model experiment	*T. Sato
S2-O11	16:15-16:30	Climatological Characteristics of Atmospheric Rivers over Northern Eurasia during Summer	*Y. Fukutomi, H. Kanamori, T. Hiyama
S2-O12	16:30-16:45	Interdecadal Variations of Monthly Water Budget Comportments in Warm Season over Siberia	*H. Kanamori, T. Hiyama

S3
Atmospheric composition and Arctic environment/climate: New assessment reports and original studies

Breakout Session/March 6, 2023

Venue 3 (D305)

Chair: Yugo Kanaya, Kohei Ikeda, Niko Karvosenoja, Ville-Veikko Paunu, Zbigniew Klimont			
S3-O01	13:00-13:18	Size Distribution and Depolarization Properties of Aerosol Particles over the Northwest Pacific and Arctic Ocean	Y. Tian, *X. Pan, Y. Sun, P. Fu, I. Uno, Z. Wang
S3-O02	13:18-13:36	Concentrations and physical properties of refractory black carbon in the atmosphere over the Pacific and the Antarctic Ocean	*S. Lim, J. Kim, M. Lee, K. Park, Y. Yoon
S3-O03	13:36-13:48	Observations of the Central Arctic Atmosphere and Surface Using Uncrewed Aircraft Systems	*G. de Boer, R. Calmer, G. Jozef, J. Cassano, J. Hamilton, U. Egerer, D. Lawrence, A. Doddi, B. Argrow
S3-O04	13:48-13:57	Potential impact of marine biota on the formation of marine bioaerosols, CCN, and INP over the Arctic Ocean	*K. Kawana, F. Taketani, K. Matsumoto, T. Miyakawa, Y. Tobo, Y. Iwamoto, A. Ito, Y. Kanaya
S3-O05	13:57-14:06	Arctic marine aerosols observed during R/V Mirai cruise in Autumn, 2021	*T. Kinase, F.Taketani, T. Miyakawa, C. Zhu, M. Takigawa, Y. Kanaya
S3-O06	14:06-14:15	Source attribution of black carbon aerosols at Poker Flat, Alaska using FLEXPART-WRF	*M. Takigawa, F. Taketani, Y. Kanaya, H. Kobayashi, T. Kinase, C. Zhu, Y. Kim
S3-O07	14:15-14:24	Ship-borne Observation of Ice Nucleating Particles over the Western North Pacific to the Arctic Ocean by R/V Mirai: Comparison with Composition of Aerosol Particles	*F. Taketani, Y. Tobo, M. Takigawa, T. Miyakawa, Y. Kanaya
	14:24-14:30	discussion on new platforms and Arctic research collaboration	
	14:30-14:45	Break	
S3-O08	14:45-15:03	Short-lived climate forcers in the Earth system: recent trends, source attribution, and future projections	*M. T. Lund
S3-O09	15:03-15:21	Impacts of Short-lived Climate Forcers on the Arctic Climate by MRI-ESM2.0 and Multi-model Analyses	*N. Oshima, M. Deushi, T. Aizawa, S. Yukimoto
S3-O10	15:21-15:33	Estimation of the Arctic CH_4 flux based on an ensemble of atmospheric inversions and aircraft observations	*D. A. Belikov, B. D. Belan, M. Y. Arshinov, N. Saitoh, P. K. Patra
S3-O11	15:33-15:45	Quantifying Contributions of Anthropogenic Aerosol Increase and Internal Variability to the Mid-20th Century Arctic Cooling by CMIP6/DAMIP Multimodel Analysis	*T. Aizawa, N. Oshima, S. Yukimoto
S3-O12	15:45-15:57	Expert Group on Black Carbon and Methane (EGBCM) - A Finnish Perspective on National Reporting	*S. Romppanen, K. Kupiainen, M. Savolahti, N. Karvosenoja
S3-O13	15:57-16:06	Synthesis of bottom-up and observation-based black carbon emission estimates from China, Japan and Korea as Observer States of Arctic Council	*Y. Kanaya, K. Yamaji, T. Miyakawa, F. Taketani, C. Zhu, Y. Choi, K. Ikeda, H. Tanimoto, D. Yamada, D. Narita, Y. Kondo, Z. Klimont
	16:06-16:15	Poster introduction & discussion on the future SLCF studies and inventories	

S4
Synoptic Arctic Survey – international collaboration for Arctic Ocean transdisciplinary studies

Breakout Session/March 8, 2023

Venue 4 (D304)

Chair: Jacqueline Grebmeier			
S4-O01	13:30-13:50	Into the deep Central Arctic Ocean – results from the Nansen Legacy Arctic Basin expedition 2021	*A. Fransson, M. Chierici, B. Bluhm, M. Reigstad
S4-O02	13:50-14:10	AdvanCing knowledge on the present Arctic Ocean by chemical-phySical, biogeochemical and biological obServAtioNs to preDict the futuRe chAnges(CASSANDRA)	*M. Azzaro , M. Bensi, G. Civitarese, M. Giani, A. Lo Giudice, F. Becherini, D. Borme , W.R.L. Cairns, D.M. Cappelletti, C. Caroppo, G. Caruso, F. Cerino, A. Cosenza, C. De Vittor, F. Decembrini, T. Dociaiuti, E. Federici, M. Feltracco, I. Gandolfi, V. Kovacevic, R. La Ferla, A. Lupi, G. Maimone, P. Mansutti, M. Mazzola, S. Miserocchi, M. Monti, M. Papale, L. Patrolecco, A.C. Rappazzo, F. Relitti, C. Rizzo, F. Spataro, V. Tirelli, C. Turetta, L. Urbini, L. Ursella, V. Vitale
S4-O03	14:10-14:30	Overview of the R/V Mirai Arctic Ocean cruise in 2022	*M. Itoh, J. Onodeara, M. Hatta, S. Nishino, A. Fujiwara, E. Watanabe, A. Murata, T. Kikuchi
S4-O04	14:30-14:50	Benthic Studies during the 2022 US Synoptic Arctic Survey	*J. Grebmeier, L. Cooper, C. Goethel, B. Marx, C. Gaffey, J. Silberberg, M. Tepper-Rasmussen
	14:50-15:15	Break	
Chair: Michiyo Yamamoto-Kawai			
~~S4-O05~~	15:15-15:35	**Cancel** ~~Seasonal and interannual variability in the surface fCO_2 of the Barents Sea and adjacent high-latitude North Atlantic~~	~~*Y. Ericson, A. Fransson, M. Chierici, E. Jones, I. Skjelvan, A. Olsen, A. Omar~~
S4-O06	15:35-15:55	Surface microplastic concentrations and water-column microplastic inventories in the Chukchi Sea, western Arctic Ocean	*T. Ikenoue, R. Nakajima, A. Fujiwara, J. Onodera, M. Itoh, J. Toyoshima, E. Watanabe, A. Murata, S. Nishino, T. Kikuchi
S4-O07	15:55-16:15	Shrink of an ocean gyre in the Pacific Arctic and Atlantification open a door of shadow zone	*S. Nishino, J. Jung, K. H. Cho, W. J. Williams, A. Fujiwara, A. Murata, M. Itoh, M. Aoyama, M. Yamamoto-Kawai, T. Kikuchi, E. J. Yang, S-H. Kang
S4-O08	16:15-16:35	Temporal changes in radiocesium in the Arctic Ocean and the northwestern North Pacific Ocean by 2020	*Y. Kumamoto, Y. Hamajima, S. Nishino, M. Inoue, A. Murata, T. Kikuchi

S7
Arctic hydrology in the context of warming climate

Breakout Session/March 6, 2023

Venue 5 (K301)

Chair: Hotaek Park, Liudmila Lebedeva			
S7-O01	14:45-15:00	River streamflow change in continuous permafrost environment in Eastern Siberian Arctic	*L. Lebedeva, D. Gustafsson, T. Hiyama
S7-O02	15:00-15:15	WATER FLOW CHANGES IN THE LENA RIVER AT KYUSYUR DURING 1936–2019	*A. Georgiadi, I. Milyukova
~~S7-O03~~	15:15-15:30	**Cancel** ~~Live by the river: adaptation to natural disasters on the case of Dygdal village in Yakutia~~	~~*V. Filippova, L. Vinokurova~~
S7-O04	15:30-15:45	Trends in River Water Chemistry Suggest Permafrost Degradation in the Kolyma River Basin	*Y. Tashiro, T. Hiyama, H. Kanamori, H. Park, O. Makarieva, N. Nesterova, K. Suzuki
S7-O05	15:45-16:00	Indicators of recent hydro-climatic and river temperature change in the Mackenzie River Basin	*R. Shrestha, J. Pesklevits, B. Bonsal
S7-O06	16:00-16:15	Radium Isotopes as Tracers of Shelf-Basin Exchange Processes in a Changing Arctic Ocean	*M. A. Charette, I. V. Polyakov, A. Robbins, L. M. Whitmore, L. E. Kipp
	16:15-16:30	Break	
Chair: Tetsuya Hiyama, David Gustafsson			
S7-O07	16:30-16:45	Arctic sea ice retreat does not enhance atmospheric hydrological cycle	*M. Tanoue, T. Nakamura, K. Oshima, K. Ichiyanagi, H. Park
S7-O08	16:45-17:00	Permafrost hydrology changes due to expansion, erosion, and merging of thermokarst lakes in Central Yakutia	*Y. Iijima, T. Abe, H. Saito, A. N. Fedorov
S7-O09	17:00-17:15	Continued warming of the permafrost regions over the Northern Hemisphere under future climate change	*G. Hu, L. Zhao, T. Wu, X. Wu, H. Park, R. Li, X. Zhu, J. Ni, D. Zou
S7-O10	17:15-17:30	Contribution of water rejuvenation induced by climate warming to evapotranspiration in subarctic boreal forest	*H. Park, T. Hiyama, K. Suzuki
S7-O11	17:30-17:45	Snow Surface Roughness across Space, Time, Land Cover, and Scales	*S. R. Fassnacht, K. Suzuki, J. E. Sanow, B. M. Simms

S9
Sustainable, responsible, and resilient Arctic tourism: lip service or concrete actions

Breakout Session/March 7, 2023
Venue 3 (D305)

Chair: Juha Saunavaara, Monika Luthje			
	15:15-15:20	Introduction of the Session	
S9-O01	15:20-15:35	Transpolar Tourism:Lessons Learned, Challenges Conquered, and Future Features, from North to South	*E. C. Frye
S9-O02	15:35-15:50	Pathways to Culturally Sensitive Tourism Policies and Practices	*M. Lüthje, E. Höckert, O. Kugapi
S9-O03	15:50-16:05	In search of the authentic experience: Case of Sàmi Indigenous Adventure Tourism	*T. Fukuyama, H. Koyabashi, H. Ueda, J. Saunavaara, C. Bernardi
S9-O04	16:05-16:20	Sustainable Tourism and Climate Change in the Arctic: Women's (Missing) Opportunities and Tourist Motivations	*D. Grafton, A. Quandt, V. Chu
S9-O05	16:20-16:35	Snowmaking as an adaptation strategy in Arctic winter tourism centers – avoiding maladaptation by a climate service	*I. Mettiäinen, M. Coath, R. Contreras, J. Toivonen, J. Moore
	16:35-16:45	General discussion	Moderated by J. Saunavaara

S10
Changing Arctic strategic and geopolitical landscapes: the impact of the war in Ukraine

Breakout Session/March 6, 2023
Venue 2 (C301)

Chair: Fujio Ohnishi			
	16:30-16:35	Introduction	*F. Ohnishi
S10-O01	16:35-16:40	Changing geopolitical landscape in the Arctic after the Russian attack on Ukraine on February 2022	*F. Ohnishi, M. Lomaeva
S10-O02	16:40-16:45	The Arctic: What role for NATO?	*P. S. Hilde
S10-O03	16:45-16:50	The Effect of Finnish and Swedish NATO Membership for the Dynamics in the Arctic	*M. Petersson
S10-O04	16:50-16:55	Greenlandic visions of sovereignty and security in the wake of the Russian war in Ukraine	*U. P. Gad
	16:55-17:40	Panel discussion	All speakers
	17:40-18:00	Questions from the floor	All speakers

S11
After the Ukraine: The Arctic, International Law, and International Scientific Cooperation

Breakout Session/March 7, 2023
Venue 2 (C301)

Chair: Akiho Shibata			
S11-O01	15:15-15:30	Russia's Invasion of Ukraine and Policy Implications for the Poles: Examination of Post-Invasion Developments	*Z. Madani
S11-O02	15:30-15:45	Arctic governance in light of Ukraine crisis: the important role of the Arctic Council in the overall governance of the region	*T. Koivurova
S11-O03	15:45-16:00	Analyzing Proposals on "the Necessary Modalities" for the A-7 States to Continue the Arctic Council's Work	*O. Inagaki
	16:00-16:10	Q&A	
S11-O04	16:10-16:25	Global governance and the two-category system in the Arctic in relation to Arctic sustainable development	*A. Bakhtaoui Van Deputte
S11-O05	16:25-16:40	The Arctic Council Task Force: "Task Force on Improved Connectivity in the Arctic" and the impact of the Ukraine crisis on Arctic connectivity	*A. Grenet
	16:40-16:45	Q&A	

S12
International Governance of the Central Arctic Ocean: Science, Indigenous Knowledge, and the Rule of Law
S22
Indigenous Co-Production of Arctic Knowledge: Toward a More Inclusive Arctic Scientific Research

Breakout Session/March 9, 2023

Venue 2 (C301)

Chair: Romain Chuffart, Lindsay Arthur, Kentaro Nishimoto			
S12-S22-O01	16:30-16:40	Shared Arctic Variables and Expert Panels as a forum for co-production and capacity sharing	*A. Bradley, M. Rudolf, H. Lihavainen, H. Eicken, S. Starkweather, H. Sevestre, I. Matero, M. Karcher
S12-S22-O02	16:40-16:50	Remaking the world in who's image? Arctic Geoengineering, consent, and the Co-production of knowledge	*A. M. Cooper
S12-S22-O03	16:50-17:00	Working together with local communities to understand changes in the coastal environment and their impact on society in Inglefield Bredning, northwestern Greenland	*M. Otsuki, Y. Sakuragi, J. B. Thiebot, M. Ogawa, R. Kusaka, E. Podolskiy, T. Oshima, S. Sugiyama
S12-S22-O04	17:00-17:10	Nordurslod Arctic Exhibition Ark & Global Indigenous Centre: A Gateway to New International Dialogue, Innovation and Constructive Action	*L. E. Arthur
S12-S22-O05	17:10-17:20	A Research Agenda for Central Arctic Ocean Fisheries Agreement: Science, Indigenous Knowledge and Rule of Law	*K. Nishimoto, A. Shibata, K. Taki, S. Nishino
S12-S22-O06	17:20-17:30	Development of the Joint Program of Scientific Research and Monitoring (JPSRM) under scientific meetings	*K. Taki
S12-S22-O07	17:30-17:40	Taking into account of Indigenous Knowledge under the CAO Fisheries Agreement: Lessons from 2022 ICC Protocols for Equitable and Ethical Engagement	*A. Shibata

S13
Building a region: Arctic identities and identity politics

Breakout Session/March 6, 2023
Venue 2 (C301)

Chair: Kristín Ingvarsdóttir, Aileen Aseron Espiritu			
S13-O01	14:45-14:55	The Rise and Demise of the Arctic as a Region? – The Arctic Council without Russia	*A. A. Espiritu
S13-O02	14:55-15:05	Region-building in the West Nordic Arctic	*K. Ingvarsdottir
S13-O03	15:05-15:15	Roles of imported whale meat from Iceland and Norway	*J. Akamine
S13-O04	15:15-15:25	Polska jako członek obserwator Rady Arktycznej (Poland as Arctic Council Observer)	*P. Markowski
S13-O05	15:25-15:35	Cooperating and Observing towards an Ideal: The Arctic in Japan's Foreign Policy Identity	*W. Yennie Lindgren
S13-O06	15:35-15:45	Constructed Proximity:Identity and China's Near-Arctic State Concept	*M. Lanteigne

S15
Redefining the well-being of Arctic communities in the context of global environmental and societal change

Breakout Session/March 8, 2023
Venue 7 (NINJAL201)

Chair: Naotaka Hayashi			
S15-O01	13:30-13:48	Using Traditional Ways of Education to Maintain Indigenous Communities	*T. Inoue
S15-O02	13:48-14:06	Ainu People and Well-being : A Case Study of Salmon Fishing and Ceremony under the Ainu Policy Promotion Act	*H. Noguchi
S15-O03	14:06-14:24	Food Life History Project in Alaska: Community-based Participatory Research on Underground Caches	*Y. Kugo, M. Koskey, G. Iwahana, T. John, K. Saito, Y. Hirasawa, S. Tatsuzawa
S15-O04	14:24-14:42	How are waste management issues recognized in people's lives in small remote villages in Alaska	*K. Ishii
S15-O05	14:42-15:00	Community-based wild reindeer monitoring and establishment of adaptive hunting area in the Siberian Arctic: as autonomous adaptation to climate change	*S. Tatsuzawa, I. Okhlopkov, E. Kirillin, M. Nikolay
	15:00-15:15	Break	
S15-O06	15:15-15:25	Livelihood of Indigenous People under A Changing Climate in Yakutia, Russia: Description and Analysis of A Quantitative Household Survey	*S. Khasanov, D. Yamada, D. Narita, T. Gavrilyeva, V. Parilova, J. Garcia Molinos
S15-O07	15:25-15:35	Arctic LNG Business in Russia: Retreat or Resume?	*M. Tokunaga
S15-O08	15:35-15:45	Economic Development in the Arctic Regions in Russia: before and after February 2022	*S. Tabata
S15-O09	15:45-15:55	Potential Climate Refugees from Permafrost Area: Are People Ready to Leave Their Native land?	*Y. Zhegusov
S15-O10	15:55-16:05	Arctic river settlements of Yakutia in changing climatic conditions (social challenges of changing the hydrological regime of the Arctic in the 21st century).	*S. Grigorev, A. Suleymanov, A. Arkhipova, S. Fedorov
S15-O11	16:05-16:15	Arctic policy and fiscal problems in Russia: the case of the Sakha Republic	*K. Yokogawa
	16:15-16:45	Discussion	

S16
Making of Arctic exhibition and material study: the potential of collaboration study with local people

Breakout Session/March 7, 2023
Venue 4 (D304)

Chair: Hiroki Takakura, Yuka Oishi			
S16-O01	15:15-15:32	Anthropology of exhibitions in Russian Arctic: Sharing the visual images beyond borders	*H. Takakura, V. Ignatyeva
S16-O02	15:32-15:49	The Relational Exhibition: Connecting Landscapes, Communities, and Research Archives	*V. Peemot
S16-O03	15:49-16:06	Life of a Big River : Russia-Japan Traveling Exhibition Project	*Y. Watanabe, *A. Logunovich, A. Kazakevich
S16-O04	16:06-16:23	Possibilities and Difficulties involved in the holding Arctic Exhibitions in Museums with Small Arctic Collections	*S. Koresawa
S16-O05	16:23-16:40	More than dissemination: two-ways interaction between science and the local community.	*A. Stammler-Gossmann
	16:40-16:45	Wrap-up	

S17
Arctic Shipping: Economic Feasibility and Challenges

Breakout Session/March 8, 2023
Venue 5 (K301)

Chair: Trang Tran, Chathumi Ayanthi Kavirathna			
S17-O01	13:30-13:44	The economic impacts of opening the Northern Sea Route under political uncertainty	*T. Tran, R. Shibasaki, W. Ding
S17-O02	13:44-13:58	Economic Prospect of Arctic Container Liner Shipping	*H. Xu
S17-O03	13:58-14:12	Multicommodity Cargo Flow Simulation of Northern Sea Route using Global Logistics Intermodal Network Model	*K. Kawachi, R. Shibasaki, N. Kosuge
S17-O04	14:12-14:26	A Model-Based Social Impact Evaluation of R&D topics related to Northern Sea Routes	*K. Morikami, R. Wada, T. Tran, R. Shibasaki, N. Otsuka
S17-O05	14:26-14:40	Analysis of Arctic Shipping Prospects under the Influence of Climate and Political Factors	X. Zhou, M. Yue, *L. Dai, H. Hu
S17-O06	14:40-14:54	A Research on the Turkish Shipyards in the Arctic: Opportunities and Challenges	*E. Caymaz
	14:54-15:15	Break	
S17-O07	15:15-15:29	Full-Scale Prediction of Ship Resistance in Ice Condition	*S-Y. Jeong, K. Choi, H-S. Kim
S17-O08	15:29-15:43	Risk-Aware Route Planning for Arctic Maritime Navigation	*L. Etienne, O. Faury, A. Cheaitou, P. Rigot-Muller, L. Fedi
S17-O09	15:43-15:57	Logistic configurations as a risk management and sustainable tool.	*O. Faury, A. Cheaitou, L. Etienne, L. Fedi, P. Rigot-Muller
S17-O10	15:57-16:11	Vessel speed optimization in China transportation market with the EU in multiple modes including the Northern Sea Route	*W. Ding, R. Shibasaki, C. A. Kavirathna
S17-O11	16:11-16:25	Bulk Vessels Diversions to the Arctic Shipping Routes with the Effect of Emission Trading System	*C. A. Kavirathna, R. Shibasaki, W. Ding
~~S17-O12~~	16:25-16:39	**Cancel** ~~Container shipping fleet CAPEX and fuel consumption concerning the Northern Sea Route~~	~~*H. Jia, R. Shibasaki, W. Ding, T. Tran~~

S18
Arctic Sea Route and Coastal Protection: environmental, engineering, and economic assessment

Breakout Session/March 9, 2023
Venue 3 (D305)

Chair: Akihisa Konno			
S18-O01	13:00-13:20	Development of Arctic data visualization system for ice navigation support	*G. Sagawa
S18-O02	13:20-13:40	Preliminary analysis for ice thickness estimation for the wide area of Arctic Sea using AMSR2	*S. Kubo, A. Konno
S18-O03	13:40-14:00	Seasonal and regional predictability of Arctic sea ice: Lagrangian ice tracking applications	*C. Brunette, B. Tremblay, R. Newton
S18-O04	14:00-14:20	Numerical Simulation of Ships Navigating Through Broken Ice Fields	*T. Tokudome, A. Konno
	14:20-14:45	Break	
S18-O05	14:45-15:05	Development of a method for evaluating brash ice channel condition for ship navigation	*Y. Yoshida, A. Konno
S18-O06	15:05-15:25	Investigation of Hydrodynamic Forces Acting on an Ice Piece Downstream of Floating Ice Pieces	*R. Hayashi, A. Konno, Z. Jinxin, D. Kitazawa
S18-O07	15:25-15:45	Laboratory Experiments of Urea-doped Water Spray Icing on Cylindrical Specimens	*T. Ozeki, S. Adachi, T. Tokudome, A. Konno

S20
Toward sustainable Arctic -developing a network of Arctic researchers and other Arctic stakeholders-

Breakout Session/March 9, 2023

Venue 7 (NINJAL201)

Chair: Natsuhiko Otsuka, Juha Saunavaara, Hajo Eicken, Yuji Kodama			
	13:00-13:05	Rationalization	N. Otsuka
S20-O01	13:05-13:20	HAI-FES: Problem-solving project for the sustainable Arctic	*Y. Kodama, N. Otsuka, J. Saunavaara, F. Ohnishi, S. Uto, T. Hirata, Y. Fukamachi
S20-O02	13:20-13:40	Developing guidelines, standards and best practices for sustainable development in the Arctic	*S. Sandven, J. Pearlman
S20-O03	13:40-14:00	Food Life History in Greater Beringia: Types, History, and Current Issues of Cold Storage	*K. Saito, G. Iwahana, Y. Kugo, H. Hirasawa, S. Tastuzawa, T. John, M. Koskey
S20-O04	14:00-14:20	Sustainability of the Northern Sea Route, commercial, environmental, and social perspectives	*N. Otsuka, F. Ohnishi
S20-O05	14:20-14:40	SMART/Dual-purpose Trans-Arctic Cables: Industry-Academia Cooperation initiative too good to be missed?	*J. Saunavaara
S20-O07	14:40-15:00	Yakutia as a platform for science diplomacy in Russia's Arctic	T. Gavrilyeva, *V. Parilova
	15:00-15:10	Break	
S20-O06	15:10-15:30	The review of the KoARC's activities and visions	*H K. Seo
	15:30-16:15	Panel Discussion	Moderator: N. Otsuka

S21
Funding International Arctic Science

Breakout Session/March 8, 2023

Venue 6 (NINJAL244)

Chair: Volker Rachold, Egill Þór Níelsson, Tetsuo Sueyoshi, Lindsay Arthur, Ágúst Hjörtur Ingþórsson			
S21-O01	13:30-13:45	Challenges in International Arctic Research Cooperation	*K. Latola
S21-O02	13:45-14:00	Overview of European Polar Research Funding	*N. Biebow, J. B. Orbaek, E. T. Nielsson, A. H. Ingporsson, L. Arthur, A. Strobel
S21-O03	14:00-14:15	Cooperation in European Polar Research: current status, and upcoming developments	*P. Elshout, R. Badhe
S21-O04	14:15-14:30	Evolution of Arctic Research System in Japan -From individual research to national project, and international collaboration	*H. Enomoto
S21-O05	14:30-14:45	Organizing funding for observing in the Arctic	*J. R. Larsen, H. Savela, N. Biebow, R. Badhe, P. Elshout, V. Spadetto, A. Strobel, S. Scory
S21-O06	14:45-15:00	New initiative toward the International Platform for Arctic Science: Call for ECSs proposal using R/V Mirai 2023 Arctic Cruise	*T. Kikuchi, and other ArCS II members
	15:00-15:15	Break	
S21-O07	15:15-15:30	Science Process and its outcomes of the third Arctic Science Ministerial (ASM3) – international cooperation in Arctic research	*T. Sueyoshi, L. E. Arthur, H. Kimura, Á. Kjartansdottir, Y. Kodama
S21-O08	15:30-15:45	Funding the future of polar research	*S. M. Strand, L. M. Grosfeld
S21-O09	15:45-16:00	Tools for Enhancing International Research Funding Opportunities: Arctic Science Ministerial Resources	*J. Baeseman, H. Yabuki, T. Sugimura, K. Iino, T. Sueyoshi, H. Kimura, Y. Kodama, L. E. Arthur, Á. Kjartansdottir
S21-O10	16:00-16:15	Strengthening international collaboration to fund Arctic science: the perspective of the French National Research Agency	*A. H. Prieur-Richard
S21-O11	16:15-16:30	Funding of Arctic science – A Norwegian perspective	*J. L. Fuglestad, J. B. Ørbæk, I. Fossum, S. L. Smedsrud, P. Soergaard
	16:30-16:45	General Discussion	

S23
Multidisciplinary observing systems in Arctic, potential and challenges

Breakout Session/March 9, 2023

Venue 6 (NINJAL244)

Chair: Heikki Lihavainen			
	13:00-13:02	Introduction and logistics	
S23-O01	13:02-13:13	Towards a High Arctic Ocean Observation System	*H. Sagen, S. Sandven
S23-O02	13:13-13:24	A New Environmental Monitoring in the Arctic: Cryosphere Integrated Observatory Network on Svalbard (CRIOS)	*M. Laska, G.D. Breedveld, A.S. Coulson, J-C. Gallet, Ø. Godøy, D. Ignatiuk, S. Jawak, H. Lihavainen, B. Luks, J. Małecki, K. Migała, D. Próchniewicz, I. Sobota, M. Strzelecki, P. Zagórski
S23-O03	13:24-13:35	GEOCRI: A Big Data Approach for Cold Region Information Service	Y. Qiu, *H. Enomoto, M. Menenti, X. Cheng, J. Key, H. K. Lappalainen, X. Li, S. Sandven, V. Vitale
S23-O04	13:35-13:46	Bridging the Fram Strait - facilitating collaboration across the largest high Arctic climatic gradient	H. H. Christiansen, S. Rysgaard, H.Skov, P. S. Mikkelsen, S. S. Jawak, C. Stedmon, *H. Lihavainen
S23-O05	13:46-13:57	Towards 'good practice' in the use of Indigenous, local and scientific knowledge for informing natural resource management	*F. Danielsen, M. Enghoff, M. K. Poulsen, L. Iversen, S. Sandven, N. Johnson, O. Lee
S23-O06	13:57-14:08	The Climate Change Tower Integrated Project (CCT-IP) and the muldisciplinary observing activities of Italy at Ny Alesund (Svalbard) since 2009	*V. Vitale, M. Mazzola, A. Viola, S. Gilardoni, E. Barbaro, R. Salvatori, R. Salzano, A. Spolaor, A. Lupi, F. Becherini, M. Vardè, B. Petkov, F. Tampieri, R. Traversi, S. Becagli, M. Severi, D. Cappelletti, B. Moroni, M. Rinaldi, M. Paglione, L. Langone, S. Miserocchi, P. Giordano, F.Giglio, T. Tesi, M. Doveri, S. Giamberini, A. Augusti, O. Gavrichkova, M. Azzaro, M. Guglielmin, N. Cannone, G.Verazzo
S23-O07	14:08-14:19	Estimation of high tundra vegetation productivity using OCO-2, Sentinel 5 and FLoX data	*K. Ostapowicz, T. Park, L. Nilsen, H. Tømmervik
S23-O08	14:19-14:30	Using Unattended Approaches to Enable Multidisciplinary Study of Seasonal Events in the Coastal Arctic Ocean	*S. Laney, S. Okkonen, K. Longnecker, L. Catipovic

Poster Session

March 8, 2023

Core time 1 (Online) : 8:20-9:20 (JST)

Core time 2 (Online) : 17:00-18:00 (JST)

R1-P01	Temporal Variations of the Mole Fraction, Carbon, and Hydrogen Isotope Ratios of Atmospheric Methane observed at Churchill, Canada	T. Ozaki, *S. Morimoto, R. Fujita, T. Umezawa, D. Worthy, D. Goto
R1-P02	Mesoscale Atmospheric Structure near the Sea Ice Edges over the Arctic Region as represented by ERA5	*R. Masunaga
R1-P03	Future changes of Arctic cloud and its radiation effect in large ensemble projections by MIROC6	*M. Abe, H. Tatebe, J. Ono, Y. Komuro
R2-P01	Comparisons of sea-ice reproducibility and their impacts on climate variability in an initialized climate model	*J. Ono, Y. Komuro, H. Tatebe
R2-P02	First look of ocean and sea-ice conditions from Ice Exercise 2022 (ICEX 2022)	*S. Kimura, A. Fujiwara, T. Kikuchi
R2-P03	Satellite-based mapping of sediment-laden sea ice	*H. Waga, H. Eicken, B. Light, Y. Fukamachi
R2-P04	Laboratory experiment of ice group formation under waves	*Y. Fujiwara, T. Waseda, T. Kodaira, T. Nose, T. Katsuno, K. Sato
R2-P05	Impacts of freshwater types on sea surface partial pressures of CO_2 in the Pacific sector of the Arctic Ocean	*M. Tozawa, D. Nomura, M. Matsuura, M. Hatta, A. Fujiwara, S. Yasunaka, A. Murata
R2-P06	Experimental research on spectral downshift of propagating waves under sea ice	*K. Sato, T. Waseda, T. Kodaira, Y. Fujiwara, T. Nose, T. Katsuno
R2-P07	Melt pond CO_2 dynamics and flux with the atmosphere in the central Arctic Ocean during summer to autumn transition	*M. Yoshimura, D. Nomura, A. Webb, Y. Li, M. Dall'osto, K. Schmidt, E. S. Droste, E. J. Chamberlain, K. Posman, H. Angot, B. Blomquist, E. Damm, J. Inoue, B. Delille
R2-P08	Sea ice variability on the Chukchi Sea and the Beaufort Sea since the Late Pleistocene	*M. Uchida, H. Kumata, K. Mantoku, C. Amano, M. Utsumi, M. Itoh, S. Nishino, K. Shimada
R2-P09	Interannual variability of phytoplankton community structure in the Pacific Arctic Region	*A. Fujiwara, S. Nishino, T. Hirawake, K. Suzuki, T. Kikuchi
R2-P10	Spatial distribution of manganese in surface waters in the East Siberian Arctic Seas	*N. Kanna, K. Tateyama, T. Waseda, A. Timofeeva, M. Papadimitraki, L. Whitmore, H. Obata, H. Ogawa, D. Nomura, I. Polyakov
R2-P11	Temporal changes in physical and biogeochemical properties of halocline waters in the Canada Basin	*H. Tsujimoto, M. Yamamoto-Kawai, W. Williams
R2-P12	Impacts of non-breaking wave induced mixing on the modelling of Arctic Cyclone through the two-way coupled numerical model	*XK. Xu, Y. Fujiwara, T. Nose, T. Kodaira, T. Waseda
R2-P13	Radiation characteristics of thin sea ice in the ice tank experiments during freezing and melting periods using multifrequency passive microwave radiometers	K. Tateyama, *H. Enomoto, K. Akiu, M. Nakayama
R3-P01	Representation of Microscale Spatial Variability in Thaw Depth in Eastern Siberian Larch Forests	*T. Nakai, T. Hiyama, A. Kotani, Y. Iijima, T. Ohta, T. C. Maximov
R3-P02	Intraseasonal permafrost thaw processes around Batagay NE Siberia detected by ALOS-2/PALSAR-2 InSAR time series analysis	*K. Yanagiya, M. Furuya, G. Iwahana, P. Danilov, N. Fedorov, A. Desyatkin, A. Fedorov
R3-P03	Deep learning-based identification of thermokarst in Eastern Siberia and its relationship with local environment and land use	*N. Kurata, K. Takaya, T. Ise, Y. Iijima
R3-P04	Thermal Denudation Features on the Yamal Peninsula	*I. Tarasevich, A. Kizyakov, M. Leibman, N. Nesterova, R. Khairullin, A. Khomutov
R3-P05	Black carbon and their isotopic signatures in soil and permafrost in Ny-Ålesund, Svalbard: Implication of sources and fate under changing Arctic climate	*M. Uchida, H. Kumata, K. Mantoku, G. Iwahana, M. Uchida
R3-P06	Detecting spatio-temporal variations in water and vegetation change areas in the East Siberian permafrost zone using backscatter coefficient and DSM	*N. Omori, Y. Iijima
R3-P07	Monitoring surface temperature and channel width of the six Arctic rivers from space using GCOM-C/SGLI	*M. Hori
R3-P08	Single-spore PCR revealed the novel parasitic fungi infecting snow algae in alpine ecosystems	*H. Nakanishi, K. Seto, J. Uetake, M. Ono, N. Takeuchi, M. Kagami
R3-P09	In-situ field observations of snow cover characteristics in Alaskan boreal forest during the snow melt season	*K. Sugiura, Y. Kitahara
R3-P10	Monitoring of snow physical parameters by spectral radiation measurements using ground-based optical instrument in Ny-Ålesund, Svalbard	*T. Tanikawa, N. Ohkawara, T. Aoki
R4-P01	Snow accumulation inferred from a GPR survey around the Southeastern Dome, Greenland Ice Sheet	*M. Minowa, K. Fujita, S. Matoba, Y. Iizuka
R4-P02	The current state and future directions of the polar regional climate model NHM–SMAP	*M. Niwano, the NHM–SMAP Model Development Team
R4-P03	Numerical modeling of biological processes on snow and glacier surfaces in the Arctic region	*Y. Onuma, M. Niwano, R. Shimada, N. Takeuchi
R4-P04	Early melt onset drives dark ice exposure on the Greenland Ice Sheet	*R. Shimada, M. Hori, N. Takeuchi, T. Aoki
R4-P05	Changes in stripe patterns of dark regions in the southwestern Greenland Ice Sheet	*A. Uruma, N. Takeuchi
R4-P06	Temporal variations of radiant fluxes and surface energy balance from 2012 to 2020 at the SIGMA-B site on Qaanaaq Ice Cap, northwestern Greenland	*M. Nishimura, T. Aoki, M. Niwano, S. Matoba, T. Tanikawa, S. Yamaguchi, T. Yamazaki
R4-P07	Mass balance and surface elevation change of Qaanaaq Ice Cap in northwestern Greenland from 2012 to 2022	*K. Watanabe, K. Kondo, S. Sugiyama

R4-P08	Meltwater discharge from Qaanaaq Glacier in the summer 2022	*T. Imazu, K. Kondo, S. Sugiyama
R4-P09	Drone survey for precise DEM construction and supraglacial stream mapping on Qaanaaq Glacier, northwestern Greenland	*S. Ukai, S. Sugiyama, K. Kondo
R4-P10	Ground penetrating radar survey on Qaanaaq Glacier in northwestern Greenland	*K. Sato, S. Sugiyama
R4-P11	The prevalence of chytrid infection of glacier algae on a glacier in Alaska	*K. Kobayashi, N. Takeuchi, M. Kagami
R4-P12	Dating and insoluble particle analysis of a shallow ice core drilled at EGRIP, Greenland	*Y. Komuro, F. Nakazawa, K. Goto-Azuma, N. Nagatsuka, M. Hirabayashi, J. Ogata, K. Fukuda, N. Kurita, K. Kitamura, G. Sinnl, S. O. Rasmussen, T. J. Popp, D. Dahl-Jensen
R4-P13	Variations in mineralogy of dust in ice cores obtained from Greenland over the past 100 years	*N. Nagatsuka, K. Goto-Azuma, A. Tsushima, K. Fujita, S. Matoba, Y. Onuma, Y. Komuro, M. Hirabayashi, J. Ogata, Y. Ogawa-Tsukagawa, K. Kitamura, T. Aoki, T. J. Popp, D. Dahl-Jensen
R4-P14	Abrupt shifts in terrestrial aerosol deposition in Greenland during Dansgaard-Oeschger events 9-13	*K. Goto-Azuma, N. Moteki, J. Ogata, K. Fukuda, M. Hirabayashi, Y. Komuro, I. Oyabu, K. Kitamura, S. Fujita, Y. Ogawa-Tsukagawa, T. Mori, S. Ohata, Y. Kondo, M. Koike, K. Kawamura, S. O. Rasmussen, D. Dahl-Jensen
R4-P15	Atmospheric CH_4 concentration during the Holocene reconstructed from the NEEM (Greenland) and Dome Fuji (East Antarctica) ice cores	*I. Oyabu, K. Kawamura, K. Kitamura, S. Morimoto, S. Aoki, K. Goto-Azuma, T. Blunier
R5-S8-P01	Characterization and discrimination of tundra plant leaves by Attenuated Total Reflection Fourier Transform Infrared spectroscopy	*T. Osono, W. Lin, M. Hasegawa, M. Uchida
R5-S8-P02	Populations and leaf-trait variations of two Labrador-tea species across permafrost gradients in interior Alaska	*G. Amada, G. Iwahana, K. Noguchi, Y. Matsuura, H. Kobayashi
R5-S8-P03	Methane emission from tree stems in interior Alaska	*T. Morishita, Y. Kim, K. Noguchi, Y. Matsuura, K. Terazawa
R5-S8-P04	Total carbon and nitrogen stocks of the degrading Ice Complex permafrost at Yukechi, central Yakutia	*N. Tananaev, A. Shepelev
R5-S8-P05	Lagging Effect of Stem Respiration on Temperature in Sub- Arctic Species, Interiro Alaska	*Y. Kim, S.-J. Park, B.-Y. Lee, S.-D. Kim
R5-S8-P06	Interrelationships of CO_2, CH_4, and N_2O fluxes in Snow-Covered Temperate Soils, Northern Japan	*Y. Kim, N. Tanaka
R5-S8-P07	Methane observations at the terminus of glaciers in Alaska	*K. Konya, G. Iwahana, T. Sueyoshi, T. Morishita, J. Uetake
R5-S8-P08	Winter Soil Temperature and Growing Season Net CO_2 Exchange in Eastern Siberian Larch Forests	*A. Kotani, T. Hiyama, T. Nakai, T. C. Maximov
R5-S8-P09	Temporal and spatial patterns of remote sensing reflectance of understory vegetation in a sparse black spruce in interior Alaska	*H. Kobayashi, G. Amada, G. Iwahana, W. Yang, A. Hama, Y. Kim
R5-S8-P10	Ecological and physiological features of the process of photosynthesis of Asian white birch (Betula platyphylla) in Central Yakutia	*M. Grigorev, T. Maximov, A. Maksimov
R5-S8-P11	Snow cover impacts greenhouse gas dynamics in subarctic, alpine catchments	*A. L. Popp, N. Valiente, K. Aalstad, S. Trier Kjær, P. Dörsch, D. Hessen
R5-S8-P12	Regional Carbon Cycle Assessment Processes 2 (RECCAP2): CO_2 uptake in the Arctic Ocean	*S. Yasunaka, M. Manizza, J. Terhaar, A. Olsen, R. Yamaguchi, P. Landschützer, E. Watanabe, D. Carroll, H. Adiwara
R6-P01	Degradation of phthalates and camphor by the deep-marine halophilic bacteria Halomonas titanicae and their relevance to the order Oceanospirillales	*M. Igarashi, J. Fleming, H. Suzuki, J. Galipon,
R6-P02	Sea ice melt timing and ammonium concentration can alter autumn phytoplankton composition in the Pacific Arctic	K. Sumiya, *K. Matsuno, K. Sato, A. Murata, S. Nishino, A. Yamaguchi
R6-P03	Biological features of Calanus glacialis in the Pacific sector of the Arctic Ocean during autumn in 2019	*M. Ishihara, K. Matsuno, K. Tokuhiro, Y. Ando, K. Sato, A. Yamaguchi
R6-P04	**Cancel** ~~Spatial shifts in fish and macroalgae abundance and distribution in coastal areas of High-Arctic fjords due to cryosphere changes~~	~~*V. G.Triginer, M. Geoffroy, A. Sen, J. Berge, B. Damsgård~~
R7-P01	Statistical study of high energy electron precipitation based on Arase satellite - EISCAT collaborative observation data	*Y. Ogawa, M. Fukizawa, Y. Miyoshi, K. Hosokawa, S. Oyama, K. Shiokawa, K. Seki, S. Kurita, K. Asamura, S. Kasahara, T. Mitani, S. Matsuda, Y. Kasahara, Y. Kato, I. Shinohara, ERG-EISCAT project team
R7-P02	Studies of pulsating aurorae: simultaneous observations with the Arase satellite and optical instruments in the Arctic	*K. Hosokawa, Y. Miyoshi, M. Ozaki, S.-I. Oyama, Y. Ogawa, S. Kurita, Y. Kasahara, Y. Kasaba, S. Yagitani, S. Matsuda, F. Tsuchiya, A. Kumamoto, R. Kataoka, K. Shiokawa, Y. Tanaka, S. Nozawa, M. Teramoto, I. Shinohara, R. Fujii
R7-P03	Relationship between pulsating auroral electrons and duct propagation of chorus waves: Simultaneous observations with EISCAT, ground-based all-sky imagers and Arase	*Y, Ito, K. Hosokawa, Y. Ogawa, Y. Miyoshi, F. Tsuchiya, M. Fukizawa, K. Murase, S.-I. Oyama, S. Nakamura, Y. Kasahara, S. Matsuda, S. Kasahara, Y. Kazama, T. Hori, S. Yokota, K. Keika, S. Wang, S. W. Y. Tam, I. Shinohara
R7-P04	Studies of nightglow emissions in the mesopause above northern Scandinavia	*P. Dalin, T. Nishiyama, P. Voelger, U. Brändström, J. Kero, T. Trondsen
R7-P05	A new spectroscopic and imaging observation of short wavelength infrared aurora and airglow (1.00-1.35 μm) at Longyearbyen (78.1°N, 16.0°E) coordinated with EISCAT Svalbard radar	*T. Nishiyama, M. Kagitani, S. Furutachi, T. Tsuda, Y. Iwasa, Y. Ogawa, F. Tsuchiya, S. Nozawa, F. Sigernes
R7-P06	Spectroscopic observation of OH airglow in 1.1-1.3 μm in the polar region	*S. Furutachi, T. Nishiyama, T. Tsuda, Y. Ogawa, S. Nozawa, F. Sigernes
R7-P07	Coordinated observations of energetic electron precipitation by subionospheric VLF/LF radio propagation with other groundbased facilities	*F. Tsuchiya, H. Ohya, Y. Miyoshi, K. Shiokawa, Y. Hobara, M. Connors, Y. Ogawa, A. Mizuno, Y. Kasahara, T. Nishiyama, H. Misawa, T. Obara

R7-P08	The 10-year summary of the sodium lidar at Tromsø, and its future plan	*S. Nozawa, T. D. Kawahara, N. Saito, T. T. Tsuda, S. Wada, M. Tsutsumi, T. Takahashi, T. Kawabata, Y. Ogawa, H. Fujiwara, S. Suzuki, M. G. Johnsen, A. Brekke
R7-P09	Ultra-narrowband Optical Filter Development for the Na lidar Observation at Tromsø	*T. D. Kawahara, S. Nozawa, N. Saito, T. T. Tsuda, T. Takahashi, T. Kawabata, S. Wada
R7-P10	A self-build FPGA-based data acquisition system for Tromsø sodium lidar	*R. Watabe, T. T. Tsuda, T. Aoki, S. Nozawa, T. Kawabata, N. Saito, T. D. Kawahara
R7-P11	Polar mesospheric cloud observations by the Advanced Himawari Imager onboard the Japanese geostationary-Earth-orbit meteorological satellite Himawari-8	*T. T. Tsuda, Y. Miyoshi, Y. Hozumi, Y. Ando, K. Hosokawa, H. Suzuki, K. T. Murata, T. Nakamura, J. Yue, K. Nielsen
~~R8-P01~~	**Cancel** ~~Preliminary strategic considerations over the Polar Routes opening~~	~~*E. G. Iida, A. Baldini~~
R9-P01	Polar Educators International and the Third Arctic Science Ministerial (2021): A Landmark for Polar Education	*M.P. Casarini, J. Dooley, S. Weeks
S2-P01	Baroclinic Blocking	*P. Martineau, H. Nakamura, A. Yamamoto, Y. Kosaka
S2-P02	Interannual-to-decadal modulation of wintertime subseasonal variability over the Eurasia-East Asian sector	*B. Taguchi
S2-P03	Interannual Variation of the Warm Arctic-Cold Eurasia Pattern Modulated by Internal Atmospheric Variability Examined by a Large Ensemble Experiment	*X. Zhou, T. Sato, S. Li
S2-P04	A hemispheric extreme warm winter in 2019-20 enhanced by the highest sea surface temperature around mid-latitude	*Y. Ando, Y. Tachibana
S2-P05	Winter atmospheric trends over East Asia analyzed for individual surface pressure patterns	*K. Tamura, T. Sato
S2-P06	Lagged remote effect from tropical ocean on sea ice variability in the Sea of Okhotsk	*M. Takehata, Y. Tachibana, Y. Ando
S2-P07	Impact of the Pacific sector sea ice loss on the sudden stratospheric warming characteristics	J. Zhang, *Y. Orsolini, V. Limpasuvan, J. Ukita
S2-P08	Arctic Sea ice loss and Eurasian cooling in winter 2020-21	*K. Nishii, B. Taguchi, M. Mori, Y. Kosaka, H. Nakamura
S3-P01	Global carbon budgets estimated from long-term observations of the atmospheric CO_2 mole fraction, isotopic ratio of CO_2 and O_2/N_2 at Ny-Alesund, Svalbard	*D. Goto, S. Morimoto, S. Ishidoya, S. Aoki
S3-P02	Evaluation of black carbon in the Arctic region using the WRF/CMAQ simulation on the Northern Hemisphere scale	*K. Yahara, K. Yamaji, F. Taketani, M. Takigawa, Y. Kanaya
S3-P03	Variations of organic aerosols at Fukue Island as affected by the large-scale lockdown due to COVID-19	*C. Zhu, T. Miyakawa, F. Taketani, B. Kunwar, D. K. Deshmukh, K. Kawamura, Y. Kanaya
S3-P04	Shipborne observations of black carbon aerosols in the Arctic Ocean during summer and autumn 2016–2020	*Y. Deng, H. Tanimoto, K. Ikeda, S. Kameyama, Y. Omori, J. Jung, Y-J. Yoon, E-J. Yang, S-H. Kang
S4-P01	Spatial and temporal variations of surface seawater carbonate properties in the western Arctic Ocean: Results from the R/V Mirai observations	*A. Murata, S. Nishino
S4-P02	Seasonal variation in nutrient concentration of the Pacific-origin water from the Chukchi Sea to the Canada Basin	*M. Yamamoto- Kawai, M. Itoh
S7-P01	Stable Water Isotopes and Tritium Concentrations Reveal Seasonal Contributions of Ground Ice and Snow Meltwater to the Lena River Basin	*T. Hiyama, L. Lebedeva, H. Park, K. Asai, A. L. Popp, D. Gustafsson
S7-P02	Seasonal Variation of Stable Isotopes in Precipitation at Fairbanks, Alaska	K. Takakura, *K. Ichiyanagi, H. Park, M. Tanoue
S7-P03	Freshwater budget of the Sea of Okhotsk and sea ice variability	*K. Oshima, Y. Tachibana, K. Komatsu
S7-P04	HYPE-ERAS: A Transdisciplinary View on Climate Change Impacts on Hydrology, Permafrost and Resilience in Eastern Siberian Arctic and Sub-Arctic	*D. Gustafsson, A. Popp, L. Lebedeva, S. Boyakova, T. Hiyama
S9-P01	Multi-actor cooperation for sustainable development of cruise tourism in the Pacific Arctic: The Case of the Russian Far East	M. Lomaeva, *J. Saunavaara
S10-P01	The Strategic Orientation of Russian Fishing Industry after Ukraine : What Implications for the Arctic ?	*Y. Favennec
S10-P02	A Research on New Dimensions of Science Diplomacy and the Changing Arctic in the Anthropocene	*E. Caymaz
S16-P01	North Greenland Inuit materials collected 50 years ago at the Little World Museum of Man	*R. Kusaka, S. Sugiyama, A. Harada
S18-P01	Improvement of an Arctic Sea Route Search System to increase calculation speed	*T. Sugimura, H. Yabuki, H. Yamaguchi
S23-P01	Monitoring of polar snow by AMSR-E and AMSR2 satellite microwave observations	R. Kasakawa, *H. Enomoto
S23-P02	Developing a regional observing system for the pan-Arctic community	*I. Matero, H. Lihavainen, R. Denkmann, C. Hübner, S. Jawak, E. Jones, Ø. Godøy, K. Holmén
S23-P03	Using NEON Active Layer Sampling Methods for Pathogen Detection in Melting Permafrost	*N. Catolico, R. Spurbeck, L. Catlin, D. Monahan, K. Gonzales, A. Vinturella
S23-P04	Data Management of Arctic Project in Japan	*H. Yabuki, K. Iino, T. Terui, T. Sugimura

Booth Exhibition

The booth exhibition will be located on the 1st floor atrium of the NIPR, and some of the information is also available on the ISAR-7 online exhibition site. Enjoy the exhibition!

Towards a New Horizon of Arctic Research

By Arctic Challenge for Sustainability II (ArCS II)

This booth exhibition introduces the Arctic research of ArCS II and the educational materials.

Research vessels supporting Arctic science: now and in the future

By Japan Agency for Marine-Earth Science and Technology (JAMSTEC)

We will introduce Japan's first research vessel with ice-breaking capabilities, which is currently under construction, and the Oceanographic Research Vessel MIRAI, which is now conducting observation activities in the Arctic Ocean.

Research on Climate Change at the National Institute for Environmental Studies

By National Institute for Environmental Studies (NIES)

The National Institute for Environmental Studies(NIES) was established in 1974. The exhibit will showcase a wide range of research on climate change, particularly observations and model analyses of greenhouse gases that cause global warming, as well as research that contributes to adaptation to future climate change impacts.

Envisioning Future Globe through Understanding the Arctic: the Challenge of the Arctic Trans-Disciplinary Community of Practice

By Arctic Trans-Disciplinary Community of Practice

The Arctic Trans-Disciplinary Community of Practice brings together researchers, government officials, business people, NPOs, students in various fields on a regular basis to share different views and exchange perspectives about complex environmental and social economic changes in the Arctic region and their impacts on the entire globe including Japan. We exhibit our reports and audio-visual materials created through our workshops. We hope that visitors broaden their interest on the Arctic and have an opportunity to deepen considerations on the connection between the Arctic and the globe.

General Information

Restaurants & Shops

Tachikawa Guide Book

- Taratta Tachikawa

Restaurant Map

- Google Map

Nearest Convenience Store/Cafe

- Tachikawa City Hall

Printing Services

- kinko's

Nearest Shopping Mall

- LaLaport
- GREEN SPRINGS

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⚠ Attention!!

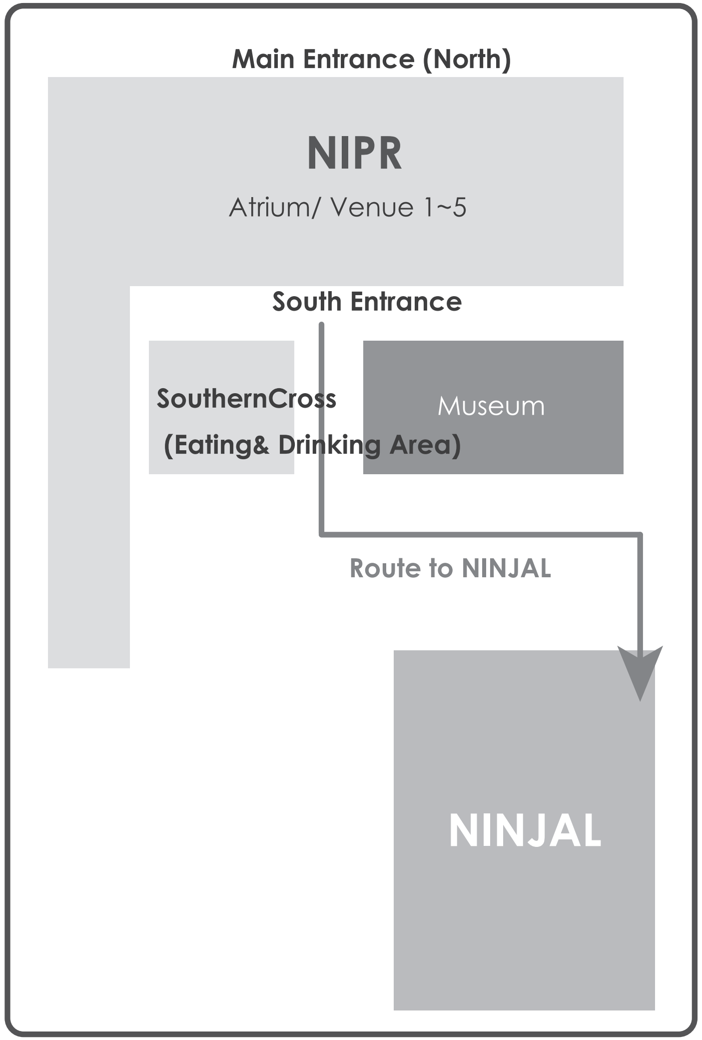
- Masks and Name Tag
  Please wear masks and name tag at all times when in the building.
- Eating ＆Drinking Area
  Eating and drinking is permitted only in designated areas.
- Smoking Area
  Smoking is permitted only in designated areas.
  Please refrain from smoking outside of the venue.
- Photo and Video Shooting
  Press and Secretariat will take photos and videos during ISAR-7.
  Those photos and video may go public.

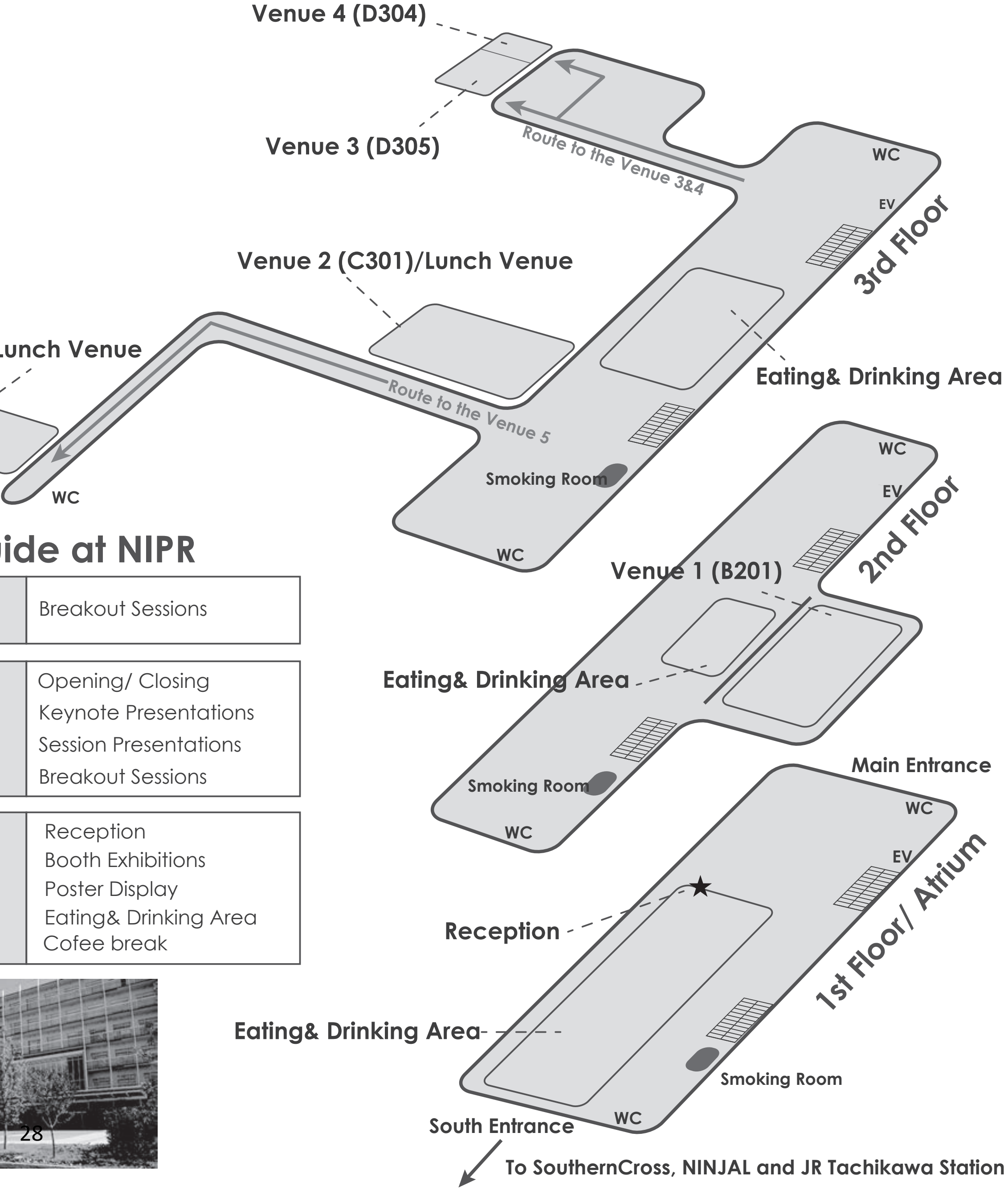
Venue Map (NIPR)

**The venue of ISAR-7 is divided into two separate buildings, NIPR and NINJAL.*
**These building are a research facility so please do not enter restricted areas that are not designated event or venue areas.*
**Eating and drinking is permitted only in designated areas.*
**Please wear name tags and masks at all times when in the building.*

Layout of NIPR and NINJAL

3 minute walk from NIPR south entrance to NINJAL



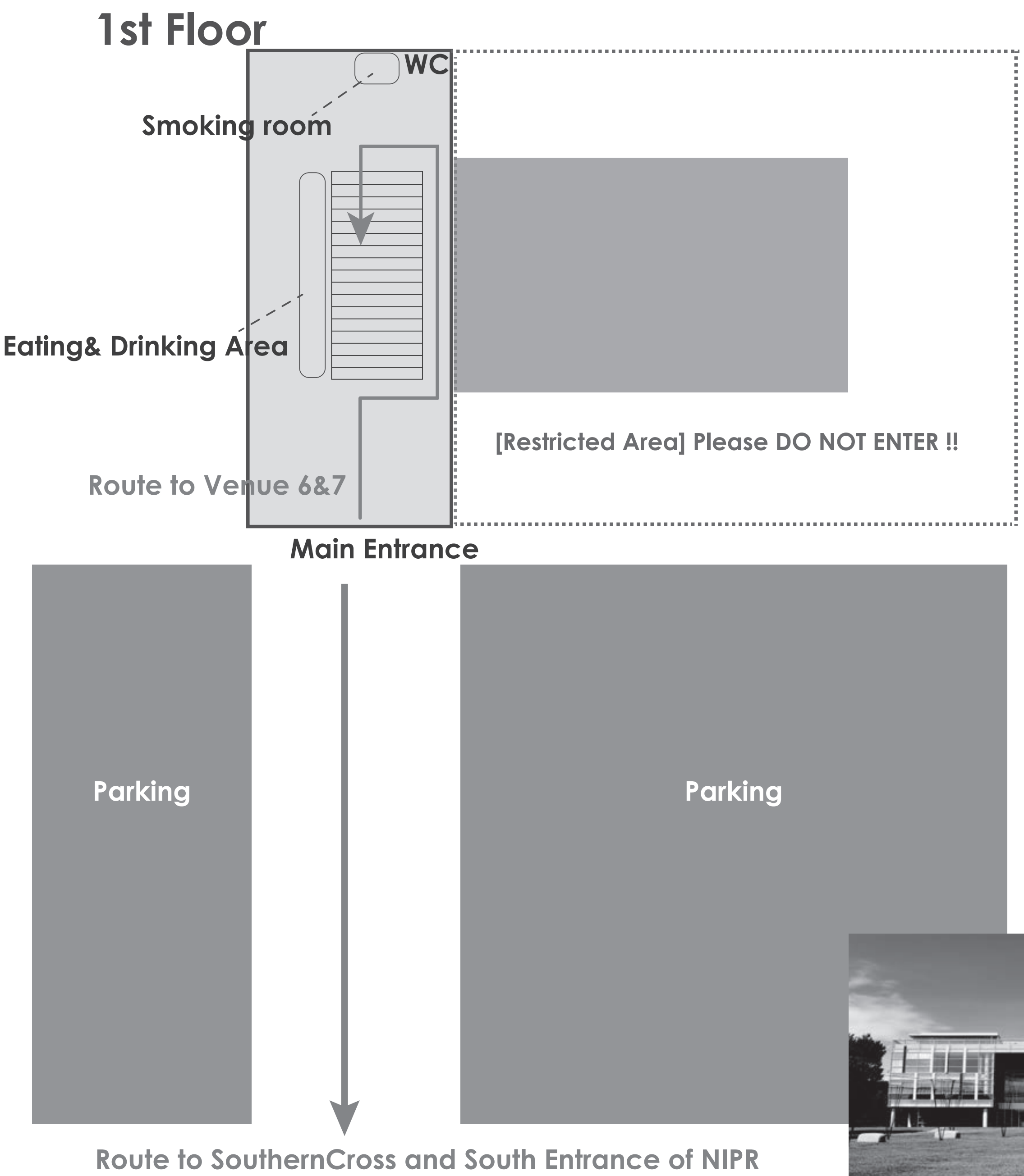


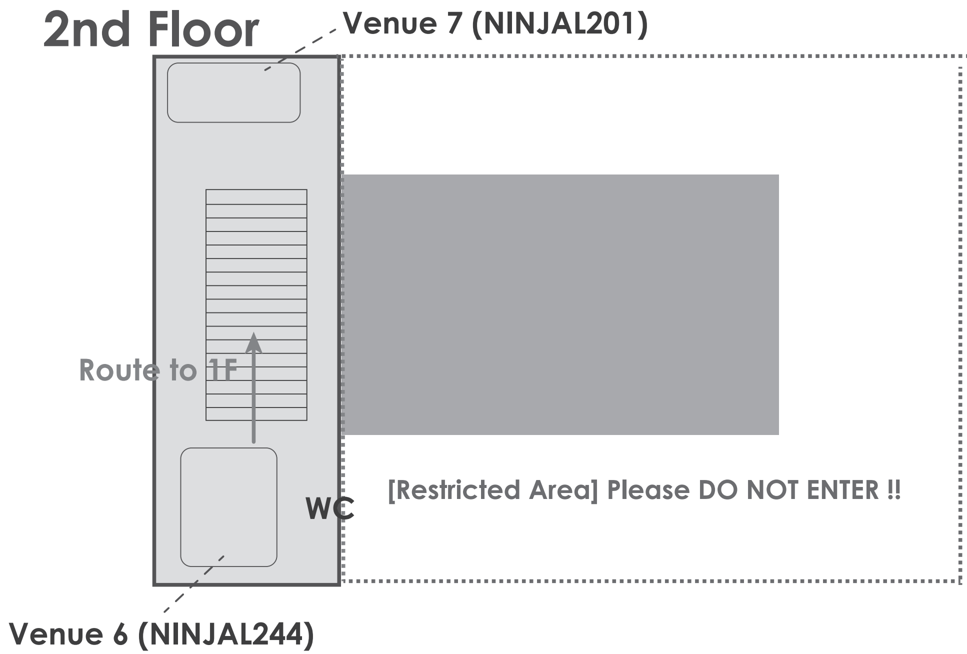
Floor Guide at NIPR

3F	Venue 2~5	Breakout Sessions
2F	Venue 1	Opening/ Closing Keynote Presentations Session Presentations Breakout Sessions
1F	Atrium	Reception Booth Exhibitions Poster Display Eating& Drinking Area Cofee break

National Institute of Polar Research (NIPR)

Venue Map (NINJAL)





Floor Guide at NINJAL

2F	Venue 6 Venue 7	Breakout Sessions
1F		Eating& Drinking Area

NINJAL is the rented venue for hosting ISAR-7. Participants are not allowed to use any areas other than the designated areas and Session Venues (NINJAL 244 and 201).

National Institute for Japanese Language and Linguistics (NINJAL)

COVID-19 Safety Protocols

ISAR-7 Secretariat will make utmost efforts to prevent the spread of COVID-19 infection at the local site. In addition to working with the venue to ensure thorough disinfection and ventilation.

- ✓ Please take your temperature beforehand and refrain from in-person attendance at the meeting if you have a fever or any other health problems.
- ✓ Your temperature will be checked at the entrance gate. If you are found to have a fever, we regret to inform you that you will not be admitted. Please leave on the spot and participate online.
- ✓ Please wear a mask (non-woven cloth is strongly recommended) in the venue.
- ✓ Please sanitize your hands frequently in the venue. (Alcohol for sterilizing is available at each location in the venue.)
- ✓ There will be a limit to the number of people who can enter each of the session rooms. If the room is full and you cannot enter, please participate the sessions online.

March 7-10 2023

Keynote Speeches
Session Presentations

Rapid Arctic Warming and its Impact on Indigenous Peoples and Other Communities

Dalee Sambo Dorough

Arctic Indigenous Peoples University of Alaska Anchorage

TBC

Arctic PASSION
- a project aiming to improve the Pan-Arctic Observing System of Systems to serve societal needs

Michael Karcher[1*]
and the Arctic PASSION project team
[1]*Alfred Wegener Institute for Polar and Marine Research, Bremerhaven, Germany*

In the Arctic the human-induced global warming already leads to changes that are faster here than anywhere else on our planet. These have environmental, societal, and economic impacts, locally and beyond the Arctic due to the Arctic's role in the global climate system. These facts highlight the need for a sustained and accessible observing system adjusted to the needs of users, from local inhabitants to academia through to industry and decision-makers [1].

Arctic PASSION aims to improve the current observing system in co-creation by extending Arctic scientific and community-based monitoring, forwarding the inclusion with Indigenous and Local knowledge, enhancing coordination and cooperation on a pan-Arctic scale, making data more accessible and by working on the economic viability and sustainability of the observing system. Arctic PASSION, funded by the European Commission, started in July 2021 and will run for four years. Over 40 organizations and Indigenous communities located in 17 countries participate in the project as partners. The presentation will address questions related to an improved observing system of systems from our perspective and present activities of Arctic PASSION such as the establishment of Shared Arctic Variables Expert Panels, the initiation of a marine Atlantic-Arctic DBO, the development of Services to provide important information to Rights-holders and stakeholders in the Arctic, or the co-creation of an event data base of CBM based on Indigenous and Local Knowledge, all performed in close collaboration with international partners from Asia, North America and Europe and institutions such as SAON, the AOS and GEO.

References

[1] Starkweather, S., Larsen, J. R., Kruemmel, E., Eicken, H., Arthurs, D., Bradley, A. C., Carlo, N., Christensen, T., Daniel, R., Danielsen, F., Kalhok, S., Karcher, M., Johansson, M., Jóhannsson, H., Kodama, Y., Lund, S., Murray, M. S., Petäjä, T., Pulsifer, P. L., Wilkinson, J.. Sustaining Arctic Observing Networks' (SAON) Roadmap for Arctic Observing and Data Systems (ROADS). *ARCTIC, 74, SUPPL. 1* (2021), 56–68.
https://doi.org/10.14430/arctic74330

Transdisciplinary research on environmental issues

Yamagiwa J

Research Institute for Humanity and Nature (RIHN)

Research Institute for humanity and nature, called RIHN, was established in 2001, and has conducted research with the awareness that the roots of global environmental problems are found in human culture. Therefore, RIHN undertakes interdisciplinary research spanning the natural sciences, humanities, and social sciences, and in recent years, has evolved towards transdisciplinary research seeking to expand the kind of knowledge that are considered valid in scientific inquiry. RIHN also collaborates with the international research platform Future Earth, which aims to integrate global environmental change research and contribute to United Nations Sustainable Development Goals (SDGs).

However, the most important concept of our daily life and our identity is missing in SDGs. It is culture. Why it's missing? Probably because culture is not quantified, and it sometimes causes conflicts between people and groups. But culture depends on experience and empathy embedded in the body. Culture is reflected in food, cloth and house. Cultural diversity is the common heritage of humanity and should be recognized and affirmed for the benefit of present and future generations. Culture can be shared globally while rooting in the region. In 2001, the same year of RHIN's founding, UNESCO adopted the Universal Declaration on Cultural Diversity. Its Article 1 states that as a source of exchange, innovation and creativity, cultural diversity is as necessary for humankind as biodiversity is for nature. Article 7 states that creation draws on the roots of cultural tradition, but flourishes in contact with other cultures. Today, local cultures are about to disappear due to the information revolution and the global movement of people and goods. Hence, RIHN research projects are designed to examine not only the diverse range of cultures that currently inhabit the Earth, but also past patterns of cultural and environmental change. In addition to conducting high quality basic research, our aim is to enable discussion of diverse perspectives of nature and their potential relevance to the future.

Since the establishment of RIHN, researchers of the institute have discussed the concept of futurability (or sustainable future), a Japanese word that combines the ideographs "future" and "potential". This concept invites us to consider the kinds of interactions between human beings and nature—some age-old and some entirely new—that various societies and communities might seek. We hope it will continue to stimulate discussion of what should be done to address environmental problems at their roots, so that future generations will not inherit the same patterns of use and degradation that now characterize our global society.

The idea that environmental problems stem from problems in human culture inevitably leads to the conclusion that environmental research needs to consider the concept of values in various human societies and cultures. Anthropogenic environmental impact is now predominant on a global scale, and the current era of Earth history is being called the "Anthropocene". Humankind is becoming increasingly conscious of its dependence on finite and limited resources, and of the many negative consequences of continued degradation of our biosphere. Humans have also progressively come to understand that a number of critical environmental problems cannot be separated from social inequity, especially in terms of access to natural resources and their benefits. RIHN is now conducting solution-oriented environmental research projects based on new forms of transdisciplinary knowledge production.

In this presentation, I will introduce the present RIHN's projects to discuss on a new holistic approach to a sustainable future for human beings at local, regional to global scales of our planet Earth.

Environmental (in-)Security in the Arctic: Expanding Interdisciplinary Approaches

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The subject of environmental security, which had long been considered a 'niche' subject of study and analysis, has taken on greater prominence in light of the cascading effects of climate change in many parts of the world, including the Polar Regions. The Arctic has become a crucial case study of how climate change is affecting various areas of security thinking, not only in regards to state and government behaviour, but in terms of development, health, and human security. Although discussion of security in the Arctic has begun to focus on hard power and military strategies as the far north becomes an area of potential competition, it is crucial to bring in different aspects and approaches, including those directly tied to environmental change, when describing 'security' in the region.

SP1-R7

Coordinated observations between the Arase satellite and ground-based observations over Arctic

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The Arase satellite was launched in 2016 and has continued observations in the inner magnetosphere [1]. The inter-continental ground-based network observations are operated by Japanese PsA [2] and PWING projects [3] over Arctic and these network observations are very powerful to monitor precipitations and related plasma waves at different latitudes and local times. Besides the network observations, the EISCAT observation is also important to measure wide range of altitudes covering the mesosphere to the thermosphere. There are various opportunities for conjugate observations between the Arase satellite and ground-based observations over Arctic, which provides new findings about couplings between the space and the Earth upper/middle atmosphere, e.g., pulsating aurora, energetic electron precipitations, proton aurora, SAR arc, aurora onset, field-aligned acceleration at very high altitudes etc. Moreover, the conjugate observations have provided new insight into the coupling between the magnetosphere and the middle atmosphere through wave-particle interactions that cause precipitations of energetic electrons and resultant ozone destruction [4]. In this presentation, we present an overview of coordinated observations between the Arase satellite and ground-based observations over Arctic during the declining phase of cycle 24 to the early rising phase of cycle 25.

References

[1] Y. Miyoshi et al., Geospace Exploration Project ERG, *Earth, Planets Space*, **70** (2018)
[2] K. Hosokawa et al., A ground-based instrument suite for integrated high-time resolution measurements of pulsating aurora with Arase, *ESSOAR*, (2020)
[3] K. Shiokawa et al., Ground-based instruments of the PWING project to investigate dynamics of the inner magnetosphere at subauroral latitudes as a part of the ERG-ground coordinated observation network, *Earth Planets Space*, **69** (2017).
[4] Y. Miyoshi et al., Penetration of MeV electrons into the mesosphere accompanying pulsating aurora, *Scientific Reports*, **11** (2021).

Planning for a Future Arctic Oil Spill: New Model Insights and Regional Security Implications

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Investment in Arctic resource extraction increased tenfold in the last decade. With that investment, increases in maritime traffic and infrastructure are increasing the likelihood of an Arctic oil spill, compelling regional and international Arctic entities to grapple with this looming threat. The consequence of an Arctic maritime oil spill is heightened by the significant lack of information surrounding oil slick migration under sea ice. Oil slick motion at the ocean and ice interface is influenced by current velocity, ice surface drag, and the geometric perturbations of the ice surface into the water column. Obscured from view, the underside of sea ice has historically lacked quantifiable characteristics and is entirely absent from all current US climate and ocean-ice models.

Analyzing five years of under ice sonar data from the Beaufort and Chukchi seas, statistical parameters for the underside geometry of thirty unique ice stages of first-year ice were isolated. Ice data was primarily lognormally distributed. The unique lognormal statistical parameters for each ice stage were employed to construct subsurface models. Gravity driven oil spreading was analyzed over these surfaces. These models produced sequestration volumes for each ice stage ranging from 50,000-600,000 cubic meters per square kilometer, and covering between 20 and 40% of the under ice surface. The results provide a theoretical maximum volume of oil that could pool beneath Arctic sea ice, as well as the extent of coverage, before spilling into neighboring domains.

Absent the presence of other movers, the underside of sea ice can sequester significant volumes of oil before a slick would spill into a neighboring domain. The implication, then, is that sea ice could transport significant volumes of oil, fully encapsulated, from a spill location in one country's territorial waters, across international boundaries. Subsequent questions arise regarding the challenges such volumes pose in the response domain, the regional security implications of large volumes of oil migrating in host ice, and the need for ongoing international partner collaboration. This work was supported in part by the Oil Spill Recovery Institute Graduate Research Fellowship [Grant number 21-10-06] and the University of Alaska Fairbanks.

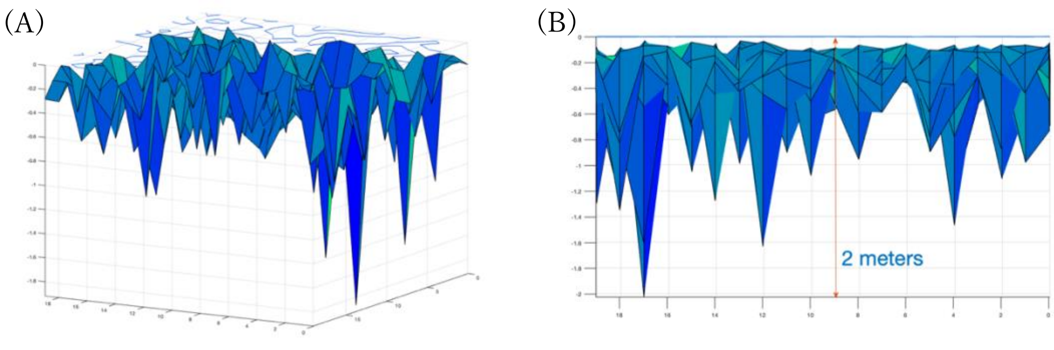

Figure 1. Modeled Arctic sea ice subsurface for "3,1,0" type ice. (A) illustrates a 3-D view of the underside of the ice and (B) is a side view of the same ice type. Modeling begins with a 3D array indicating ice depth (z) and cell indices. For this visualization, a surface mesh is applied to the data, which uses linear interpolation between points.

Evaluation of black carbon simulations in CMIP6 with long-term observations in East Asia during 2009–2020

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Black carbon (BC) emitted from East Asia accounts for 30% of global anthropogenic emissions and has influences on global and regional climate, including the Arctic. Thus, accurate estimates of BC emissions from East Asia and their trends are essential to assess the impacts on climate change using climate models. Recently, our evaluations of BC emissions in bottom-up inventories using chemical transport models (GEOS-Chem and WRF/CMAQ) and long-term observations at Fukue Island in western Japan indicated that the anthropogenic emissions inventory (CEDS) used in CMIP6 overestimated BC emissions from China [1-2].

In this study, we evaluated historical simulations for 2009–2014 and scenario simulations for 2015–2020 under two emission scenarios (SSP1-2.6 and SSP3-7.0) by 11 climate models participating in CMIP6 in terms of mass concentration level and long-term trend of BC over East Asia by comparing surface observations at two remote sites (Fukue Island and Noto Peninsula). The historical simulations by each climate model generally reproduced the observed seasonal variation of the monthly mean concentrations at Fukue, with good agreement in the multi-model mean (r=0.78). However, the concentration levels at both Fukue and Noto tended to be overestimated in the historical simulations (NMB=103% and 94% for the multi-model mean). Annual mean concentrations at Fukue during 2009–2019 show a decreasing trend of -5.3±0.5%/yr, which is not consistent with the multi-model mean of the historical simulations. This is because the CEDS inventory for CMIP6 estimated an increase of BC emissions from China until 2014. The multi-model mean for the SSP1-2.6 experiments showed a decreasing trend from 2015 (-3.9±0.4%/yr) due to the decrease in Chinese BC emissions. However, their concentration levels were higher than the observations because the SSP scenarios started based on the last year of the CEDS inventory.

We also performed model simulations using GEOS-Chem driven by reanalysis meteorological data (MERRA-2) with CEDS for CMIP6/SSP scenarios and ECLIPSv6b to estimate differences in temporal variations and radiative effects of BC due to the uncertainty in the BC emission estimates. The results using the CEDS/SSP scenarios were basically similar to the multi-model mean of the CMIP6 simulations. On the other hand, the simulation using ECLIPSEv6b showed good agreement with the observed concentration levels and trends. The difference in direct radiative forcing of BC in 2014 between CEDS for CMIP6 and ECLIPSEv6b was estimated to be 72% in East Asia and 25% globally.

References
[1] Y. Kanaya et al., Rapid reduction in black carbon emissions from China: evidence from 2009–2019 observations on Fukue Island, Japan, *Atmos. Chem. Phys.*, **20**, 6339–6356 (2020)
[2] K. Ikeda et al., Evaluation of anthropogenic emissions of black carbon from East Asia in six inventories: Constraints from model simulations and surface observations on Fukue Island, Japan, *Environmental Science: Atmospheres*, **2**, 416–427 (2022)

Contribution of the decline in Chukchi and Bering sea ice to cold East Asian winter

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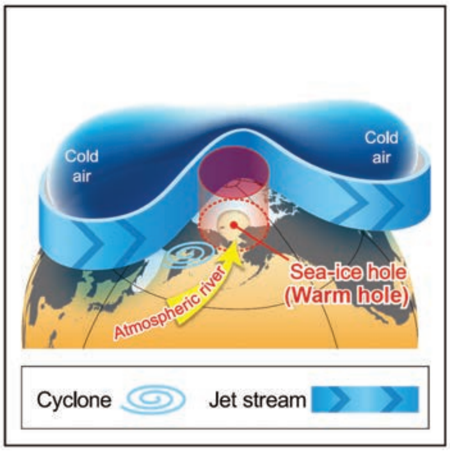
The Chukchi Sea, on the Pacific side of the Arctic Ocean, recorded its largest ice-free area in the winter of 2017-18, a period when the Arctic Oscillation (AO) was persistently in its negative phase. In association with the negative AO, East Asia suffered its coldest winter since 1985 while the Arctic region was anomalously warm. Recent studies argued that the decline in Chukchi Sea ice forced the jet stream to meander southward over Asia and America, allowing cold air to spread there (e.g., Tachibana et al., 2019; Overland et al., 2021). However, cold Asian winters are typically explained by La Niña and reduced Arctic ice in the Atlantic sector. As Chukchi Sea ice coverage has severely declined in recent years, the importance of its role with respect to these traditional factors should be investigated on a multiannual time scale in light of anticipated global warming. Here we present a statistical analysis showing that 2017-18 was the only winter since 1985 in which declining ice in the Chukchi Sea played a leading role and that previously its contribution was much smaller than those of Barents Sea ice and La Niña. A simple numerical experiment involving an anomalous heat source over the Pacific sector of the Arctic successfully simulated a cold Asia and warm Arctic. Thus, an anomalous negative AO along with the cold Asian winter of 2017-18 may be partially explained by the decline in Chukchi Sea ice. In the context of global warming, long-term forecasts of Chukchi Sea ice may improve predictions of Asian climate.



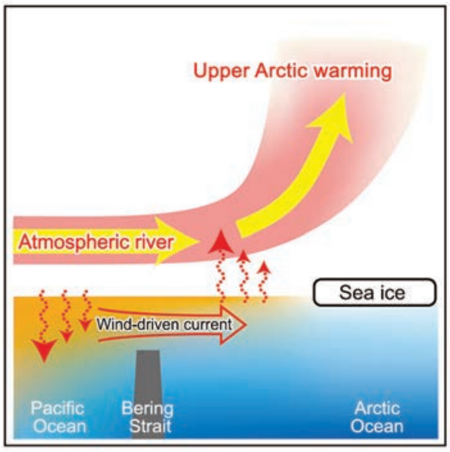


Figure 1. Possible processes for cold Asia and America viewed from an atmosphere-ocean coupled system (Tachibana et al., 2019)

References
[1] Tachibana, Y., et al., Warm hole in Pacific Arctic sea ice cover forced mid-latitude Northern Hemisphere cooling during winter 2017-18, ***Scientific Reports,*** 9, 5567, DOI: https://doi.org/10.1038/s41598-019-41682-4 , 2019
[2] Overland, et al., Communicating Arctic-Midlatitude Weather and Ecosystem Connections: Direct Observations and Sources of Intermittency, ***Environmental Research Letters,*** 16, 105006, DOI: https://doi.org/10.1088/1748-9326/ac25bc , 2021

Effect of the extreme wet event on temporal variations in NDVI and ecosystem parameters of larch forest in northeastern Siberia

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Extreme wet events are predicted to be more frequent and intensive worldwide, especially in northern regions under Arctic amplification. The taiga ecosystem in northeastern Siberia, a semi-arid and nitrogen-limited ecosystem on permafrost, has changed under such event in 2007. This study aims to investigate temporal variations in forest conditions of larch forest at the Spasskaya Pad station near Yakutsk (Russia) before and after the extreme wet event. We set a transect (60 m × 510 m) with 34 plots (30 m × 30 m), which were divided into unaffected (typical forest; TF) and affected by the extreme wet event. The forest conditions of the plots in 1999-2019 were determined by a satellite-derived proxy of above-ground production, normalized difference vegetation index (NDVI, a forest greenness) calculated from Landsat images with a spatial resolution of 30 m. To study the forest conditions of the TF in 1999-2019, seasonal peak TF NDVI in the transect was compared with the long-term observed ecosystem parameters at TF out of the transect, such as tree-ring width index (RWI), soil moisture water equivalent (SWE), carbon and nitrogen stable isotopes ($\delta^{13}C$ and $\delta^{15}N$) and ratio of carbon and nitrogen contents (C/N) of larch needles.

Year-to-year variation in NDVI showed a large difference between the TF plots and affected plots after 2007, because NDVI in the affected plots was lowered by a high tree mortality and a presence of surface water. In the TF, hydrological conditions of the previous year were a controlling factor of the needle production based on a statistically significant temporal correlation between the TF NDVI and previous summer SWE. But this correlation was changed from positive in 1999-2006 to negative in 2008-2019. Besides, the TF NDVI showed a significant positive correlation with the needle N content (or negative one with the C/N) before 2007, which also remained after the wet event, in 2008-2018. That is, the production of soil inorganic N and, consequently, the needle production may increase at wet year before the wet event, but after the wet event they decrease at an extreme wet year. The wood production (RWI) showed a similar trend with the needle production (TF NDVI) only before 2007, which could mean a simultaneous response of the two to a change in environmental factors, such as water and nitrogen availability. The needle $\delta^{15}N$ was generally decreasing during the entire observation period, suggesting that larches used less inorganic N from deeper soils, which usually has higher $\delta^{15}N$. The needle $\delta^{13}C$ was found to be strongly dependent on the previous-August SWE for the entire observation period 1999-2019, that confirmed an importance of the preceding year's water availability.

Role of Snow for Hydrological Change in Lena River Basin

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The aim of this study is to investigate the role of snow for the climate change impacts in hydrological regimes across the river basins in Yakutia, Eastern Siberia. River runoff observations in large and medium sized rivers show an increase over recent decades associated with increasing air temperature and precipitation [1], however, streamflow changes can also be related to evaporation, snow, glaciers, and permafrost. We assessed the relation between changes in snow and streamflow using the satellite-based ESA CCI snow data and the Yakutia-HYPE model. The streamflow trend analysis showed a general pattern of increasing monthly mean and minimum stream flows from October to April, but more frequent in larger river basins, and especially if the last 20 years are included in the trend analysis [1]. This can be explained by the increasing autumn precipitation, but the absence of change in annual maximum flow and streamflow in June also suggests relation to changes in the snow. The snow data shows a pattern of decreasing maximum SWE in the western part of the model domain, and a corresponding decreasing trend of number of days with snow cover (quantified here by the number of days with SWE>5 mm) (Figure 1). These results are in line with the trends in streamflow found by [1]; a short snow cover period (and increasing amount of autumn and winter rainfall, not shown here) as well as a lower maximum SWE accumulation could contribute both to the increasing winter runoff, and the absence of increasing streamflow in early summer.

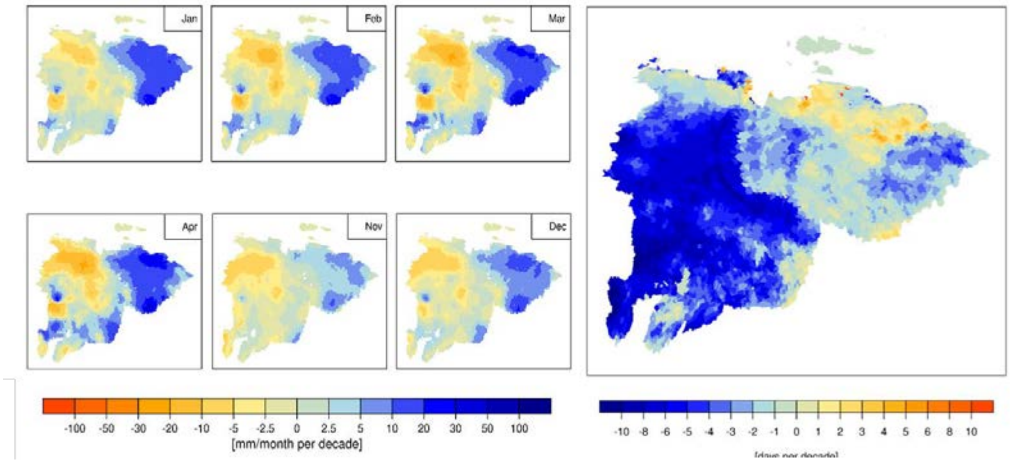

Figure 1, left: Trends in monthly maximum snow water equivalent (mm/decade, Nov-Apr 1989-2018), right: trend in number of days with more than 5 mm snow (days/decade, 1989-2018) over the Republic of Sakha (Yakutia), derived from the Snow CCI v1.2 product.

This work was conducted as part of the HYPE-ERAS project funded by FORMAS (project DNR: 2019-02332), RFBR (project No. 20-55-71005), and JST (Grant No. JPMJBF2003) through the Belmont Forum Collaborative Research Action: Resilience in the Rapidly Changing Arctic.

References

[1] L. Lebedeva et al., Streamflow Changes of Small and Large Rivers in the Aldan River Basin, Eastern Siberia, Water, **13** (2021).

Taking the Pulse of the Arctic Ocean System, from the Shelves to the Pole – A US Contribution to the International Synoptic Arctic Survey Program

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The Central Arctic Ocean remains profoundly understudied, particularly with respect to carbon cycling, ecosystem alteration, and the associated changes in atmospheric, ice and ocean physics that drive those biological and biogeochemical systems. Because of relatively limited understanding of fundamental characteristics and processes in the region, predicting changes in these parameters and in their Pan-Arctic linkages under ongoing climate change remains challenging. As a US contribution funded by the US National Science Foundation to the international Synoptic Arctic Survey, an expedition to quantify the present states of the physical, biological, and biogeochemical systems of the Pacific Arctic and Amerasian Basin was conducted from the *USCGC Healy* during September and October 2022.

The cruise track approximately followed the transects of the 2015 GEOTRACES and 1994 Trans Arctic Section cruises to allow for comparative analyses. Stations were widely spaced in order to accommodate both the long sampling duration required at each site (18+ hours at deep locations) and steady progression along the planned track lines. Research undertaken by the team included physical oceanography, meteorology, mesozooplankton and macrobenthic distributions and ecology, marine mammal and seabird observations, water column and sediment chlorophyll, water column nutrients and $\delta^{18}O_{water}$, seawater carbonate and dissolved organic carbon, dissolved gases, rates of water column photosynthesis, respiration and net community production, water column particulate carbon, nitrogen, and stable isotope content and optical properties, and water column and air methane content.

During the cruise, the team sampled along the Chukchi shelf-break and slope, Chukchi Borderlands and Northwind Ridge, and in the Canada, Amundsen, and Makarov Basins. For much of the track, the ice was unexpectedly thin with multiple leads. At some latitudes (e.g., 86-87°N), bands of heavy ice impeded northward progress but elsewhere multiple leads hastened navigation, even nearing the Pole where long N-S leads extending many kilometers provided a "road" north. An overview of the expedition and some early results will be presented.

Reconsidering climate change research from a more extensive scope of community development studies

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This paper reconsiders the framework of climate change research from a wider viewpoint of community development studies. The impetus of this thought was my realization that much of recent climate change research (regarding the social scientific one) might have merely seen the tip of the iceberg of community dynamics under a rapidly changing environment. Arctic (and northern) communities have witnessed both environmental change and local effects of the global economy. As an environmental anthropologist, I have been focusing on the climatic and environmental change in Greenland; however, I must now pay attention to the influence of a capitalist economy and other influences derived from political and social changes in Greenland. On the other hand, the academic discipline of Development Studies, although it has a different view of social change than Anthropology, has been combatting poverty, economic inequality, and community empowerment. Development Studies' approach to community dynamics is rather holistic, viewing a community as a heterogeneous group and an agent of change. It also examines the informal economy and weak ties of networks within and between communities. Yet, Development Studies has historically focused on so-call Third World countries, mainly Global South, and does not deal with northern development.

In this presentation, I discuss that the study of the social impact of climate change can be conducted within a larger framework of community development research. To this end, in my presentation, I draw on examples from Greenland and Hokkaido, northern Japan, although the latter is not in the Arctic per sé (yet it is still in a northern region).

Food Sovereignty and Well-being in the remote Arctic: Investigating Barriers to Food Consumption and Harvesting in NW Greenland

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Food sovereignty in the Arctic is about local people's ability to access foods sufficient to meet their dietary needs for healthy lifestyles and also, most especially, to enable them to access culturally important foods. Such food preferences are key to healthy and resilient individuals and communities as these foods fulfil socio-cultural needs. People's right to food is also inherently political, with communities having the right to define their own food systems [1].

Arctic peoples face significant barriers to maintaining food sovereignty. Using a case study approach, this presentation reports on anthropological research conducted in Qaanaaq, Greenland, a community with around 650 people. One of the most northernmost settlements in the world, the community faces significant logistics and transportation challenges. Qualitative interviews and discussions (30) were conducted with ministry, hunting and fishing union, and natural resource management representatives, as well as interviews and participant observation with hunters, fishers, and community members, including women. Obstacles to high quality of life and food sovereignty, including politics, climate change, resource management, and safety are presented, along with recent, local development efforts surrounding food harvests.

Figure 1. Evening meal with traditional foods.

Figure 2. Landing a "white narwhal"

Acknowledgements
This research was conducted as part of Arctic Challenge for Sustainability II (ArCS II) Project, Grant Number JPMXD1420318865.

References

[1] Organ, J., et al. "Contemporary programs in support of traditional ways: Inuit perspectives on community freezers as a mechanism to alleviate pressures of wild food access in Nain, Nunatsiavut." *Health & place*, *30*, pp.251-259. (2014). [2] E. B. Møller, T. Lading, Current building strategies in Greenland, *E3S Web Conferences* 172 (2020).

The economic impacts of opening the Northern Sea Route under political uncertainty

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The opening of the Northern Sea Route potentially reduces distances to transport goods between East Asia and Europe compared to the traditional Southern Sea Route. At the same time, political uncertainty in the region could hinder the adoption of a commercial service. This study examines the economic impacts of opening this route, considering the trade-off between the benefit of the shorter traveled time and potentially high political uncertainty. Utilizing several economic and political uncertainty indices (namely the World Uncertainty Index and the Geopolitical Index), the elasticity of trade costs with respect to political uncertainty is estimated and then used for simulation in a trade model.

In the simulation model, consumers have love of variety, which differs from the standard Armington model, where each country's goods are treated as unique. The elasticity of substitution between modes of transportation is estimated from the data, which allows for potential changes in modes of transportation. The world economy is projected to every five years from 2015 to 2030 with different growth scenarios. The economic impacts (namely the change in trade cost, trade volume, GDP, and welfare) of the opening of the Northern Sea Route is evaluated for the different magnitudes of potential political uncertainty.

SP2-S18

Experimental Study on Wave-ice Interaction for Small Ice Floes and Plate Ice in Regular Wave

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Reduction of sea ice coverage in the Arctic Sea has increased vessel operations in marginal ice zones (MIZ). The ice condition in MIZ consists of various types of the floating sea ices such as level ice, small and large ice floes. Vessels operating in MIZ interact with sea ices and wave. The ice load estimation acting on the ship hull with ship, ice and wave interactions is necessary for the safe and efficient operation for ice-going vessel. The precise estimation of ice load needs understanding of the ice motion and displacement floating on the wave [1]. This research investigates the ice motions and displacement in the regular wave experimentally. The experiment was conducted in the 2D tank in Osaka University, Japan. The motion (velocity and acceleration) and displacement (vertical and horizontal direction) of the small ice floes and plate ice in the regular wave were measured. Figure 1 shows the experimental setup for the measurement of the plate ice motion and deformation in the regular wave. The rectangular polypropylene (PP) plate ice was used as a sea ice. As shown in Figure 2, the plate ice deforms and moves up and down by the regular wave. Furthermore, the measurement for the small ice floes in the regular wave and the small ice floes interacting with vertical structure in regular wave were conducted.

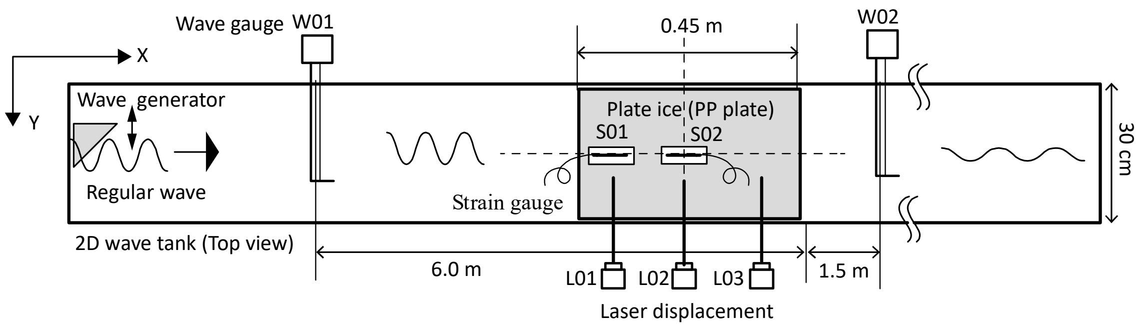

Figure 1. Experimental setup (plate ice deformation in regular wave).

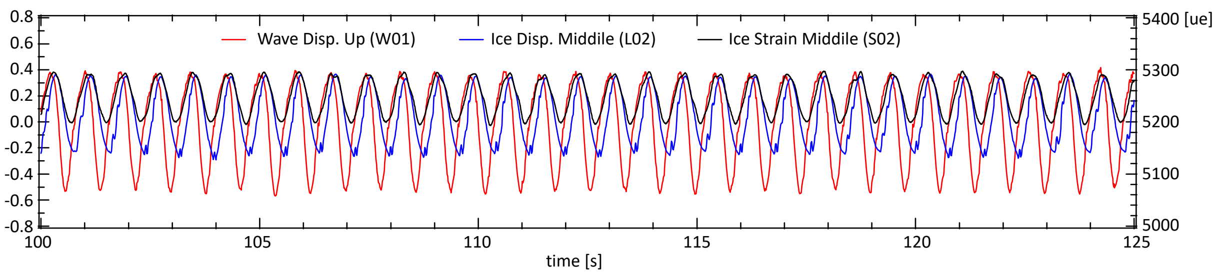

Figure 2. Time history of inlet wave and ice vertical displacement, ice bending strain (wave height = 0.01 m, wave length = 1 m, plate ice thickness).

References

[1] Junji Sawamura, Kensuke Imaki, Takaya Shiraishi and Hidetaka Senga, Ice resistance test using synthetic ice of a ship in small pack ice floes and wave interaction, The proceeding of 28th International Offshore and Polar Engineering Conference, pp.1586-1590, 2018.

The need for International Arctic Science Funding to answer the "Big Questions"

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The remoteness of the Arctic and the harsh climate conditions, in particular during winter, pose a challenge for Arctic research and complex scientific activities cannot be organized by one country alone. The best example is the recent MOSAiC (Multidisciplinary drifting Observatory for the Study of Arctic Climate) expedition that was coordinated by the German Alfred Wegener Institute and involved 20 nations. Complex expeditions such as MOSAiC are required to answer "big questions".

There are a number of international processes to shape the Arctic research agenda and to identify those "big questions". The International Polar Year (IPY) is organized since 1882/1883 and the most recent IPY 2007/2008 was the largest coordinated polar research program ever, addressing both the Arctic and the Antarctic. Since 1995, the International Arctic Science Committee (IASC) periodically conducts an International Conference on Arctic Research Planning (ICARP) and 2016 the United States initiated the Arctic Science Ministerial meeting which is organized every second year. Another important mechanism is the Agreement on Enhancing International Arctic Scientific Cooperation that was developed under the auspices of the Arctic Council and signed by the eight Arctic States in 2017.

This presentation addresses the need to better coordinate the funding for international Arctic research. Funding models can include both the pooling of national funds to support international research programs, such as the European Commission Horizon 2020 program and its successor program Horizon Europe but also the alignment of national funding in multi- or bilateral programs, like for example the Changing Arctic Oceans Program (a collaboration between the UK National Environmental Research Council and the German Federal Ministry for Education and Research) and the Canada-Inuit Nunangat-United Kingdom Arctic Research Program (a joint program of the UK Natural Environment Research Council, Inuit Tapiriit Kanatami, Polar Knowledge Canada, National Research Council of Canada, Parks Canada and Fonds de Recherche du Quebec).

Revision of global fossil fuel methane emissions based on trends and meridional gradients of CH_4 and $^{13}CH_4$ during 1990-2020

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Reducing methane (CH_4) emissions is a top priority for climate action because of its short lifetime and high global warming potential. Emissions of CH_4 mainly comes from fugitive fossil fuel exploitation (oil and natural gas, coal, geological), microbial processes (enteric fermentation, rice cultivation, wetland, waste management etc.) and biomass burning sectors, where the fossil fuel sector contributes ~15-22% of global CH_4 emissions (Chandra et al., 2021). However, the CH_4 emissions by source sector are largely uncertain than the total flux, and attribution of total emissions to different sources remained largely uncertain at regional and global scale. The atmospheric CH_4 data alone do not include source-type information. In contrast, $\delta^{13}C$-CH_4 ratio in the atmosphere are controlled by the relative contributions from source types with distinctive isotope signatures, hence help to probe sectoral emissions more precisely with the help of atmospheric chemistry transport model.

We have simulated the global history (1985-2020) of CH_4 and $\delta^{13}C$-CH_4 using MIROC4-ACTM, and compared the results at a network of monitoring stations. The best fit emission scenarios are found by compiling geographical distributions of isotopic signatures of source categories, different emission scenarios by reviewing recent literature (Höglund-Isaksson et al., 2020), and regional emission trends from MIROC4-ACTM inversion (Chandra et al., 2021). Based on the reconstruction of the latitudinal gradient and trends of CH_4 and $\delta^{13}C$-CH_4, we find a decline in emissions from fossil fuel exploitations during 1985-2020 in contrary to increasing trends from EDGARv6 inventory. An earlier version of EDGARv4.3.2 was used in our inversion study.

References

[1] Chandra, N., Patra, P. K., Bisht, J. S. H., Ito, A., Umezawa, T., Saigusa, N., Morimoto, S., Aoki, S., Janssens-Maenhout, G., Fujita, R., Takigawa, M., Watanabe, S., Saitoh, N., and Canadell, J. G.: Emissions from the Oil and Gas Sectors, Coal Mining and Ruminant Farming Drive Methane Growth over the Past Three Decades, J. Meteorol. Soc. Japan. Ser. II, 99, 2021–015, https://doi.org/10.2151/jmsj.2021-015, 2021.

[2] Höglund-Isaksson, L., Gómez-Sanabria, A., Klimont, Z., Rafaj, P., & Schöpp, W. (2020). Technical potentials and costs for reducing global anthropogenic methane emissions in the 2050 timeframe –results from the GAINS model. Environmental Research Communications, 2(2), 025004. https://doi.org/10.1088/2515-7620/ab7457

Consequences of wildfires in boreal forests underlain by ice-rich permafrost near Batagay, NE Siberia

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Post-fire changes in Arctic landscapes are gathering attention from local land managers, residents, and worldwide audiences because the impact of fires could induce irreversible permafrost thaw and catastrophic deformation of landforms. Batagay in the Sakha Republic, Russia, is located in Eastern Siberia and is one of the regions where ice-rich permafrost is broadly distributed. This highly ice-rich permafrost is susceptible to landform changes by thermal and hydrological erosions due to the excess ice composition. As reported by several studies on the Batagaika megaslump, 50-80 m thick of the ice-rich permafrost can be eroded, releasing a considerable amount of sediments and carbons formerly consolidated in permafrost for more than thousands of years. Global warming has already affected the stability of Arctic land, and numerous studies reported the associated permafrost degradation. However, we still have limited knowledge about permafrost land changes after wildfire disturbances.

Batagay area is underlain by at least 50-80 m thick ice-rich permafrost. Recent wildfires burned an extensive area near Batagay, which triggered prominent thermokarst processes due to the surface disturbance by the fires. We set study sites B14 and U14 at burned and unburned areas with gentle slopes near the southern edge of the 2014 fire burn scar, respectively. Sites B19 and U19 were set at burned and unburned areas in the southeastern edge of the 2019 fire burn scar divided by a firebreak line.

We conducted Interferometric Synthetic Aperture Radar (InSAR) analysis to generate ground deformation maps over the post-wildfire area. To investigate ground surface changes, we also used optical satellite images. Five snow-free and cloud-free Landsat8 images acquired during 2014-2018 were used to generate the 2014 fire perimeter based on dNBR. We conducted fieldwork campaigns in three consecutive thawing seasons during 2019-2021. In late September 2019, we measured relative height, soil moisture, ground temperature, and thaw depth along a 30 m transect at B14. Soil geochemistry of the active layer at each site was analyzed in the laboratory. Similar field surveys followed at the end of the thawing seasons of 2020 and 2021.

We detected seasonal deformation from 2017 to 2018, whose magnitude and spatial patterns of the tendencies of subsidence and uplift were consistent in both InSAR results using different satellite data regardless of the season. The fires enhanced seasonal ground displacement and triggered interannual thermokarst subsidence at each burned area. In the field, we confirmed that the burned areas had deeper thaw depths up to three times as deep as unburned areas. Soil moisture profiles at the burned site were significantly higher. Soil chemistry analysis indicates enhanced leaching of ions and micro-elements in the upper active layer at burned site. The most destructive changes were gully formations triggered naturally and anthropogenically after the fires.

The Pelagic Ecosystem in the Central Arctic Ocean with Increased Pressures as Future Prospect

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The deep and remote Central Arctic Ocean (CAO) is one of the least studied ecosystems on Earth. As the region warms and sea ice retreats, previously inaccessible areas are becoming accessible, paving the way for new activities. Changes in sea-ice cover, water column structure and composition have already affected the pelagic ecosystem in the CAO, and more pressures will become apparent from rapid climate change and human activities. New measurements collected by research expeditions to the CAO are needed to enable effective management and adaptation to a rapidly changing environment.

The Norwegian Polar Institute conducted a research expedition to the CAO with RV *Kronprins Haakon* 22 July – 20 August 2022, from Svalbard to the slope and deep waters of the CAO with continuation to the North Pole and return across the Amundsen and Nansen basins. A purpose of this cruise was to establish a long-term observing system in the CAO based on two new moorings placed at 4000 m depth in the Amundsen and Nansen basins. They will collect data on water masses, sea ice and biological matter for the next two years until retrieval. An important aspect will be to link oceanographic and sea ice information with ecosystem processes in a framework of climate change.

First-year sea ice encountered on the way to the North Pole was rather thin, generally <1.5 m, but became thicker when steaming SW to the transect start, including areas of multiyear ice over the Amundsen Basin. Leads were relatively frequently encountered, and pelagic trawling with Harstad trawl was done in some of the larger ones. Zooplankton was sampled with Mammoth Multinet, stratified in the water column with nine closing nets, and MIK and Bongo nets hauled vertically in the upper 1000 m. Pelagic organisms, particularly in the mesopelagic layer at 200-350 m depth, were surveyed with Simrad EK80 echo sounder, with post-processing in the Large Scale Surveying System (LSSS).

Fishes were caught on the shelf and slope north of Svalbard (N 80,71°) at 350 m depth, with capelin dominating (45% of the biomass), followed by Atlantic cod (*Gadus morhua*) with 30% and krill with 20%. Others included deepwater lantern fish (*Benthosema glaciale*) and juvenile polar cod (*Boreogadus saida*), Atlantic wolffish (*Anarhichas lupus*) and Greenland halibut (*Reinhardtius hippoglossoides*). Trawling at N 82,82° caught only few deepwater lantern fish and mostly krill and pelagic amphipods. In the North Pole region, there were no pelagic fish. Jellyplankton occupied the third trophic level, mostly with arow worms (*Eukrohnia hamata*) and ctenophores (*Mertensia ovum*) feeding on Arctic copepods *Calanus hyperboreus* and *C. glacialis*.

Future pressures will involve drivers related to both climate change and anthropogenic activities. Less sea ice, warmer temperature, and associated changes in light and nutrients may enhance the pelagic production. Boreal fishes are expected to expand seasonally into the Atlantic layer at 200-600 m depth to feed on the lipid-rich Arctic zooplankton. Shipping and pollution will likely increase, with effects on marine life. Continuous monitoring is pertinent in order to detect and quantify such changes.

SP3-S1

Variability and evolution of fire weather conditions in boreal regions under levels of global warming

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We present a detailed and systematic characterization of the distribution and variability of fire weather and its underlying meteorological drivers across five high-latitude boreal regions in North America, Scandinavia, and Russia – under 1850-1900 conditions and for global warming levels up to +4°C.

Recent years have seen unprecedented fire activity at Arctic latitudes. While wildfire occurrence and severity result from a complex interplay between natural and anthropogenic factors, weather is a key factor. Weather conditions that promote high wildfire risk are characterized by the combination of high temperatures, little precipitation and low humidity, and often high winds, all of which are affected by human-induced climate change. Such effects not only manifest as shifts in the means and extremes of the weather conditions but can also change the shapes of their distribution. Using initial condition ensembles from two global climate models, we quantify the full probability density distributions (PDFs) of daily maximum surface air temperature, precipitation, wind, and minimum relative humidity. These contain information on expected weather not apparent from the distribution mean or tails, but through changes to their overall shape. The resulting aggregate change in fire risk is quantified using the Canadian Fire Weather Index (FWI).

Our results provide a comprehensive picture of the potential future changes in drivers of fire weather at high latitudes, including differences between regions. We find consistent increases in both means and upper tails of the FWI distribution, and a widening suggesting increased variability. The largest changes occur in Canada and the smallest in Alaska. The main drivers are the projected increase in mean daily surface temperature and a decline in the mean daily minimum relative humidity, marked already at +1 and +2°C global warming. While the occurrence and severity of wildfires ultimately depend also on other factors, we show that continuing global warming can push the high-latitude regions into increasingly unfamiliar fire weather regimes.

March 9

Breakout Session

R1

Atmosphere

Trend of N_2O isotope ratios in the Arctic atmosphere

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Nitrous oxide (N_2O) is one of the increasing greenhouse gases and is the most important stratospheric ozone-depleting gas emitted in the 21st century. Because secular trend of isotope ratios of atmospheric N_2O can be used to deduce relative contribution from each source, several efforts have been made by measuring air trapped in the polar firn or by analyzing air samples collected at monitoring stations. However, the latter measurements are reported for only a few stations in temperate region and Antarctica, and monitoring period is limited. Here we present a 17-year record of monthly or biweekly isotope ratios of N_2O obtained at two sites in the Arctic region: Novosibirsk in the western Siberia, Russia (55°N, 83°E) (since 2005), and Churchill, northern Canada (59°N, 94°W) (since 2011).

The bulk nitrogen isotope ratio ($\delta^{15}N^{bulk}$) is decreasing at about −0.04‰ yr^{-1} while the N_2O mixing ratio are increasing (about 0.8 ppbv yr^{-1}). This suggests sources emitting isotopically light N_2O contributes to the increase. The rate of $\delta^{15}N^{bulk}$ is similar to those observed with whole air sampling at other sites in the mid-latitude Northern/Southern Hemisphere and Antarctica, and those obtained by firn air analyses. When compared at the same year, however, the value of $\delta^{15}N^{bulk}$ is about 0.2‰ lower in the Northern Hemisphere than in the Southern Hemisphere. The oxygen isotope ratio ($\delta^{18}O$) also shows decreasing trend with smaller rate, but north-to-south gradient is not detectable with the precision of the analysis. The ^{15}N-site preference in N_2O (SP) does not show secular increasing nor decreasing trend, and north-to-south gradient is not detectable. Our long-term monitoring confirms universal nature of N_2O isotopic trend. Further analysis of short-term variations and detailed comparison between Arctic and other regions will be discussed.

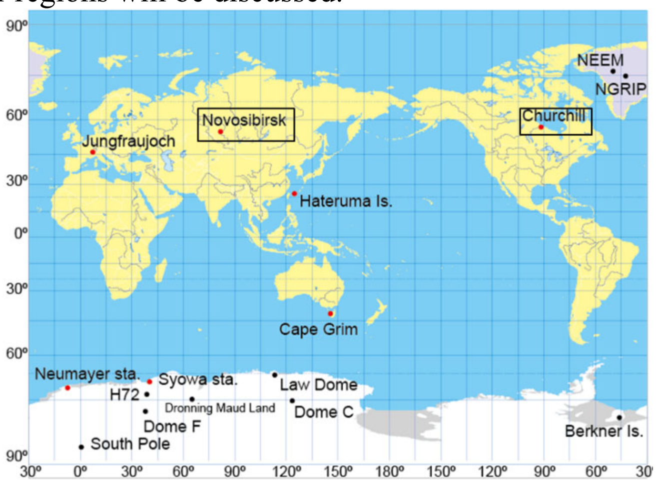

Figure 1. Map showing the sampling locations of this study and others. Red dots indicate direct air sampling stations; black, firn air sampling sites

Preliminary results of the atmospheric particulate matter variations in the summer of 2022 in Qaanaaq, Greenland

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It is well-known that atmospheric pollution and human health are highly related. The Arctic region is also not an exception. Therefore, our research group has developed a mobile and low-cost $PM_{2.5}$ measurement system for cold regions [1], which can be installed even in severely frigid regions such as the Arctic. The sensor we incorporated into our system was the low-cost $PM_{2.5}$ sensor developed by Nagoya University and Panasonic Co., Ltd. [2]. The commercial version of the $PM_{2.5}$ measurement system is now available via a Japanese company, Tanaka Co., Ltd. (http://kktanaka.co.jp/products).

In the summer of 2022, we installed the commercial version of the $PM_{2.5}$ measurement system on the roof of a house in Qaanaaq, Greenland. We measured the particulate matter smaller than 2.5 μm (i.e., $PM_{2.5}$) from July 20 to August 13, 2022. The coefficient of 1.3 was used to convert the measured raw data to $PM_{2.5}$ mass concentration based on Nakayama et al. [2]. During the period, we often observed highly increased $PM_{2.5}$ mass concentrations, and its maximum concentration was greater than 100 $\mu m\ m^{-3}$ in the 10-second interval data. In addition, from August 8, we observed the smoke from the open waste burning in the village. We will discuss more on the characteristics of the $PM_{2.5}$ variations during the observation on the day of the presentation.

This study was partially supported by the Grant-in-Aid for Scientific Research (B) (JSPS KAKENHI Grant Numbers: 19H01976) and the Arctic Challenge for Sustainability II project (ArCS II: JPMXD1420318865).

References

[1] Yasunari, T. J., S. Wakabayashi, Y. Matsumi, and S. Matoba, Developing an insulation box with automatic temperature control for $PM_{2.5}$ measurements in cold regions, *J. Environ. Manage.*, **311**, 114784 (2022). https://doi.org/10.1016/j.jenvman.2022.114784

[2] Nakayama, T., Y. Matsumi, K. Kawahito, and Y. Watabe, Development and evaluation of a palm-sized optical $PM_{2.5}$ sensor, *Aerosol Sci. Technol.*, **52**, 2-12 (2018). https://doi.org/10.1080/02786826.2017.1375078

R1-O04

Slow-down in summer warming over Greenland in the past decade linked to central Pacific El Niño

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Greenland warming and ice loss have slowed down since the early 2010s, in contrast to the rest of the Arctic region. Both natural variability and anthropogenic forcing contribute to recent Greenland warming by reducing cloud cover and surface albedo, yet most climate models are unable to reasonably simulate the unforced natural variability. Here we show that a simplified atmospheric circulation model successfully simulates an atmospheric teleconnection from the tropics towards Greenland, which accounts for Greenland cooling through an intensified cyclonic circulation. Synthesis from observational analysis and model experiments indicate that over the last decade, more central Pacific El Niño events than canonical El Niño events have generated the atmospheric teleconnection by shifting the tropical rainfall zone poleward, which led to an intensified cyclonic circulation over Greenland. The intensified cyclonic circulation further extends into the Arctic Ocean in observations, whereas the model does not show a direct remote forcing from the tropics, implying the contribution of an indirect atmospheric forcing. We conclude that the frequent occurrence of central Pacific El Niño events has played a key role in the slow-down of Greenland warming and possibly Arctic sea-ice loss. This paper was published in [1].

References

[1] Matsumura, S., Yamazaki, K. & Suzuki, K. Slow-down in summer warming over Greenland in the past decade linked to central Pacific El Niño. Commun Earth Environ 2, 257 (2021). https://doi.org/10.1038/s43247-021-00329-xC.R.

Regional ensemble of global climate models for Sakha (Yakutia) Republic, Northern Eurasia

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[2]North-Eastern Federal University, Russia

Climate warming progresses rapidly in Northern Eurasia owing to the effect known as 'Arctic Amplification', leading to important subsequent changes in hydrology, permafrost, landscape and societies. Regional adaptation and mitigation strategies should be based on reliable climate forecasts, currently provided by CMIP6-generation global climate models (GCMs). The use of multi-member model ensembles increases long-term forecasts' reliability and better describe the uncertainties. Indiscriminate GCM selection for the regional ensemble treats all model outcomes as equally probable, while discriminate selection evaluates GCM performance against historical data across the region of interest.

Our research aims at developing a regional GCM ensemble for Sakha (Yakutia) Republic, the largest administrative region globally, based on near-surface air temperature (CMIP6 *tas* variable). The following protocol was employed: (1) selecting best-fit historical reanalysis model as a baseline for comparison with GCM outputs; (2) calculating spatial correlation between observed (reanalysis) and modeled *tas* fields for reference periods, as well as *tas* change between two reference periods, 1961-1990 and 1981-2010; (3) discriminate selection and combination of GSM outputs based on spatial correlation metrics. In a large region with complex terrain and high-altitude relief this approach of giving higher priority to model ensembles that better reproduce change between periods rather than any single period deemed plausible. Data analysis was performed in QGIS 3.11.22 LTS and RStudio, a GUI to R programming language.

Several reanalysis models were tested in comparison with observation data, and GHCN-CAMS was selected as a baseline historical climate and treated as observed climate. This reanalysis was second best in terms of correlation with observed *tas* and its change, but was less biased toward higher values than ERA5-Land. A total of 48 GCM outputs from the CMIP6 *historical* experiment were compared to baseline climate for 1961-1990, 1981-2020 periods, and change between these two periods, using Pearson spatial correlation and Dutilleul's modified t-test for bivariate raster correlation.

Various combinations of ten best performing models were tested, both indiscriminate and discriminate, the latter was implemented via weighting based on Pearson spatial correlation coefficient, against GHCN-CAMS reanalysis baseline. A single best model was MPI-ESM-1-2-HR, with Pearson's r = 0.52 between observed (GHCN-CAMS reanalysis) and predicted change between 1961-1990 and 1981-2010 periods. The only GCM ensemble that outperformed this single model, with Pearson's r = 0.54 and RMSE = 0.24, was a combination of five GCMs weighted by their respective Pearson's r values: CESM2-WACCM (r = 0.38), CMCC-ESM2 (r = 0.42), CNRM-CM6-1-HR (r = 0.23), INM-CM5-0 (r = 0.21) and MPI-ESM-1-2-HR (r = 0.52). This combination was accepted as a regional GCM ensemble for Sakha (Yakutia) Republic.

This study is funded by Russian Science Foundation, Project No. 22-27-00344.

March 6

Breakout Session

R2

Ocean and Sea Ice

R2-O01

Development of a high latitudinal SST and sea ice dataset derived from GCOM-C/SGLI

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The Second-Generation Global Imager (SGLI) is an optical sensor aboard the Global Change Observation Mission -Climate (GCOM-C) satellite. GCOM-C, which was launched in December 2017, is one of the two polar-orbiting satellites for the GCOM mission conducted by the Japan Aerospace Exploration Agency (JAXA). SGLI obtains data at the spatial resolution of 250 m to 1 km and has generated a lot of important geophysical datasets through the five-year operation so far. In particular, the Sea Surface Temperatures (SSTs) are key geophysical parameter to understand the global climate system. In previous dataset using thermal infrared, the polar region SSTs contained the many missing data ascribed to calibration and cloud detection. In GCOM-C mission, we are trying to solve these issues through improvement of the calibration accuracies and algorithms including SSTs retrieval and cloud detection. The SSTs are retrieved from the thermal infrared data obtained with the split window channels. SGLI has improved SST monitoring, especially at high latitudes, through high accuracy and high spatial resolution observations. Sea ice masks are determined using visible, shortwave infrared and thermal infrared data. The high spatial resolution is a strong advantage to detect sea ices. SGLI SSTs and sea ice masks as standard products are provided in near real time as SGLI level 2 products, respectively. These 8-day and monthly statistics are calculated at each equal-latitude-longitude bin and provided as level 3 products. However, the level 3 SST and the level 3 sea ice mask are provided separately, and the equal-latitude-longitude grided statistics are not suitable for high latitudes since the area decreases with increasing latitude. Because sea ices are not masked in the SST product, the sea ice data is beneficial to improve the retrieved SSTs, and vice versa. Therefore, we developed the arctic region SSTs and ice mask product. We gathered the SGLI level 2 SSTs and sea ice masks in arctic seas at each ~10 km bin on the polar stereo coordinate and calculated the statistics for each month from June (Fig. 1) to September 2021. Monthly statistics were determined by iterating the statistics calculation and quality testing. To improve the results, we validated SSTs and sea ice masks by comparison with in-situ data and other satellite products and compared the monthly statistics with those from other data sources. We are planning to analyze the data from May to September in each year from 2018 to the latest. Monthly SSTs, sea ice masks and statistical information used to determine the monthly composite will be provided as a high latitude SGLI product.

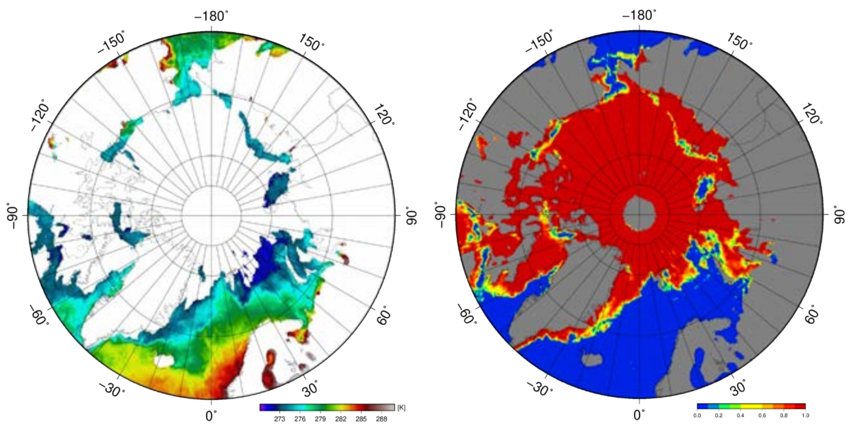

Figure 1. Monthly mean SST (left) and sea ice frequency (right) in June 2021.

Retrieving sea ice strength in the Beaufort Sea using variational data assimilation

G. Panteleev*[1], M.Yaremchuk[1]

[1] *Naval Research Laboratory, Ocean Science Division, Stennis Space Center, USA*

In this study, we consider an extension of a simplified 2d Elasto-Visco-Plastic (EVP) sea ice model [1] using a spatially variable representation of the sea ice rheological parameters and analyze feasibility of the parameter optimization using variational assimilation of the sea ice concentration, thickness and velocity observations. It was found the Tangent Linear and Adjoint models for the EVP momentum balance are unstable, but can be regularized by introducing the Newtonian dumping terms. Observing System Simulating Experiments (OSSEs) are configured for a rectangular domain with cyclonic sea ice circulation pattern, under pack ice conditions and variable wind/ocean forcing. Multiple OSSE's indicate that spatially varying ice strength parameter can be relatively accurately reconstructed for the medium resolution (~30km) models (Fig.1). The developed variational data assimilation EVP model was applied to the sea ice velocity (https://nsidc.org/data/nsidc-0116/versions/4), sea ice concentration (https://nsidc.org/data/) and CryoSat-2 sea ice thickness observations collected around three moorings in the Beaufort Sea for the periods with intensive sea ice convergence. The satellite sea ice thickness observations were collocated with the sea ice draft observation from ULS from three moorings (https://www2.whoi.edu/site/beaufortgyre/data). Ocean currents from moorings and atmospheric wind speed (NCEP-NCAR) were assimilated as well. Preliminary results for the Beaufort Sea are discussed

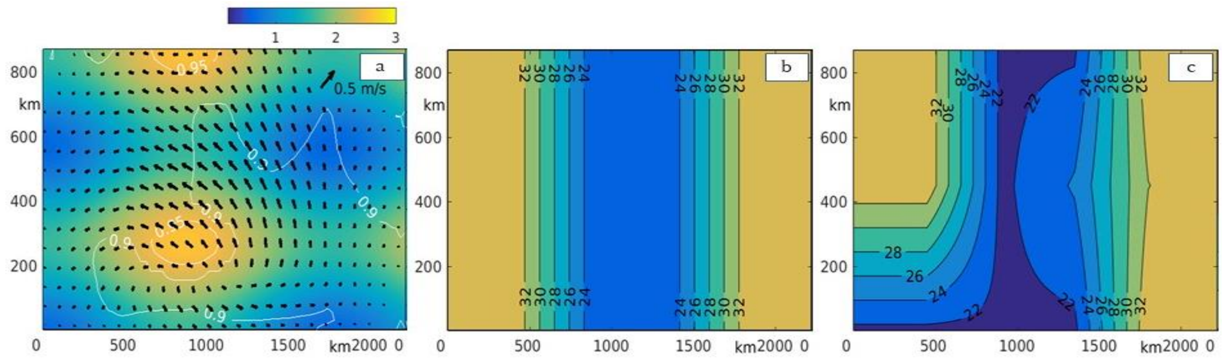

Figure 1. a) Sea ice velocities and sea ice thickness in the OSSE; b) "true" sea ice compressive strength distribution utilized in OSSE's; c) Reconstructed sea ice compressive strength distribution.

References
[1] E.C.Hunke and J.K.Dujiwucz, An elastic-Viscous-Plastic Model for Sea Ice Dynamics, J.Phys. Ocean, **(27),** 1997.

R2-O03

Automatic Sea Ice Concentration Segmentation of Sentinel-1 Imagery using a Convolutional Neural Network

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Arctic countries have been manually creating sea ice charts based on satellite imagery. However, sea ice charts produced by sea ice expert analysts always contain subjective elements. Furthermore, the manual production of sea ice charts is time-consuming, resulting in a long delay between the acquisition and publication of the information. Delays can be fatal for navigators in the Arctic Ocean because sea ice is very fluid due to the presence of winds and strong currents. The purpose of this initiative is to produce less subjective sea ice charts in a shorter time by applying the sea ice concentration (SIC) automatic segmentation method to SAR imagery.

In this study, a modified network of U-Net [1], a convolutional neural network architecture, was used to take the Weekly SIC charts from the Russian Arctic and Antarctic Research Institute (AARI) and Canadian Ice Service (CIS) and the SAR images (Sentinel-1) with NERSC noise reduction technique [2] as learning data to automatically perform SIC segmentation of SAR images. As a result, a less subjective SIC was automatically produced in a short time with an accuracy close to that of manual SIC produced by AARI and CIS (Figure 1). Output images created by this method can clearly show SIC, which is difficult to determine from the original SAR images. In addition, it was confirmed that even sea ice that was not detected by AMSR2 could be detected by using higher resolution SAR (Figure 2).

As a future issue, improvements are needed because false detections have also been observed in scenes with rough waves due to storms, as well as in scenes with e.g. nilas with significantly lower backscatter and small drift ice.

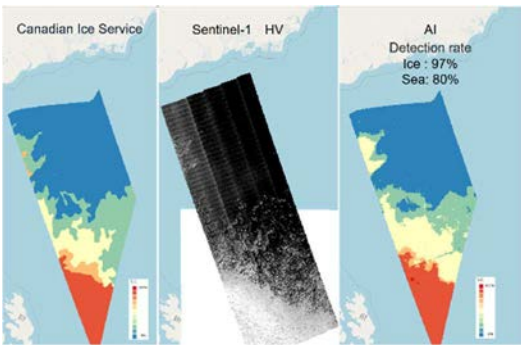

Figure 1

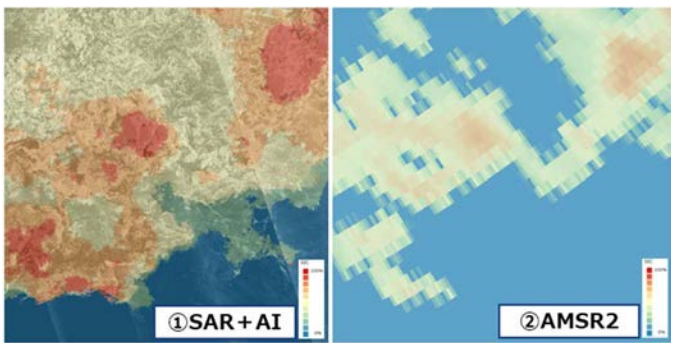

Figure 2

References

[1] A. Stokholm, T. Wulf, A. Kucik, R. Saldo, J. Buus-Hinkler and S. M. Hvidegaard, "AI4SeaIce: Toward Solving Ambiguous SAR Textures in Convolutional Neural Networks for Automatic Sea Ice Concentration Charting," in IEEE Transactions on Geoscience and Remote Sensing, vol. 60, pp. 1-13, 2022, Art no. 4304013, doi: 10.1109/TGRS.2022.3149323.

[2] J. -W. Park, J. -S. Won, A. A. Korosov, M. Babiker and N. Miranda, "Textural Noise Correction for Sentinel-1 TOPSAR Cross-Polarization Channel Images," in IEEE Transactions on Geoscience and Remote Sensing, vol. 57, no. 6, pp. 4040-4049, June 2019, doi: 10.1109/TGRS.2018.2889381.

R2-O04

The arctic summer sea ice prediction based on sea-ice histories

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The summer arctic sea-ice has decreased due to the warming. Because of evaluating the availability of taking NSR, Arctic Sea Ice Information Center (ASIO) developed the mid-term forecast of the summer sea-ice distribution and published the forecast on our website in May, Jun, and July. The prediction method follows Kimura et al (2013) [1]. The method assumes that there is a correlation between the sea ice divergence/convergence (SID) from winter to spring and sea ice concentration (DSIC) in summer. On 2022 forecasts, in order to consider the distribution of the thick multi-year ice, new parameters; sea-ice age (SIA), mean divergence of ice motion (MDI), and an accumulated absolute divergence/convergence of ice motion (AADI) were introduced. These parameters represent the resistance to melting related to the ice age or thickness, derived from backward tracking of sea ice for 4 years (SIA and MDI) or 3 months (AADI). When the particle reaches open ocean area, we assume it to be ice formation. SIA is obtained by number of days from ice production. MDI and AADI are calculated by divergence/convergence of sea ice within that period. Ice predictions in the first, second, and third reports are performed by the multiple regression analysis of DSIC-SID-SIA-MDI, DSIC-SID-AADI, and DSIC-SID-SIE, respectively. Predicted ice distributions on September 10 are shown in Fig1. In the Beaufort Sea, all of the predictions agree approximately with the observation while the predictions in the Chukchi Sea/East Siberian Sea are overprediction/underprediction. The predictions become better by considering the multi-year ice distribution. We aim to improve our prediction methods by identifying the causes of the gaps between the forecast and observation.

Acknowledgements

We thank the Arctic Data Archive system (ADS) for the gridded AMSR-E and AMSR2 data. This work was a part of the Arctic Challenge for Sustainability II (ArCS II, programme grant no.JPMXD1420318865) projects.

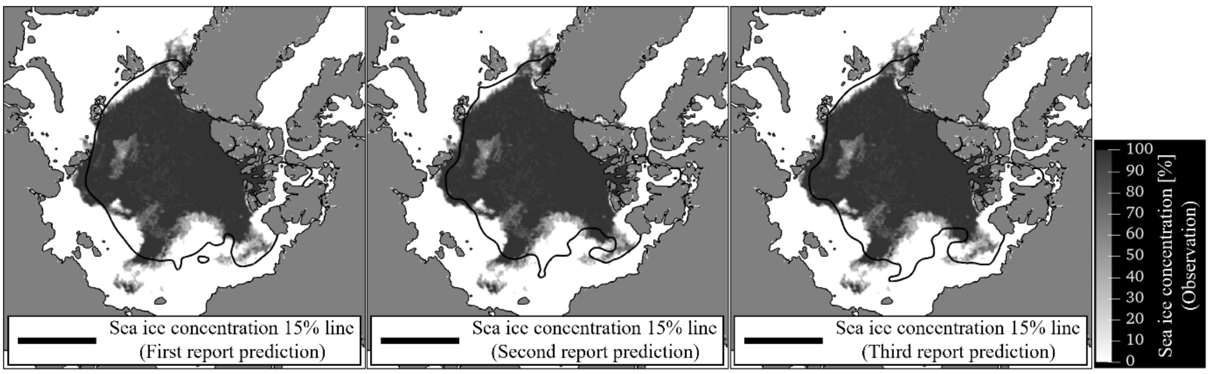

Figure 1. Comparison of observation and predictions

References

[1] N. Kimura, A. Nishimura, Y. Tanaka and H. Yamaguchi, Influence of winter sea ice motion on summer ice cover in the Arctic, Polar Research, 32, 20193, 2013.

R2-O05

Estimation of sea ice thickness based on the ice histories

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Ice thickness is the most important information of sea ice. There are various ice-thickness products based on satellite observations (radar and laser altimeter, microwave sensor, etc.) and numerical models. These products generally agree in the spatial distribution and basin-scale gradients of the thickness but differ in their absolute value.

This study tries to derive the ice thickness by a new way based on the history from the formation of individual sea ice. We first analyze the ice trajectory traced back to the ice formation. For this analysis, daily ice velocity product for 2003-2022, derived from images by satellite microwave sensors Advanced Microwave Scanning Radiometer-Earth Observing System (AMSR-E) and AMSR2 ([1]Kimura et al., 2013) is prepared. Based on the backward trajectory, we focus the age in day, history of ice convergence, and history of heat budget.

Generally ice thickness changes through thermodynamic growth/melt and dynamic deformation (thickening). These processes can be related to the derived parameters of heat budget and ice convergence, respectively. We aim to derive the ice thickness through comparisons between the time-integrated parameters from the backward tracking and independent thickness measurements obtained by field observations. Aa a first step, we calculated the daily heat budget at the sea surface and integrated it over the lifetime of sea ice taking into account differences in growth speed due to the ice thickness. Compared to observations from vessels and moored Upward Looking Sonar (ULS), the estimated ice thickness agreed well with the observed thickness in both its distribution and temporal variation. In the future, we plan to improve the calculation method of the heat budget and incorporate parameters on the dynamic deformation into the calculation, in order to estimate sea ice thickness more accurately.

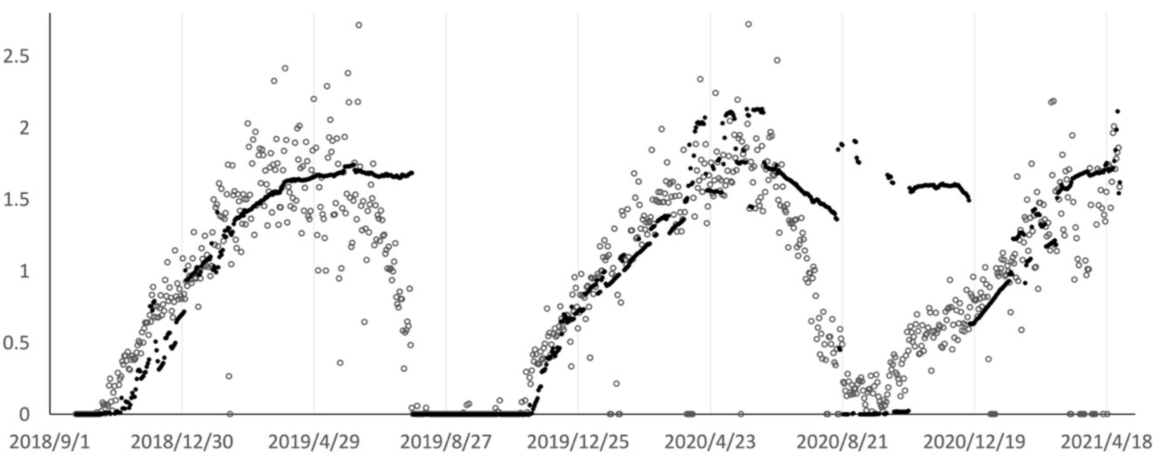

Figure 1. Temporal change of sea ice thickness at a point in the Beaufort Sea observed by moored ULS by Woods Hole Oceanographic Institution (open dot) and estimated by this study (closed dot).

References

[1] N. Kimura, A. Nishimura, Y. Tanaka and H. Yamaguchi, Influence of winter sea ice motion on summer ice cover in the Arctic, Polar Research **32** (2013)

Estimation of sea ice thickness using UAV-SfM in Utoro, Hokkaido on the shores of the Sea of Okhotsk

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Sea ice thickness is important information for elucidating the effects of climate change and for economic activities in ice covered sea area. An Unmanned Aerial Vehicle with Structure from Motion (UAV-SfM) is applied for sea ice thickness measurement in order to achieve low cost, high efficiency, and accurate observation over a wide area under low temperature conditions.

Observations of snow and ice surfaces heights by UAV-SfM have been conducted most on the lake ice of the Saroma-ko Lagoon and the land-fast sea ice near the coast. In this study, aerial photographs of sea ice were taken by UAV “DJI Phantom4-pro” and the photographs were analyzed by SfM software “Metashape”. In addition, A Global Navigation Satellite System (GNSS) receiver was mounted on the UAV to get coordinates of each aerial photograph. Figure 1 shows the location and the observation area of the Utoro port of eastern Hokkaido, Japan. The observation date is on February 12, 2022. Ice cake existed in the port on that day. The flight time was from 9:36 a.m. to 10:56 a.m. We got 414 photographs by three flights. We measured sea ice thickness at 10 points by a drill-hole method to compare actual and estimated values. The Digital Surface Model (DSM) of sea ice surface height was generated from the SfM software. Freeboard and thickness of sea ice were estimated from the DSM and hydrostatic equilibrium. Figure 2 shows the estimated freeboard distribution in the observation area (Fig. 1). Mean Absolute Error (MAE) and Root Mean Squared Error (RMSE) between actual and estimated values were 2.3cm and 2.8cm. Total ice thickness was estimated and compared using the method based on the relationship between freeboard and ice thickness measured by drill holes and the method of hydrostatic equilibrium based on densities.

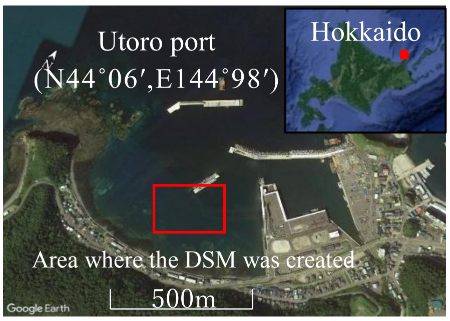

Figure 1. The location of observation area

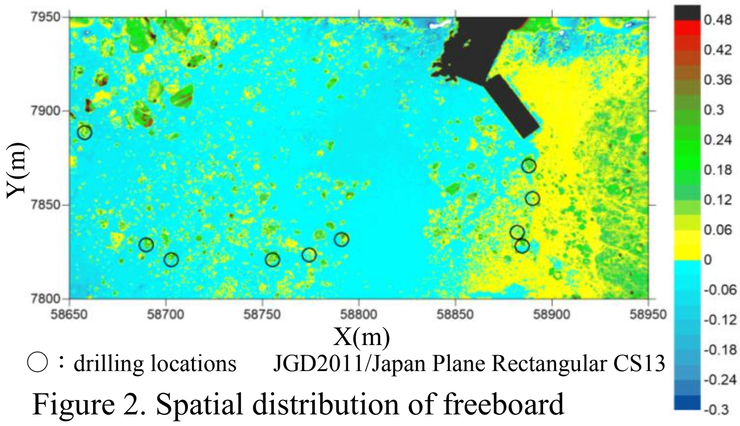

Figure 2. Spatial distribution of freeboard over the area of red square in Fig.1.

Seasonal variations of sea-ice thickness in the Northwind Abyssal Plain of the Arctic Ocean: Data analysis of moored ice-profiling sonar

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Since the 1990s, moored observations using Ice-Profiling Sonar (IPS), which provides high resolution sea ice draft data, have been performed in various sea areas [1]. The Northwind Abyssal Plain (NAP) is a seasonal ice zone located relatively offshore in the western Canada basin, where biogenic particles are transported from Chukchi shelf by mesoscale eddies as well as the Beaufort Gyre [2]. In order to clarify the sea ice characteristics in the NAP, in this study, we performed statistical investigation of sea-ice draft and movement based on mooring system, together with auxiliary data regarding atmospheric and oceanic conditions.

The NAP18t mooring system was installed at 74°39.012'N, 161°50.340'W, where the full water depth is about 1824 m, and was equipped with IPS and Acoustic Doppler Current Profiler (ADCP). The IPS provided timeseries of sea ice draft, which was then converted to pseudo-spatial series using sea ice velocity estimated by ADCP horizontal current and surface wind velocity (NCEP CFSv2).

To investigate the features and variability of the ice field at the NAP, we calculated the temporal evolution of the probability density function (PDF) of the IPS ice draft. In general, drafts with high probability were distributed around the primary mode (i.e., the draft with the highest probability), while the secondary mode appeared at a relatively shallow draft of about 30-40 cm before and after around February. Regarding the primary mode, the evolution from October onward can be interpreted by the simple, one-dimensional heat balance [3], with NCEP CFSv2 air temperature used as an input parameter. Meanwhile, the secondary mode characterized by thinner draft, can be only reproduced by the model when the onset of ice formation is set to delay by about 4-5 months. We speculate that the direction of prevailing ice drift has drastically changed around February, i.e., from northwestward to northeastward, which resulted in the significant thinning of the drifting sea ice.

References

[1] Melling, H. and D. A. Riedel, Development of seasonal pack ice in the Beaufort Sea during the winter of 1991-1992: A view from below, *J. Geophys. Res.,* **101** (1996)
[2] Watanabe, E., J. Onodera, N. Harada, M. C. Honda, K. Kimoto, T. Kikuchi, S. Nishino, K. Matsuno, A. Yamaguchi, A. Ishida, M. J. Kishi, Enhanced role of eddies in the Arctic marine biological pump, *Nature Comm.*, **5** (2014)
[3] Behrendt, A., W. Dierking, and H. Witte, Thermodynamic Sea ice growth in the center Weddell Sea, observed in upward-looking sonar data, *J. Geophys. Res.,* **120** (2015)

Energy Cascade in Eurasian Basin of the Central Arctic Ocean: interpretation of horizontal wavenumber spectra of density derived from an autonomous buoy and the FESOM2 Model

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Submesoscale ocean dynamics bridge transitional patterns in the upper ocean [1]. Thinning sea ice is expected to have a profound impact on the thermohaline dynamics of the Arctic Ocean and modify the energy cascade. We study the spatio-temporal variability and ocean dynamics utilizing in-situ-Lagrangian measurements of temperature and salinity from the Multidisciplinary drifting Observatory for the Study of Arctic Climate (MOSAiC) expedition, along with density field derived from the Finite-volumE Sea ice-Ocean Model (FESOM2). Horizontal wavenumber spectra of density variance in the upper-ocean layer (10, 20, 50, 75, and 100 m) were computed from observed density measurements based on thirteen ~100-km long transects during October 2019 to May 2020. We also analyzed a virtual ~1200 km-long transect spanning the drift trajectory during MOSAiC using FESOM2 products. We focus on the steepness of horizontal wavenumber spectra of density for horizontal scales of 500 m to 25 km to investigate the inherent oceanic physics [2]. Under the assumption of quasi-geostrophic balance and stable stratification, spectra with a slope of -3 are primarily governed by the interior dynamics, according to theory. On the other hand, a slope of -5/3 implies that surface buoyancy forcing may be important [3]. We assume that our observed variable spectral slopes in the upper ocean may be affected by the background stratification [4]. Our results show that the variation in the patterns of spectral slopes indicates a response to changing upper-ocean stratification. Differences between spectral slopes using MOSAiC measurements and FESOM2 products in the near-surface layer become more aligned as the mixed-layer depth increases in late winter, while this is not the case for the comparisons of the halocline layer. Further exploration of the winter state of the regional stratification in the central Arctic is needed.

References

[1] E. Kunze, J. M. Klymak, R.-C. Lien, R. Ferrari, C. M. Lee, M. A. Sundermeyer, & L. Goodman, Submesoscale Water-Mass Spectra in the Sargasso Sea, *Journal of Physical Oceanography* **45** (2015)

[2] A. J. G. Nurser, & S. Bacon, The Rossby radius in the Arctic Ocean, *Ocean Science* **10** (2014)

[3] J. Callies, & R. Ferrari, Interpreting energy and tracer spectra of upper-ocean turbulence in the submesoscale range (1-200 km), *Journal of Physical Oceanography* **43** (2013)

[4] J. A. MacKinnon, J. D. Nash, M. H. Alford, A. J. Lucas, J. B. Mickett, E. L. Shroyer, A. F. Waterhouse, A. Tandon, D. Sengupta, A. Mahadevan, M. Ravichandran, R. Pinkel, D. L. Rudnick, C. B. Whalen, M. S. Alberty, J. S. Lekha, E. C. Fine, D. Chaudhuri, & G. L. Wagner, A Tale of Two Spicy Seas, *Oceanography* **29** (2016)

R2-O09

Impact of the sea ice divergence on the sea ice thickness distribution in the Beaufort Gyre

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The impact of the sea ice divergence and maximum sea ice shear on the sea ice thickness distribution are analyzed based on observations. The data includes ULS observations from moorings in the central Beaufort Gyre (2007-2021) (https://www2.whoi.edu/site/beaufortgyre/data), high resolution (10km) sea ice velocity and deformation rates (2017-2021) derived from sequential SAR images (https://resources.marine.copernicus.eu/product-detail/SEAICE_GLO_SEAICE_L4_NRT_OBSERVATIONS_011_006), and coarser (25km) resolution velocity observations (https://nsidc.org/data/nsidc-0116/versions/4) (2007-2021). It was found that during the periods of stronger sea ice divergence, the maximum in sea ice thickness distribution shifts approximately 1 m to thinner categories as compared to the periods of strong sea convergence and weak sea ice divergence/convergence. The corresponding shifts in the sea ice probability density functions were obtained both for the high-resolution sea ice velocity data in the period of 2017-2021 (Figure 1a) and for the coarser resolution data obtained during 2007-2021 (Figure 1b). Interestingly, the average sea ice thickness distribution was not as responsive to the sea ice deformation rate, suggesting much stronger impact of the sea ice divergence on sea ice thickness re-distribution function in the multicategory sea ice models (e.g. Thorndike 1974, Hibler, (1980). All estimates were derived for the periods with well-developed sea ice conditions, i.e. when 10-day mean sea ice thickness exceeded 0.3m, sea ice concentration was close to 100% and thin (<0.15m) was excluded from consideration. Results are compared with output from a multi-category sea ice model (CICE6).

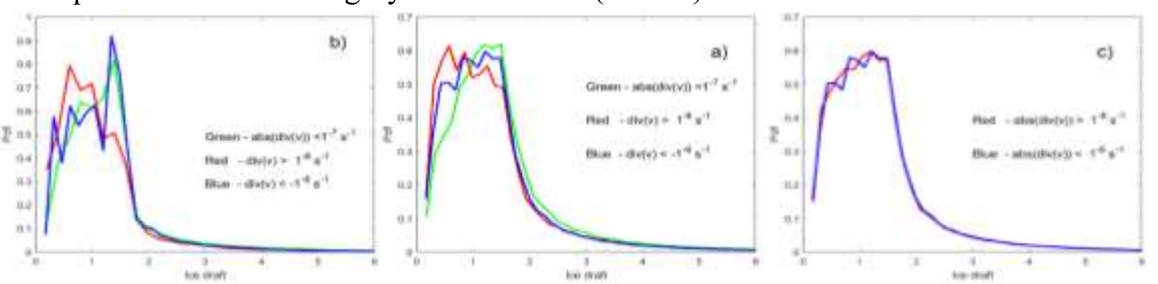

Figure 1. a) Mean (2017-2021) pdf of the sea ice thickness distribution during the periods of positive (red), near zero (green) and negative sea ice divergence derived from sequential SAR images. b) The same as a), but for the divergence derived from coarser resolution velocity observations during in 2007-2021. c) mean pdf of the sea ice thickness distribution during the periods of strong (blue) and weak (green) maximum shear deformation.

References

[1] C.R. Thorndike et al, The thickness Distribution of Sea Ice, *J.Geoph.Res*, (**80**),(1975)
[2] W.Hibler, Modeling a Variable Thickness Sea Ice Cover, *Mon.Whe.Rev* **(108),** (1980)

Best practice: How we reconciled biologists' and physicists' ice coring methodology for the MOSAiC expedition

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Sea ice mediates interactions between the polar ocean and the atmosphere. It is a key component of polar marine ecosystems and the global climate. Physical processes in the sea ice cover regulate the energy exchange and biogeochemical processes within the sea ice matrix. For decades ice coring and core sampling methodologies have varied between different disciplines. Data resulting from various core sectioning schemes are difficult to compare. Building upon long-term sea ice physical observations in Utqiaġvik, AK, we developed a novel approach for the Multidisciplinary drifting Observatory for the Study of Arctic Climate (MOSAiC). This method connects measurements of physical and biological ice core properties. By sectioning with respect to the closest interface (ocean/ice or ice surface), we facilitate comparison from same-depth samples across different ice cores and/or sampling events. Spatial and temporal variability within large ice core collections exposes large discrepancies in ice core lengths even for cores collected during a single coring event. These differences in length measurements are problematic, especially when data profiles from several cores have to be combined to compute another property (e.g., brine volume fraction from salinity, temperature, and density). We developed an analysis framework to aggregate ice core data and reconcile profiles of different lengths based on physical processes and stratigraphy, which account for non-linear profiles. While the primary goal is to generate composite ice profiles for physical properties, the method is also relevant for the study of biological and biogeochemical processes.

Observations of landfast sea ice in Utqiaġvik, AK were made on Iñupiat lands and permitted by the North Slope Borough and the Ukpeaġvik Inupiat Corporation. The field campaigns were supported by UIC Science. UIC Science obtains permission from the Barrow Whaling Captains Association for accessing landfast ice during the whaling season. Research during the MOSAiC expedition was conducted in international waters and supported by a multi-national consortium. Our offices and laboratory are on the traditional lands of the Troth Yeddha' Dena people of the Lower Tanana River.

Biogeochemical Evolution of Sea Ice During the Spring Melt

Laura Whitmore[1*], Marc Oggier[1], Mette Kaufman[1], Kyle Dilliplaine[2], Channing Bolt[3], Hajo Eicken[1], Robert Rember[1], Ana Aguilar-Islas[2]

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Biogeochemical processes in the Arctic Ocean are influenced by interactions with the cryosphere. Sea ice cycling, as it relates to geochemistry, is difficult to constrain because of the inaccessibility of polar regions and the heterogeneous, dynamic nature of sea ice. We aim to describe and quantify changes in nutrient and micronutrient (trace element) distributions during spring melt. This study leverages two time series data sets. The first study sampled landfast sea ice off the coast of Utqiaġvik, AK between late April to mid-June of 2021. Nutrient, oxygen isotopes of water, temperature, and salinity samples were obtained three times per week. Trace element samples were collected one to two times per week. The second study obtained samples from a floe with both first-year and second-year old ice on a weekly basis from October 2019 – Sept 2020 as a part of the Multidisciplinary drifting Observatory for the Study of Arctic Climate (MOSAiC) Campaign. For both campaigns, ice core drilling and sampling procedures followed established international standards developed for and practiced during MOSAiC. Sea ice temperature and salinity profiles had expected distributions throughout the melt. Macronutrient concentrations were high April – May in the bottom 5 cm of the core and declined rapidly when the brine drained; this timing was concomitant with the cessation of macroalgae growth. By combining physical and biogeochemical data, we aim to address knowledge gaps in sea ice biogeochemical cycling and its connectivity to the water column, as well as gaps in current model parameterizations.

We acknowledge the Alaska Native nations upon whose traditional lands our research was conducted. Observations of landfast ice were made in Iñupiat lands and was permitted by the North Slope Borough; the field campaign was conducted with logistical support from the Ukpeaġvik Inupiat Corporation. Our offices and laboratory are on the traditional lands of the Troth Yeddha' Dena people of the Lower Tanana River. Research during the MOSAiC Campaign was conducted in international waters and was supported by a multi-national consortium.

R2-O12

Future Projection of Ice-Algal Production in the Arctic Ocean: Model Intercomparison

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Background

Ice algae (IA) play a fundamental role in the polar biogeochemical cycle. IA not only regulate the carbon cycle, but also act as important food source for zooplankton and benthos in the marginal sea-ice zone. The response of IA community to remarkable Arctic sea ice retreat is of great research interest. Due to limited observational data, regional differences and long-term variation of IA is not understood well. An international project "Ice Algae Moel Intercomparison Project phase 2" (IAMIP2) is ongoing to address these scientific questions and estimate the uncertainties among different models and future climate scenarios.

Method

Historical (1958-2018) and future projection experiments (2015-2100) were conducted by a global sea ice-ocean model (ACCESS-OM2, abbr. AO) and an Arctic Ocean regional model (COCO-Arctic NEMURO, abbr. CN), respectively [1]. The research target region is the entire Arctic Ocean. For atmospheric forcing, JRA55-do [2] and EC-Earth3 output under the share socioeconomic pathway (SSP5-8.5) [3] were used in historical and future projection experiments, respectively.

Results

In this study, we analyzed three phases of the entire experiment period (1958-2100): phase 1 (1979-2018), phase 2 (2021-2060), phase 3 (2061-2100) in four major subregions (Chukchi Sea, Canada Basin, Eurasian Basin, Barents Sea). Two models show similar spatial pattern of ice-algal production (ice-PP), which is high in the Arctic shelf areas and low in the central basins in all phases. The highest ice-PP is simulated in the Chukchi Sea and the lowest ice-PP is simulated in the Barents Sea among four subregions.

AO model presents higher ice-PP than CN model, this difference caused by higher nitrate concentration both in sea ice and ocean surface in AO model. Both AO and CN models show the fastest ice-PP decline in phase 2 that is caused by the rapid decrease in sea ice and ocean nitrate concentration. Sea ice concentration in spring does not show significant decrease during phases 1-3, indicating that the ice-PP decline is not caused by habitat loss. In spite of the different light condition between two models, its impact on ice-PP variation is less significant than nitrate. Therefore, it is suggested that nitrate concentration is the dominant factor for future changes in ice-PP.

As a next step, we plan to analyze and compare experiment results under different climate scenarios (e.g., SSP1-2.6), as well as compare with other IAMIP2 model, to estimate the potential uncertainties in ice-PP future projections and IA impact on the Arctic marine ecosystem and carbon cycle.

Reference:

[1] Hayashida, H., Jin, M., Steiner, N. S., Swart, N. C., Watanabe, E., Fiedler, R., et al., Ice Algae Model Intercomparison Project phase 2 (IAMIP2), Geosci. Model Dev., 14, 6847–6861, 2021a.

[2] Tsujino, H., Urakawa, S., Nakano, H., Small, R. J., Kim, W. M., Yeager, S., et al., JRA-55 based surface dataset for driving ocean–sea-ice models (JRA55-do), Ocean Model, 130, 79–139, 2018.

[3] Hayashida, H.: EC-Earth3 SSP585 atmospheric forcing dataset for the Ice Algae Model Intercomparison Project phase 2 (IAMIP2) projection experiment v1.0, NCI National Research Data Collection [data set], https://doi.org/10.25914/606edd5d96a88, 2021b.

R2-O13

Interannual dynamics of particle transportation in shelf-slope area of the western Arctic Ocean from 2010 to 2021

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In the changing environments of the Arctic Ocean, the dynamics of upper ocean circulation around shelf-slope areas affect lower-trophic marine ecosystems and basin-shelf interaction such as the transportation of materials. To observe the relationships between particle transportation and oceanographic condition, multi-year observation of setting particles have been conducted by the deployment of bottom-tethered moorings with time-series sediment traps in the southern Northwind Abyssal Plain (2010-2014, 2018-2021), northern Hanna Canyon (2015-2017), and north of the Barrow Canyon (2015-2019). The settling particles collected by sediment trap are mainly composed of lithogenic matter with silt grain size in addition to biogenic matter, suggesting an advection of re-suspended particles from the shelf to the Canada basin. The setting particle flux in this study showed maxima in not only the productive summer season but also physical oceanographic events like the passing of oceanic eddies over the mooring position area. In an interannual comparison of obtained results in the southern Northwind Abyssal Plain, total mass flux for 2018-2021 (median: 101.8mg m^{-2} day^{-1} at ~200 m depth) was higher than that for the previous period of 2010-2014 (median: 31.9mg m^{-2} day^{-1}). The settling particle fluxes in the north of the Barrow Canyon also show an increasing trend. There were no large changes in the bulk component of trapped materials, and the lithogenic matter was usually dominant during the studied period. The physical oceanographic-ecosystem model showed an increase in the transportation of resuspended matter with the intensified westward current along the shelf slope of the Chukchi Sea in 2017. The related physical oceanographic observation suggests a southward position shift of oceanic Beaufort Gyre and the intensification of the westward shelf-slope current along the shelf edge of the Chukchi Sea after 2017. In a large sense, the changes in physical oceanographic conditions around the studied area are the possible main causes of the recent increase in the observed settling particle fluxes.

R2-O14

Multidecadal decreasing trend of sea ice production and melt in the Bering Sea revealed by ocean observations

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The Bering Sea plays a crucial role in the Pacific Arctic (Bering Sea, Chukchi Sea, Beaufort Sea) physical and biogeochemical properties. It provides up to 40% of the freshwater flux to the Arctic Ocean, contributes to the stratification of the Pacific Arctic, and is also a primary source of nutrients to this ocean. Contrary to the Chukchi Sea and the Beaufort Sea, the Bering Sea does not contain multi-year sea ice, having only a seasonal sea ice cover between December and June. While both the Chukchi and Beaufort seas have been affected by significant loss of their seasonal and multi-year ice content over the past few decades, no clear trend in sea ice extent, concentration, or production has been detected in the Bering Sea since the beginning of sea ice satellite measurements (1979). In this study, we use historical data of ocean temperature and salinity from 1930 to 2020 to estimate sea ice melt and establish meltwater thickness climatologies spanning the period before (1930-1980) and after (1981-2020) the beginning of satellite measurements. The climatologies and yearly time series of sea ice melt reveal a decreasing trend, with a difference in meltwater thickness of -7.1 cm (-15% of the total meltwater thickness) between the after/before 1980 climatologies. To further confirm this trend, we also produced decadal climatologies of the Bering Sea winter water salinity, which is used as a proxy for sea ice production. These climatologies also revealed a significant salinity decrease (-0.14) between 1940-1960 and 2000-2020. Lastly, vertical profiles of climatological salinity indicate an increase in sea surface salinity and a decrease in subsurface (below 30 m) salinity between before and after 1980. All three variables that we estimated are consistent with one another in indicating a decrease of sea ice production (corresponding to the decrease of winter water and subsurface salinity) and sea ice melt (the increase in surface salinity) in the Bering Sea, whose start occurred before the beginning of the satellite era.

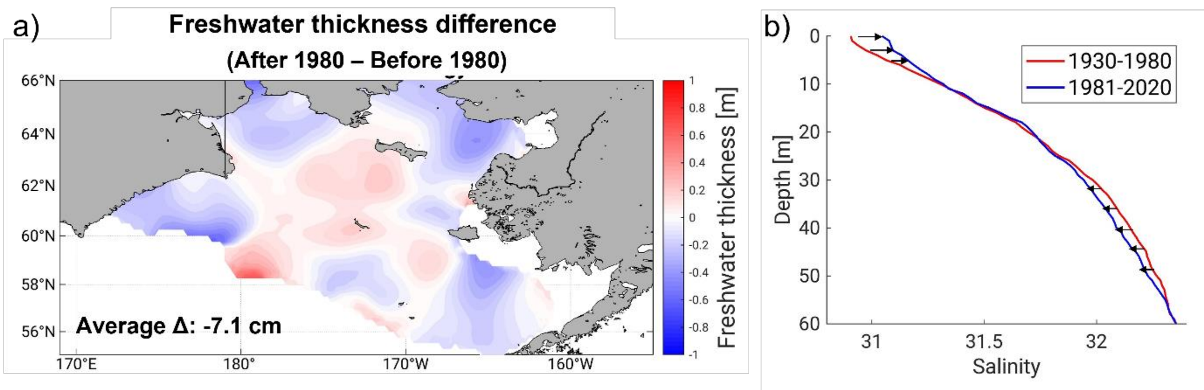

Figure 1. (a) Difference in Meltwater thickness between (1981-2020) and (1930-1980) climatologies, and (b) climatological vertical profile of salinity in the Bering Sea before (red) and after (blue) 1980. The black arrows indicate the increase in surface salinity and the decrease in subsurface salinity.

R2-O15

Development and validation of a sea ice melt estimation method based on T-S analysis in the Pacific Arctic Region

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Over the past few decades, Arctic sea ice has declined significantly, and melting sea ice will affect seawater stratification and the transport of freshwater and nutrients. Until now, sea ice melt has been estimated mostly by satellite observations, but such estimates contain high uncertainties and are limited to the past 20 years. In this study, we use historical ocean temperature and salinity data (Method 2) to estimate sea ice melt in the Pacific Arctic Ocean via a T-S end-member analysis. The test region is set in the Bering Sea. Our results reveal that this method yields melt water thickness spatial distribution similar to that of sea ice thickness from the merged (satellite) SMOS-Cryosat2 product. The average value of sea ice melt (0.47 m) is also consistent with that of the SMOS-Cryosat2 sea ice thickness. This method also yields a good match with the time series of sea ice production. We also compared our results with another successful melt water estimation method based on automatically finding the depth of the melt water layer. We found that both methods yield practically equivalent results in the Bering Sea, and both methods validate each other's results. Due to the intrusion of Pacific Water in other parts of the Pacific Arctic (Chukchi Sea and Beaufort Sea), we suggest the use of our T-S end-member analysis might be adequate in the rest of the Pacific Arctic region.

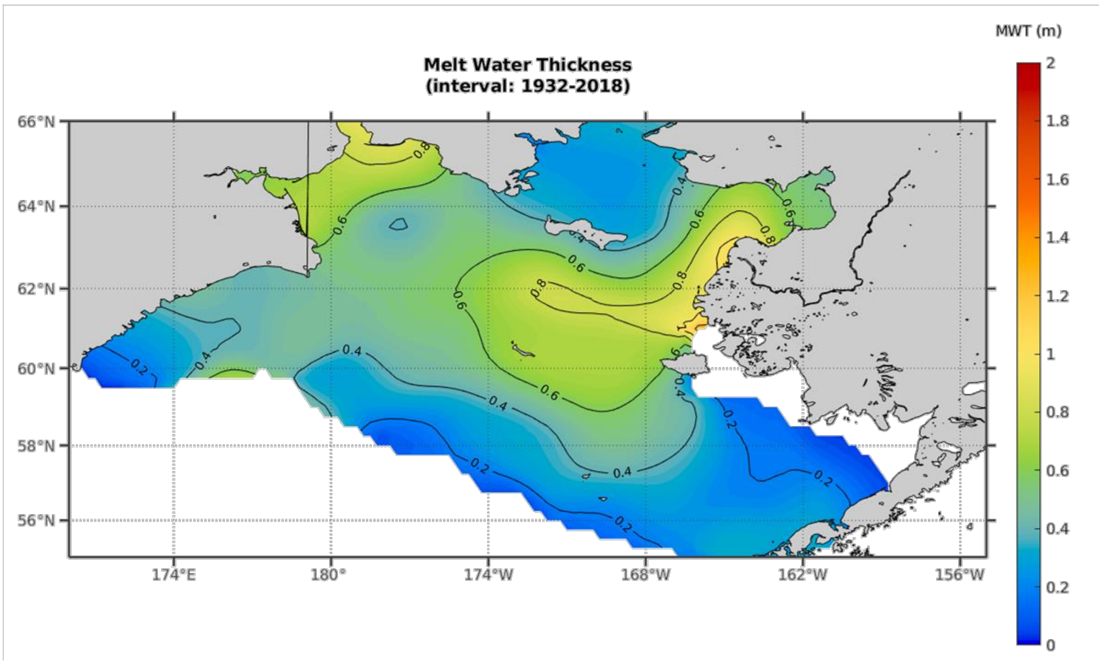

Figure 1. Climatology of fresh water thickness in the Bering Sea, estimated by T-S analysis method.

References

[1] O.I. Mamayev, Temperature - Salinity Analysis of World Ocean Waters, *Elsevier Oceanography Series* **11** (1975)

R2-O16

Enhancement of turbulent mixing by the eddy-wave interaction in the Canada Basin: Results from autonomous observations using ITP-V

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The interaction between eddy and near-inertial internal wave (NIW) near the Beaufort Sea has been reported by Kawaguchi et al. (2016) [1]. In this study, we tried to reveal how often and much eddy-NIW interaction (ENI) enhances the ocean interior mixing using the 3 years long data collected by the five sets of autonomous observing system. Ice-tethered profiler with velocity successfully collected 8820 vertical profiles of temperature, salinity, pressure, and horizontal velocity between 8-250 m depth with 3 h interval freely drifting along the sea ice. In total, 67 eddies were detected during entire observation period of September 2013 to May 2015. Most of the eddies were the deep eddy whose core were in the Pacific Winter Water layer of 100-250 m. Only 11% of eddies were the shallow eddy whose core was at depth range of 50-100 m, where the Pacific Summer Water intrudes. All eddies showed anticyclonic feature of lens-shaped isopycnal with a negative vorticity core that was surrounded by positive vorticity. Among 67 eddies, 33% of it showed NIW amplification. During the eddy encounter, the turbulent mixing by the NIW was enhanced showing the nearly doubled parameterized eddy diffusivity (K). In order to show the typical feature of ENI, we select the representative case of each deep and shallow eddies. The deep eddy case showed the near-inertial current at 2 cm s^{-1} with nearly vertical NIW phase signal indicating the negligible vertical wave energy propagation. By the NIW signal within the eddy, K increased by a few orders higher than the background level, which was comparable to the molecular level. On the other hand, we can find only one case of the shallow eddy case. During shallow eddy encounter, the NIW was amplified at a depth range of 100-200 m where it was 50 m deeper than its bottom. The near-inertial current speed reached to 11 cm s^{-1} by the wave amplification and the most wave energy propagated to a deeper layer. Accordingly, the turbulent mixing also reinforced by the amplified NIW with the K~ $O(10^{-5.5}\ m^2\ s^{-1})$. A spectral analysis revealed that the most NIW energy was concentrated at vertical and horizontal wavelengths at 100 m and 14 km, respectively. Furthermore, the most energetic wave had a frequency at $0.98f$, where f is local inertial frequency. Also, the shallow eddy case showed an asymmetricity in turbulence mixing, where the eastern flank was strengthened. We were able to reveal the asymmetricity was originated from the strong baroclinicity at the rim side of the eddy. However, the baroclinicity could not solve a question that why NIW amplification appears such a deep depth. We speculate the small eddy that has the horizontal and vertical size of 11 km and 40 m cannot contain the larger wave packet. Main part of the present study is published as Son et al. (2022) [2].

References:

[1] Y. Kawaguchi, S. Nishino, J. Inoue, K. Maeno, H. Takeda, K. Oshima, Enhanced diapycnal mixing due to near-inertial internal waves propagating through an anticyclonic eddy in the ice free Chukchi Plteau, *J. Phys. Oceanogr.* **46**, **2457-2481** (2016)
[2] E. Y. Son, Y. Kawaguchi, S. T. Cole, J. M. Toole, H. K. Ha, Assessment of turbulent Mixing associated with eddy-wave coupling based on autonomous observations from the Arctic Canada Basin, *Journal of Geophysical Research,* **127**, **e2022JC018489** (2022)

R2-O17

Sea ice timing feedback in observed freeze-up and melt dates across the Arctic

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Trends towards thinner sea ice are a hallmark of climate change in the Arctic. Whether these trends accelerate in a primarily first-year ice Arctic depends on an annual feedback cycle: shorter ice growth seasons resulting in thinner sea ice, earlier opening/retreat, longer summers, and delayed freeze-up. We analyze correlations between freeze-up and melt dates to evaluate whether this feedback process is evident in the Arctic Sea Ice Seasonal Change and Melt/Freeze Climate Indicators from Satellite Data [1] observations. The summer process shows consistently high correlations across the Arctic, but the winter process is less broadly supported by the data, except in narrow cases that account for modes of climate variability that drive ice drift over the winter. Patterns in the winter correlations are compared to ice drift models to show that there is evidence for a weak over-winter ice timing feedback in the observational data. The timing feedback process plays a general role in overall thinning of Arctic sea ice but between a weak winter feedback and the effects of ice motion, this research suggests that ice “memory" may be short-term and scattered.

References

[1] Steele, M., A. C. Bliss, G. Peng, W. N. Meier, and S. Dickinson. (2019). Arctic Sea Ice Seasonal Change and Melt/Freeze Climate Indicators from Satellite Data, Version 1 [Data Set]. Boulder, Colorado USA. NASA National Snow and Ice Data Center Distributed Active Archive Center. https://doi.org/10.5067/KINANQKEZI4T.

March 9

Breakout Session

R3

Rivers, Lakes, Permafrost and Snow Cover

Landslides and Hydrological Environment of Sedimentary Rock Slope in northwest Greenland

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A lot of recent studies suggest that rapid climate change in the Arctic. Chance of mass-movements is probably increasing by its related phenomena. For example, increase chances of rain events are remarkable effect to destabilize slope condition. Sedimentary rock areas in the Arctic have thick colluvium on slope, and their surface has unique structure formed by periglacial environment. However, the effect of erosion by abundant rain water and/or water flow to the slope has been little known. In Siorapaluk, the northernmost settlement of Greenland, the fjord cliff is covered with such thick colluvium. The colluvium collapsed and slid down by strong rainfalls in summers of 2016 and 2017 (Yamasaki and Watanabe, 2019; Walls et al., 2020). Those landslides are extremely large (the maximum width is 125 m, and two to three meters thick) as colluvium slope failures. To prevent landslide disasters from small settlement in the Arctic, the landslide mechanism should be clarified. The authors investigated the Siorapaluk case in 2018 and 2022. According to our investigation, thick colluvium consists of large angular boulders and sandy fragments, which are weathering products of sedimentary rocks. Sand fills the gap between the boulder, but the strength reduction by saturation could not be main factor of landsliding. Because the sand is relatively low permeability due to poor sorting. On the other hand, the basement rock exposed at the upper slope, the rock generally has numerous and wide-open cracks. Those structural characters of basement are common feature in the area. Probably repeated change of glacier stress and freeze-thaw cycle has made deep cracky zone on the basement of colluvium. At the heavy rain event, rain water penetrates from upper slope to lower part through the cracky zone, and then it enhances pore pressure behind the low permeable colluvium cover, leading to landslide. The source area of landslides tends to distribute on middle parts of slope. Water flow converges at lower parts of slope, but landslides are not likely to occur at lowest part, because the colluvium is too thick to move. Also, the distribution of landslides tends to be controlled by the basement form to receive water flow. For example, some strata on sedimentary rock surface are prominent laterally due to high resistibility against weathering. The source areas sometimes aligned along those strata.

R3-O02

Supraglacial lake evolution on Tracy and Heilprin Glaciers in northwestern Greenland from 2014 to 2021

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Supraglacial lakes form during the melt season as meltwater collects within topographic depressions on the surface of glaciers and ice sheets. They affect the mass balance of glaciers and ice sheets in two ways: (1) enhance ice surface melt by lowing the surface albedo [1], (2) accelerate the ice flow by delivering a large amount of meltwater into the subglacial environment during lake-drainage events and reducing basal friction [2]. Therefore, studying the evolution of supraglacial lakes helps us further understand the effect of meltwater on glaciers and ice sheets. With this background, we analyzed satellite images acquired between 2014 and 2021 to investigate the evolution of lakes on two large marine-terminating glaciers in northwestern Greenland.

To generate a high spatiotemporal resolution record of the lake area over Heilprin and Tracy Glaciers, we applied a machine learning method on two medium-resolution optical satellite datasets (Sentinel-2 and Landsat 8) within Google Earth Engine. Although the basin areas of the two glaciers are similar (654 km^2 and 540 km^2), the maximum lake extent on Heilprin Glacier (22.84 km^2) was approximately three times larger than that on Tracy Glacier (7.60 km^2). The lakes began forming in early June, which was followed by substantial expansion from the middle of June. After reaching a maximum thereafter, the lake area significantly decreased in August. The lake area peaked at different timing every year, depending on meteorological conditions. In 2016, 2019, and 2020, the lake area reached a peak between late June and the beginning of July. In 2017 and 2018, however, the peaks were observed in late July because of relatively cold summer temperature. Regarding to the inter-annual variation, the maximum lake coverage during the study period was observed in 2019 (12.41 km^2 for Heilprin Glacier and 4.05 km^2 for Tracy Glacier), whereas the lake extents were substantially smaller in 2017 and 2018 (Fig. 1). The lake area was small in these two years because lakes were undeveloped in the region above 800 m a.s.l.

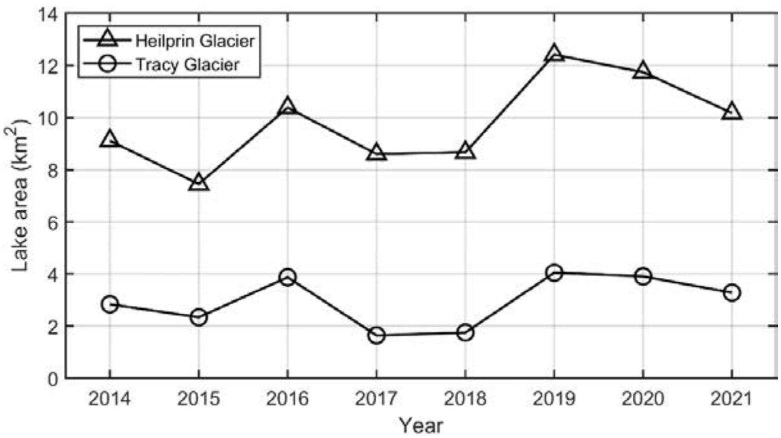

Figure 1. Annual variations of the maximum lake areas on Heilprin and Tracy Glaciers.

References
[1] Tedesco, Marco, et al. *Geophysical Research Letters* 39.2 (2012).
[2] Stevens, Laura A., et al. *Nature* 522.7554 (2015): 73-76.

25 years of high-frequency ground penetrating radar measurements for snow studies in Svalbard

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The warming of the Arctic climate, which is well documented [1], causes progressive and ongoing changes in the cryosphere [2-5]. The seasonal snowpack, which covers ~60 (summer) to 100% (winter) of the land in Svalbard, is very sensitive to the changing climate [6]. Large scale snow thickness and snow structural information are needed across Svalbard are needed to better understand the spatial distribution of snow accumulation and its interannual variability. In addition, such measurements provide a snapshot into spatial patterns of seasonal precipitation that otherwise is barely covered by the operational precipitation gauges. Surveys by ground penetrating radar (GPR) are accurate and cost-efficient, and have been conducted on Svalbard for more than 25 years, thus permitting the assessment of long-term changes. These data complement the single-point snow monitoring measurements and seasonal measurement campaigns on glaciers and tundra. The campaigns so far have focused on particular areas, so the data is sparse. The purpose of presented results from the State of Environmental Science in Svalbard (SESS) Report published by SIOS (Svalbard Integrated Arctic Earth Observing System) was to compile information about the conducted GPR snow cover measurements as well as to define standards for measurements and data sharing.

References
[1] IPCC: The Ocean and Cryosphere in a Changing Climate, https: www.ipcc.ch (2019)
[2] J.E. Box, W.T. Colgan, B. Wouters, D.O. Burgess, S. O'Neel, L.I. Thomson, S. Mernild, Global sea-level contribution from Arctic land ice: 1971 to 2017, *Environ. Res. Lett.* **13** (2019)
[3] W. Van Pelt, V. Pohjola, R. Pettersson, S. Marchenko, J. Kohler, B. Luks, J.O. Hagen, T.V. Schuler, T. Dunse, B. Noël, C. Reijmer, A long-term dataset of climatic mass balance, snow conditions, and runoff in Svalbard (1957-2018), *The Cryosphere* **13** (2019)
[4] T.V. Schuler, J. Kohler, N. Elagina, J.O. Hagen, A. Hodson, J. Jania, A. Kääb, B. Luks, J. Małecki, G. Moholdt, V. Pohjola, I. Sobota, W. Van Pelt, Reconciling Svalbard Glacier Mass Balance, *Front. Earth Sci.* **8** (2020)
[5] M.Błaszczyk, J. Jania, M. Ciepły, M. Grabiec, D. Ignatiuk, L. Kolondra, A. Kruss, B. Luks, M. Moskalik, T. Pastusiak, A. Strzelewicz, W. Walczowski, T. Wawrzyniak, Factors Controlling Terminus Position of Hansbreen, a Tidewater Glacier in Svalbard, *J. Geophys. Res. Earth Surf.* **126** (2021)
[6] J-C. Gallet, M.P. Björkman, C.P. Borstad, A. Hodson, H-W. Jakobi, C. Larose, B. Luks, A. Spolaor, T.V. Schuler, A. Urazgildeeva, C. Zdanowicz, Snow research in Svalbard: current status and knowledge gaps. In: Orr et al. (eds): *SESS report* **2018** (2019)

Bottom-tracking ADCP measurements of river ice floes during collisions with a concrete structure

Takaaki Abe [1*], Hiroshi Yokoyama[2] and Hiroya Ogushi[3]

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In cold snowy regions like Hokkaido, Japan, river ice forms inside river. In spring snowmelt season river ice is broken into pieces and they flow downstream. In estuarine reaches of rivers ice floes are sometimes observed to run-up inside channel. In the Abashiri river, concrete revetments are thought to be deteriorated due to chloride damage, cold temperature, and repeated collision of ice floes with these structures [1]. To establish a reliable design standard for concrete structures against severe winter conditions, there is a need for clarifying the ice floe movements around them inside the river channel. This study performs a detailed field observation of ice floe motions during winter season in the Abashiri river, Hokkaido, Japan. A video camera is installed above the right-hand side of the targeted section located about 3 km from the river mouth. An acoustic Doppler current profiler (ADCP) is installed upward at the riverbed of the section for bottom tracking of ice floes passing through the section. The field survey is conducted 2018-2019 winter season.

The video imagery clearly captured the ice floe motion, e.g., collision with concrete revetment. Figure 1 shows an ice floe motion taken in the early hours of the morning; around 1:30 am at February 5, 2019. The camera image with lens distortion correction is suitable for detecting approaching and escaping velocity of ice during ice floe collision. The floe has 0.23 m/s of approaching velocity with 5 degrees of angle, resulting in the escaping velocity of 0.15 m/s. The thickness of ice floe is estimated using ADCP bottom-tracking data, water level and elevation of the ADCP installation point. Time histories of estimated ice floe thickness is shown in Figure 2. Each four beam irradiated upward from the ADCP is used for thickness estimation. The time-series value of each beam indicates the passing ice floes have thickness values around 0.4 m. The captured collision is occurred between 1:23:44 - 1:23:51. Estimated ice thicknesses averaged in this period are 0.39, 0.44, 0.45 and 0.40 for beams 1, 2, 3 and 4, respectively. Using this procedure, the size of ice floe, variation in momentum of ice floe and its thickness is efficiently obtained. This method can be a reliable tool for ice floe impact force estimation.

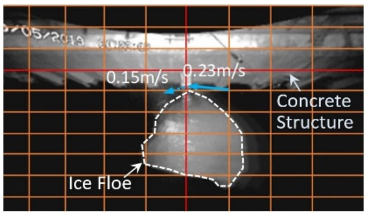

Figure 1. captured coliision of ice floe with concrete structures (Feb.5)

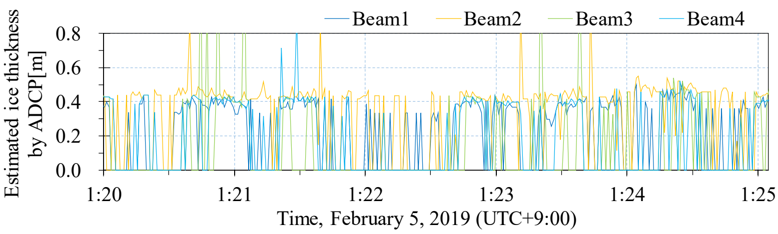

Figure 2. Time histories of estimated ice thickness (m) by ADCP bottom tracking measurement

References

[1] H. Yokoyama, Y. Inami, I. Naitoh, S. Maeda, H.Yabe, Y. Yoshikawa, Observation of colliding force on concrete structure with progress of combined deterioration in river, *Advances in River Engineering*, **29** (2019) (in Japanese with English abstract)

R3-O06

Deep learning-based satellite image classification using the chopped picture method for thermokarst detection

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The polar region is sensitive and vulnerable to climate change, and monitoring of Arctic regions is becoming increasingly important. Permafrost is widely distributed in the Arctic regions; it underlies about 24% of the land surface in the Northern Hemisphere. The warming of the ground can cause permafrost degradation through active layer thickening and the development of thermokarst landforms in ice-rich permafrost regions. Permafrost degradation can release greenhouse gases from decayed carbon and significantly alter the local ecosystem. Thermokarst is an indicator of permafrost degradation; thus, the distribution of these landforms is essential for understanding carbon exchange and ecosystem impacts at regional and global scales. In previous studies, fieldwork mapping and satellite image analysis were conducted to detect thermokarst. However, manual analysis from field surveys and remote sensing images is time-consuming. Therefore, automatic detection using deep learning has begun to be conducted. While deep learning image recognition techniques are beneficial, the thermokarst significantly varies in characteristics, and thus a large number of training images were needed to create region-specific AI models. A recently developed method, the chopped picture method, is suitable for identifying ambiguous and amorphous objects such as the thermokarst. This method is also appropriate for creating region-specific AI models because it efficiently produces the training images. The objective of this study was to evaluate the feasibility of thermokarst identification using this method. If this approach is valuable, region-specific AI models can be created easily and at a low cost. This study uses high-resolution panchromatic and pan-sharpened images to reveal differences in the detection of thermokarst by satellite images. We also changed the chopped size applied to each satellite image to obtain the best parameters to detect thermokarst. In this study, we discuss the potential and future prospects for thermokarst detection using a combination of satellite images and the chopped picture method.

This study was supported by the Arctic Challenge for Sustainability Research Projects II (JPMXD1420318865) funded by the Ministry of Education, Culture, Sports, Science, and Technology of Japan,

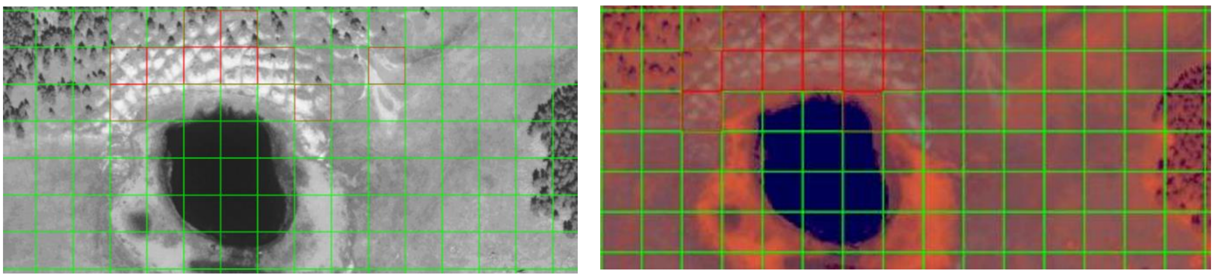

Figure 1. Classification results of thermokarst using chopped picture method from satellite image: (left) panchromatic image and (right) pan-sharpened image. Red squares indicate thermokarst, and green indicates others.

Spatial and temporal change patterns of CO2 and CH4 concentrations in Mongolian permafrost regions

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Greenhouse gases (GHGs) released from permafrost regions may have positive feedback to climate change, but there is much uncertainty about additional warming from the permafrost carbon cycle [1]. One of the main reasons for this uncertainty is that the observation data of large-scale GHG concentrations are sparse, especially for areas with rapid permafrost degradation. We selected study sites in the Altai, Khuvsgul, Khentii mountains in Mongolian permafrost regions. We first analyzed the active layer thickness and ground temperature changes using borehole observations. Based on ground observation data, we assessed the applicability of Greenhouse Gases Observing Satellite (GOSAT) carbon dioxide (CO_2) and methane (CH_4) datasets. The GOSAT Level 4 (L4) data product consists of Level 4A (L4A) surface CO_2 and CH_4 fluxes data, and Level 4B (L4B) three dimensional CO_2 and CH_4 concentrations distributions simulated with L4A surface fluxes. Therefore, we used the L4B data to quantitatively analyze CO_2 and CH_4 concentrations in this study. During the field work, we measured CO_2 concentrations and fluxes at 140 points in Altai, Khangai, Khuvsgul mountains using the Environmental Gas Monitoring-4 (EGM-4) equipment. Furthermore, we used datasets from the fifth-generation European Centre for Medium Range Weather Forecasts (ECMWF) atmospheric reanalysis (ERA5). ERA5 provides hourly data with 0.25° spatial resolution from 1979 to near real time, and is easy to access from Climate Data Store [2]. Finally, we analyzed the temporal and spatial changes in near-surface CO_2 and CH_4 concentrations from 2010 to 2017 and their patterns in different permafrost regions. The results showed that the Mongolian permafrost has been experiencing rapid degradation. The annual average near-surface CO_2 concentration increased gradually between 2.19 ppmv/yr and 2.38 ppmv/yr, whereas the near-surface CH_4 concentration increased significantly from 7.76 ppbv/yr to 8.49 ppbv/yr. There were significant seasonal variations in near-surface CO_2 and CH_4 concentrations for continuous, discontinuous, sporadic, and isolated permafrost zones. The continuous and discontinuous permafrost zones had lower near-surface CO_2 and CH_4 concentrations in summer and autumn, whereas sporadic and isolated permafrost zones had higher near-surface CO_2 and CH_4 concentrations in winter and spring. Our results indicated that climate warming led to rapid permafrost degradation, and carbon-based GHG concentrations also increased rapidly in Mongolia. Although, GHG concentrations increased at rates similar to the global average and many factors can account for their changes, GHG concentration in the permafrost regions merits more attention in the future because the spatiotemporal distribution has indicated a different driving force for regional warming.

References

[1] E. Schuur, A. McGuire, C. Schädel, G. Grosse, J. Harden, D. Hayes, Climate change and the permafrost carbon feedback. *Nature* **520**, 171–179 (2015)
[2] S. Gleixner, T. Demissie, G.T. Diro, Did ERA5 improve temperature and precipitation reanalysis over East Africa? *Atmosphere* **11**, 996 (2020)

Thermokarst development in the Lena-Aldan interfluve, eastern Siberia, observed by satellite remote sensing

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Thermokarst is an irreversible process that changes local landforms with underlying ice-rich permafrost. In the area between the Lena and Aldan rivers in Eastern Siberia, topographic changes due to thermokarst have been remarkably identified, which has significantly impacted on lives of neighbors in relation to the destruction of infrastructure, and changes in the water cycle and ecosystems. Continuous observation for thermokarst has been performed in Yukechi during the last three decades, and the inter-annual ground-surface subsidence and expansion of thermokarst lakes have been revealed [1-2]. However, there had been no comprehensive observations of thermokarst subsidence, which led to uncertainty in assessing permafrost degradation in the entire area. The spatial distribution of thermokarst subsidence could be an essential index to evaluate permafrost degradation in the area.

This study used satellite-based remote sensing data to reveal surface changes due to thermokarst. Interferometric Synthetic Aperture Radar (InSAR) time-series analysis using L-band SAR data by ALOS-2 [3] was applied to reveal inter-annual ground subsidence around some populated areas in the interfluve. Our result shows that 6–25 cm ground subsidence was detected in farming and abandoned arable land in Mayya, Churapcha, Amga, and Tyungyulyu from 2014 to 2021. Polygonal relief was also identified in such areas. High-resolution optical images (WorldView and Pleiades) were utilized to count the number of polygons and calculate their spatial concentration. The concentrations in each area may reflect the size and distribution of underlying ice wedges. Frequency analysis was also performed on panchromatic images to evaluate the degree of polygonal texture development. The amplitude spectrum in the spatial frequency bandwidth corresponding to the size of polygons was greater in images with clearly visible polygons than in those with unclearly visible ones. These statistical features may reflect that as polygons develop, the valleys (troughs) between polygons become deeper, making the shading in the image clearer.

This study was supported by four funds; the Arctic Challenge for Sustainability Research Projects II (JPMXD1420318865) funded by the Ministry of Education, Culture, Sports, Science, and Technology of Japan, the Grant for Joint Research Program of the Japan Arctic Research Network Center (FS04), JSPS KAKENHI (18H03353), Joint Research Program of Earthquake Research Institute, the University of Tokyo (2021-B-03). ALOS-2 SLC data are shared among the PALSAR Interferometry Consortium to Study our Evolving Land Surface (PIXEL) and provided by JAXA under a cooperative research contract with JAXA.

References

[1] A. N. Fedorov, P. P. Gavriliev, P. Y. Konstantinov, T. Hiyama, Y. Iijima, and G. Iwahana, Estimating the water balance of a thermokarst lake in the middle of the Lena River basin, eastern Siberia, *Ecohydrology* **7** (2014)

[2] M. Ulrich, H. Matthes, L. Schirrmeister, J. Schütze, H. Park, Y. Iijima, and A. N. Fedorov, Differences in behavior and distribution of permafrost-related lakes in Central Yakutia and their responses to climatic drivers, *Water Resources Research* **53** (2017)

[3] T. Abe, G. Iwahana, T. Tadono, and Y. Iijima, Ground surface displacement after a forest fire near Mayya, Eastern Siberia, using InSAR: Observation and implication for geophysical modelling, *Earth and Space Science* **9** (2022)

R3-O09

Oxygen-18 Content in Natural Waters of the Upper Kolyma River Basin

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The research presents the characteristic of δ18O and δD content in precipitation and river water in the mountainous region of the upper Kolyma River basin. Precipitation samples were collected over the two-year (2020-2022) period at four meteorological stations spanning 300 km from the Okhotsk Sea shore. River water samples were collected at least once a month in the Anmangynda river and its tributaries. The Anmangynda River has the basin area 376 km^2, it is characterized by giant spring aufeis field reaching maximum area up to 6.6 km^2 and volume up to 11.7 mln m^3 which is formed here. The stable water isotopes content in precipitation varies from -4,39‰/-31,40‰ to -42,50‰/-337,32‰ (dH/18O). It is somehow heavier than that in more continental locations at the same temperature [1]. The heaviest precipitation is brought from the Pacific Ocean and the Okhotsk sea, since the air-mass trajectories in this case are relatively short. However, due to monsoonal circulation and the westerlies, the role of these moisture sources is uneven throughout a year. The rough topography of the region further complicates moisture transport and depletion patterns. The general local meteoric water line has a slope of 7.8 and the intercept of 1.95‰. However, there are significant differences in δ18O/δD and δ18O/T°C ratios between the coastal and in-land stations. The differences are mostly explained by the increased role of local moisture sources (the Okhotsk and Bering seas) at the coast. Interestingly, this role is significantly reduced already at 100-300 km distance from the sea [2]. The average river water isotopic composition corresponds well to that of precipitations. The δ18O content in Anmangynda river water is almost constant. It varies in a narrow range from -22.23‰ to -21.17‰, rising up to -20.85‰ during the floods and dropping down to -24.14‰ at the short freshwater period. However, there is a clear annual cycle with isotopic content getting heavier over the warm period (from June to October) and then gradually lightening from October to May. The Olchan river, the tributary of the Anmangynda River, in turn, is the subject to enhanced annual variability of water isotopic composition (from -19.83‰ to -23.45‰). The amplitude of these variations is a characteristic of watershed regulating capacity. Further analysis may lead the light on the origin, water sources and dynamic under climate change impact of the giant aufeis typical for the study region.
The study is supported by St. Petersburg State University (project id 75295776).

References

[1] N. Kurita, N. Yoshida, G. Inoue, E. Chayanova, Modern isotope climatology of Russia: A first assessment, *J. Geophys. Res. (Atmospheres)*, **109** (2004)
[2] V.A. Khomiakova, A.A. Zemlianskova, A.A. Ekaykin, O.M. Makarieva, N.V. Nesterova, A.A. Ostashov, N.A. Tebenkova, Stable oxygen isotopes in precipitation in Tenkinsky district, Magadan region, *Russian Meteorology and Hydrology* [In print]

Taliks and streamflow generation at the small watershed in continuous permafrost

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Hydrological and hydrogeological processes in continuous permafrost environment are associated with the existence of through and non-through water-bearing taliks. The aim of the study was to evaluate the relationship between suprapermafrost subaerial talik aquifers and streamflow generation on the example of a small watershed of the Shestakovka River in the continuous permafrost zone of Central Yakutia, Russia. Water-bearing taliks up to 20 m thick occupy about 20% of the catchment and are confined to gentle slopes composed of sandy deposits and covered with sparse bearberry pine forests. The groundwater level in taliks has a pronounced seasonal variation with the highest values during the period of maximum freezing from January to March and a decline during the warm season (figure 1). Water balance calculations show that about 70% of the annual runoff is formed by talik groundwater. 80% of the watershed, covered with pine forests without taliks, larch-birch forests and swamps, contribute only 32% of the river flow or 10 mm/year. On the springflood rise, the streamflow is formed mainly by the swamps and larch-birch forests, where snowmelt water flows down the roof of the frozen ground in the organic layer into the river. Hydrochemical and isotope data suggest that taliks groundwater contribute to the river during the summer-autumn low water period.

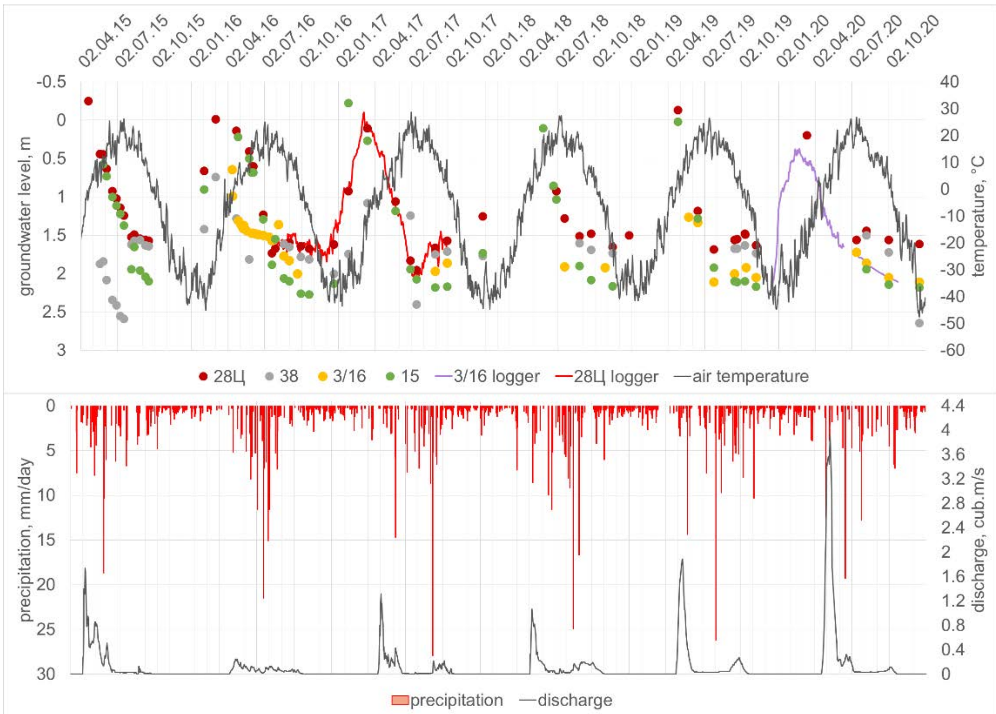

Figure 1. Talik groundwater level at 4 hydrogeological wells, air temperature, precipitation and river discharge at the Shestakovka River watershed. Manual measurements are shown by circles, automated records – by lines.

This study was financially supported by the Russian Science Foundation grant No 22-17-20040 «Subaerial and lake taliks in continuous permafrost in Eastern Siberia: genesis, current state and reaction to climate change».

Betula nana growth rings as indicators of permafrost degradation in subarctic Sweden

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Accelerating Arctic permafrost degradation results in increasing methane emissions significantly affecting not only regional, but also global climate [1]. Moreover, thawing of discontinuous permafrost can have large impacts on hydrology and vegetation composition and coverage. Still, the rate of permafrost degradation can be difficult to estimate with remote sensing, field surveys and modelling. However, using ecological indicators, it may be possible to detect and monitor changes near-surface permafrost degradation [2]. Dwarf birch (Betula nana), a common species in the Swedish subarctic tundra, shrub rings were collected close to Latnjajávri Research station (68°21' N, 18°29' E), and analysed regarding their suitability as permafrost indicators. Previous research show that patchy permafrost existed here in 1993 but was gone in 2001 [3]. Microsections were mounted and annual growth rings measured under a microscope. These were crossdated within sections, followed by between sections within samples and between samples. The resulting shrub-ring chronology which successfully established is one of the most northerly dwarf birch ones used in dendrochronology. July mean temperature ($r=0.74$, $p<0.001$), and to a lesser degree September precipitation ($r=0,52$, $p<0.01$) had the strongest positive associations with radial growth. The shrub-ring data indicated higher growth levels and lower standard deviation after the permafrost degradation, while the opposite was evident before. In addition, recruitment rates seem to have increased after the permafrost degradation started. Our results suggest that dwarf birch can be used to assess permafrost dynamics though time. This field study needs to be replicated to increase certainty of how the species responds to permafrost change at larger spatial scales.

References

[1] J.E. Box et al., Key indicators of Arctic climate change: 1971–2017, 2019 *Environmental Research Letters* **14** (2019)
[2] Y. Yue, H. Liu, J. Xue, Y. Li, W. Guo, Ecological indicators of near-surface permafrost habitat at the southern margin of the boreal forest in China, *Ecological Indicators* **108** (2020)
[3] U. Molau, Long-term impacts of observed and induced climate change on tussock tundra near its southern limit in northern Sweden. *Plant Ecology and Diversity* **3** (2010)

R3-O12

Assessment of the effects of short-term warming on permafrost by meta-omics analysis

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According to the National Snow and Ice Data Center, approximately 24% of the Earth's surface is covering a deep-frozen ground called permafrost or permanently frozen ground. However, due to global warming, it is predicted that 25% of the current permafrost might disappear in the next 100 years [1], emphasizing the urgency to conduct this study.

The goal of this research is to better understand the possible consequences linked to global warming on permafrost. To achieve our goal, we conducted fieldwork experiments in Alaska in October 2022. After extraction of permafrost cores from the Holocene and Pleistocene inside and around the US Army CRREL Fox tunnel, we conducted a short-term warming simulation on these cores. Accelerated global warming was simulated by artificially heating crushed permafrost from -4ºC to 4ºC, with an increase of 4ºC per day. For each condition, we extracted both DNA and RNA. As a control, we also extracted nucleic acid from the active layer around the Fox tunnel, and from the dust accumulating on the inner surface of the tunnel.

In parallel, another goal of this research is to assess the impact of storing permafrost cores at extremely cold temperatures (such as -20ºC or -80ºC), as previous studies have not addressed the issue of optimal storage conditions[2], [3]. Sudden temperature changes, whether it be warming or cooling, is likely to affect the cold-adapted microbial community of permafrost. Therefore, we are also conducting a long-term storage experiment at different temperatures and comparing it to DNA and RNA extracted immediately upon sampling, to gauge the effect of current practices.

After gaining insight on the above, we plan to study the effect of short-term warming and storing conditions on the gene networks expressed by the microbial community in the permafrost.

References

[1] J. Deng, C. Li, S. Frolking, Y. Zhang, K. Bäckstrand, and P. Crill, “Assessing effects of permafrost thaw on C fluxes based on multiyear modeling across a permafrost thaw gradient at Stordalen, Sweden,” *Biogeosciences*, vol. 11, no. 17, pp. 4753–4770, Sep. 2014, doi: 10.5194/bg-11-4753-2014.

[2] M. J. L. Coolen and W. D. Orsi, “The transcriptional response of microbial communities in thawing Alaskan permafrost soils,” *Front. Microbiol.*, vol. 6, 2015, doi: 10.3389/fmicb.2015.00197.

[3] J. Hultman *et al.*, “Multi-omics of permafrost, active layer and thermokarst bog soil microbiomes,” *Nature*, vol. 521, no. 7551, Art. no. 7551, May 2015, doi: 10.1038/nature14238.

A mobile Suitcase Lab for onsite genome-wide analysis of DNA and RNA in remote locations

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Fieldwork is easily affected by limitations in transportation and travel restrictions, and the international export of samples containing live organisms such as soil and plants requires months of tedious paperwork. This makes transient reactions, such as stress responses, challenging to study in real time. Traditionally, these types of study are only feasible when the sampling site is within close proximity of a laboratory, and in practice, data shows that even for the study of stable targets such as DNA, samples tend to be collected in close proximity to research facilities [1].

This is the result of current technology having been developed on the premise that power consumption, weight, and bulkiness of research equipment are generally not an issue. If we rethink protocols, methods, and equipment with the assumption that everything should be done in the field, different methods would have arisen to meet associated requirements. To demonstrate feasibility, we developed a molecular biology "Suitcase Lab" that is able to process up to 24 DNA and RNA samples a day in the field, therefore enabling the study of stress responses directly in the original, natural habitat. Furthermore, our Suitcase Lab is sufficiently light to be sent over as a kit by international air mail, and is compatible with all safety regulations for airplanes, even as a checked-in luggage. This was confirmed multiple times so far, including a remote fieldwork in the Mongolian Gobi in 2020. We also confirmed that when RNA is converted to a cDNA library for next-generation sequencing, the library is stable at room temperature three weeks. This is useful in remote areas with no immediate access to a laboratory, and expected to expand the range of possible studies.

Finally, the needs of each study can be met by expanding the "Suitcase Lab" concept to a "Backpack Lab", "Home Lab", "Car Lab", "Drone Lab", "Crawler Lab" and so on. We would like to continue developing solutions for remote specialized molecular fieldwork in collaboration with local fieldwork experts, by providing the means for smoother international collaborations.

References

[1] Guerra, C.A., Heintz-Buschart, A., Sikorski, J. et al. Blind spots in global soil biodiversity and ecosystem function research. Nat Commun 11, 3870 (2020). https://doi.org/10.1038/s41467-020-17688-2

New Data on Ground Temperature in the Upper Kolyma Basin

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Upper Kolyma basin is the mountainous, permafrost, hard-to-reach and poorly gauged region. The information about ground temperature and the transformation of permafrost due to climate change impact is practically absent. For year-round monitoring of the permafrost in the upper Kolyma basin nine thermometric wells up to 15 m deep were drilled and equipped in 2021-2022. The wells are located at altitudes from 618 to 1182 m in characteristic mountain landscapes such as rocky talus, mountainous tundra and sparse larch-forest (Figure 1a). One of the wells is located in the talik zone, another well characterizes thermal regime of a giant spring aufeis glade. Continuous 4-hour monitoring of soil temperature at various depths is carried out. Data were obtained on the average annual temperature of ground, the depth of seasonal thawing/freezing, the amplitude of temperatures on the surface of ground, as well as the depth of zero annual amplitudes. Preliminary analysis of the data shows that within the same region, geocryological conditions differ significantly. The depth of seasonal thawing varies from 0.9 to 2.6 m; the temperature at the depth of zero annual amplitudes varies from -0.1 to -3.8°C (Figure 1b). Based on the data obtained, it can be concluded that the optimal depth for thermometric wells in this area is about 15 m, since it allows reliable assessment of the depth of zero annual amplitudes. The results of data analysis will be presented. Further monitoring and development of the network will make it possible to trace the dynamics, identify trends in temperature regime changes, and also make it possible to predict changes in the permafrost zone of the study area. The study is supported by St. Petersburg State University (project id 75295776).

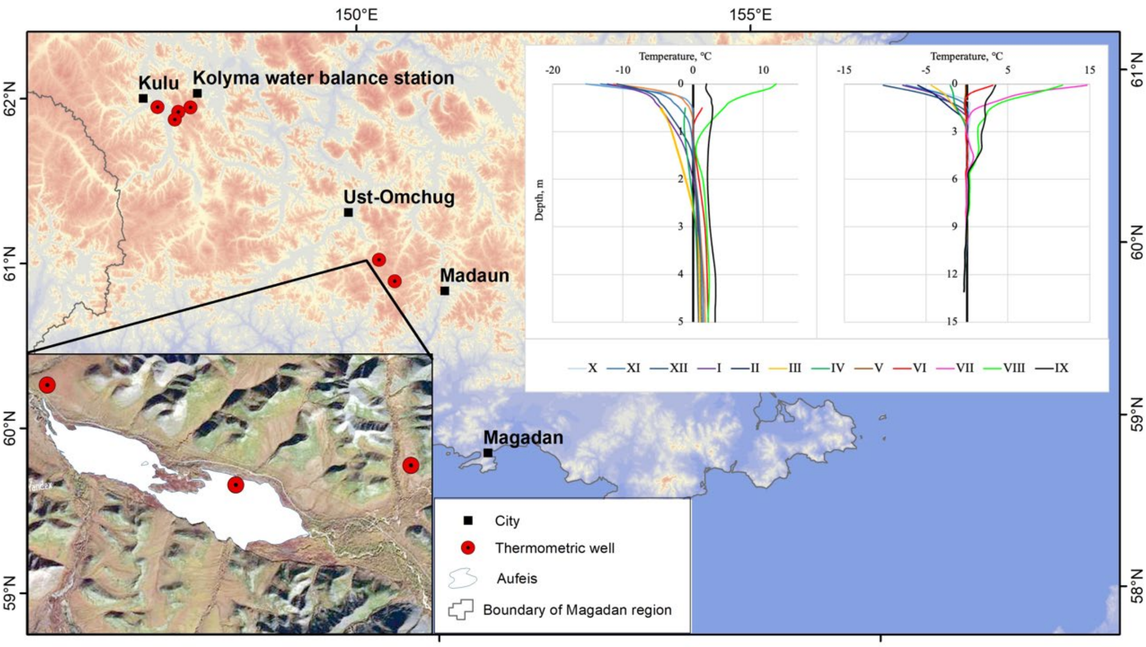

Figure 1. The distribution of monitoring wells with the examples of ground temperature distribution in 2021-2022.

R3-O15

Modelling of Heat Transfer Processes in Subaerial Taliks of Central Yakutia, Russia

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In recent decades, the Arctic has seen a trend towards gradual degradation of permafrost caused by climate change. This has a negative impact on the ground thermal state, and leads to very detrimental consequences, especially for Yakutia, Russia. Taliks are the most sensitive indicators of thermal processes in the permafrost. Therefore, their study can reveal the expected permafrost behavior in future. This scientific work is devoted to the description of the mathematical model and the first results of modelling thermal processes in Yakutian taliks.

The model is based on solving the multiphase Stefan problem. The model is assumed to be three-dimensional, but this research discusses the most common solution for one-dimensional space. Generally, the subaerial talik Ω_M (fig. 1) can be both water-saturated and unsaturated, but anyway it is located above the permafrost Ω_P and below the seasonally frozen Ω_F or thawed Ω_M soil. The talik and the thawed soil are marked with the same labels, since they are the same area and there are no physical boundaries between them, because the talik is just a thawed medium throughout the year. The talik's roof is depicted by hatching area in fig. 1. If the talik is water-saturated, the water inside it moves through the pore space at a velocity of $\mathbf{v}_{WT}$. In the upper part of Ω_M (fig. 1), rainwater is filtered at a velocity of $\mathbf{v}_{WM}$. During the cold period, the frozen soil Ω_F is covered with snow Ω_S, which begins to melt with the onset warm weather. The upper part of the Ω_F starts to melt in summer, which leads to the appearance of the Ω_M zone, which can extend up to the talik. The basis for modelling is the data collected in a field [1].

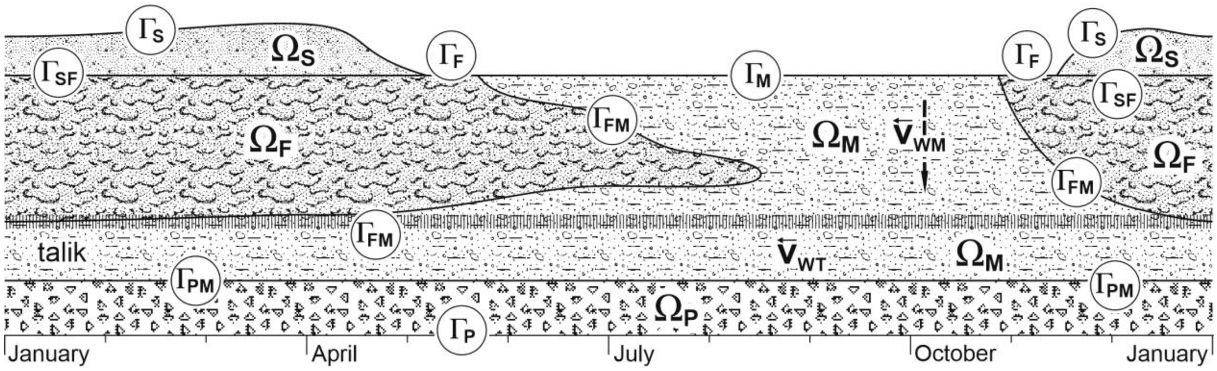

Figure 1. Sketch illustrating the description of the model. See text for explanation.

This study was financially supported by the Russian Science Foundation grant No 22-17-20040 «Subaerial and lake taliks in continuous permafrost in Eastern Siberia: genesis, current state and reaction to climate change».

References

[1] L.S. Lebedeva, K.I. Bazhin, I.I. Khristoforov, et al., Suprapermafrost subaerial taliks, Central Yakutia, Shestakovka river basin, *Kriosfera Zemli. Earth's Cryosphere* XXIII (2019) DOI: 10.21782/EC2541-9994-2019-1(35-44)

March 8

Breakout Session

R4

Ice Sheets, Glaciers and Ice Cores

R4-O02

Accumulation rate at a semiannual accuracy and melting history of an ice core from southeastern Greenland (SE-Dome Ⅱ) dating back to preindustrial

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Recent Arctic warming has accelerated surface melting even in the highland areas of the Greenland ice sheet. Understanding of the relationship between climate and surface melting since the Industrial Revolution is essential for improving the estimates of ice-sheet mass loss due to global warming. To reconstruct the melt events with an ice core, the age scale and accumulation rate are important factors. In this study, we analyzed an ice core (hereafter SE-Dome II ice core) drilled in the southeastern dome of the Greenland ice sheet in 2021[1], which has an exceptionally high accumulation rate. From stratigraphical observations, dielectric profile (DEP), H_2O_2, and tritium concentration, we established a time scale for 1799–2020 at a semiannual accuracy, which was validated by several datable layers, and then compared the annual accumulation rate to the reanalysis data by ERA5 project (1950–2020). The annual accumulation rate from the ice core (1.04 ± 0.20 m w.e. yr^{-1}) shows no significant trend in 220 years, which is consistent with the ERA5 precipitation (0.84 ± 0.16 m yr^{-1}) during 1950–2020. However, on the seasonal basis, significant underestimation of summer precipitation by ERA5 was suggested, despite agreements in other seasons. We consider that the underestimation is due to the less summer precipitation observed in Tasiilaq, which is downscaled to the ERA5 data. We found that the ice layer thickness per year has increased through the 19th –21st centuries. There is a good correlation between ice layer thickness and time-integrated summer temperature anomaly in southeastern Greenland by ERA5 air temperature data (1950–2020). In addition, we found exceptionally thick ice layers in 1889 and 1927, indicating extensive melt events before 1950 without the reanalysis data. The event in 1889 is widely observed in the previous ice core studies [2]. The thick ice layer in 1927 suggests that the summer in 1927 was exceptionally warm in the strongly warming decade [3]. The number of ice layers started to increase since 1845, suggesting that the little ice age ended up in 1845 in this region.

[1] Iizuka et al., 2021: *Bull. Glaciol. Res.,*39, 1–12.
[2] Keegan et al., 2014: *PNAS*, 111(22), 7964–7967.
[3] Chylek et al., 2006: *Geophys. Res. Lett.,* 33, L11707.

R4-O03

MODIS-derived snow/ice physical parameters and their relationships to albedo over the Greenland ice sheet

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The Greenland ice sheet (GrIS) rapidly shrinks, contributing to rising global sea levels. Accelerated surface melting and glacier discharge are the main drivers of mass loss [1]. The former is strongly related to surface albedo reduction, so-called "darkening". The possible causes of the surface darkening are the increase of light-absorbing constituents in snow/ice, snow grain growth in the accumulation area, and expansions of bare ice extent (BIE) and dark ice extent (DIE) in the ablation area [2]. In this study, the monthly mean values of snow grain radius (SGR) are retrieved from the Moderate-resolution Imaging Spectroradiometer (MODIS) data since 2000 with a look-up table method [3] calculated using a non-spherical snow grain shape model [4]. We confirm that MODIS-derived SGR agrees well with in-situ measurements conducted at eight sites over the GrIS. The monthly mean BIE and DIE are retrieved from the same satellite data with a threshold method using the visible and near-infrared bands [5]. We analyzed the interannual variations of those snow/ice physical parameters and the relationships between the snow/ice parameters and the monthly mean surface albedo calculated from MODIS snow product [6]. Here we show the SGR (albedo) over the entire GrIS has the maximum (minimum) in July and had increased (decreased) interannually in April - August ($p<0.01$ for July) until 2012. The interannual trends of both parameters are small for the entire period since 2000 due to their increasing interannual variabilities since 2013. BIE and DIE appeared mostly in the region lower than an elevation of 2 km, mainly in summer (July and August) and had been expanding ($p<0.01$ for July) until 2012, but their interannual trends are not significant for the entire period since 2000. We finally show that surface albedo strongly depends on SGR, BIE, and DIE. Their highest correlation coefficients are June for SGR, July for BIE, and August for DIE.

References

[1] van den Broeke et al., *The Cryosphere*, **10**, 1933-1946, (2016).
[2] Tedesco et al., *The Cryosphere*, 10, 477–496, doi:10.5194/tc-10-477-2016, (2016).
[3] Stamnes et al., *Remote Sens. Environ.,* **111**, 258-273, doi:10.1016/j.rse.2007.03.023 (2007).
[4] Ishimoto et al., *J. Quant. Spectrosc. Radiat. Transf.,* **209**, 113–128, doi:10.1016/j.jqsrt.2018.01.021, (2018).
[5] Shimada et al., *Front. Earth Sci.,* 4:43, doi:10.3389/feart.2016.00043, (2016).
[6] Hall et al., *Remote Sens. Environ.*, **54**, 127–140, doi:10.1016/0034-4257(95)00137-P, (1995).

R4-O04

Study of water circulation by water stable isotope and crystal shape of snow fall in northwestern Greenland

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North Water, located on the northwest coast of Greenland, is a polynya area where sea ice is repeatedly generated and discharged by ocean currents and strong northerly winds, and the ocean surface is locally exposed in winter. The sea ice fluctuations in North Water affect the surrounding water cycle. On the other hand, Baffin Bay, located on the midwest coast of Greenland, has recently been free of sea ice even in winter, providing water vapor that brings precipitation to the coastal areas of Greenland [1]. In this study, we investigated the crystal shapes of snowfall, which depend on air temperature and supersaturation of water vapor during crystal formation and water stable isotope ratios of snowfall, which are controlled by the atmospheric environment in the vapor source and during the transportation from the vapor source in Siorapaluk (77°47’11”N, 71°21’00”W), northwestern Greenland, and determined the influences of water vapor originating from the North Water and the Baffin Bay on snowfall in northwest Greenland.

We conducted snow and meteorological observations from 8 December 2021 to 11 March 2022 in Siorapaluk. Snow samples were collected in clean polyethylene bags using a stainless sampler immediately after snowfall accumulated. The snow samples were melted in ambient temperature and were decantated into polypropylene bottles. The liquid samples were kept frozen during storage in Siorapaluk and transportation to Japan. The water stable isotope ratio of the samples was determined using a wavelength-scanned cavity ring-down spectroscopy (Picarro L2130i). Photographs of snow crystals were taken at the same time as snow sampling. A translucent black plate was placed on a white box containing an LED lantern, and snowfall crystals deposited on the plate were photographed. The camera used for the photography was an OLYMPUS Tough TG-6. 795 snowfall crystals photographed were classified as columnar, plate-like, or other (hail, ice crystals, etc.) based on the snow crystal classification by Kikuchi et al (2021). [2]

$\delta^{18}O$ of snowfall correlated highly with air temperature (Fig.1). In the case of low $\delta^{18}O$, the dominant shape of snow crystal was column type and d-excess was high. Back trajectory analyses indicated the vapor source was North Water. On the other hand, in high $\delta^{18}O$, the dominant shape was plate and d-excess was low, and the vapor source was Baffin Bay.

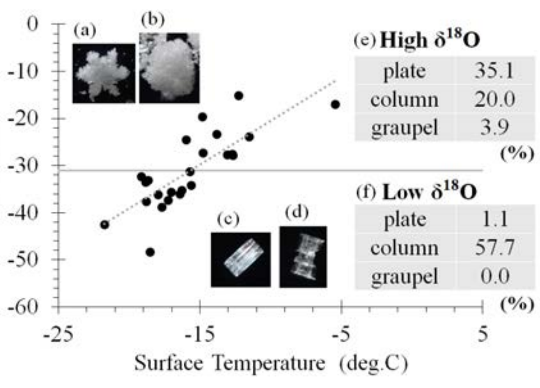

Figure 1. Correlation between air temperature and $\delta^{18}O$ in snowfall

References
[1] Kurosaki et al., 2020: J. Geophys. Res.-Atom., 125, e2019JD03166.
[2] Kikuchi et al., 2021: Seppyo, 74(3), 223-241

Reduced mass loss from the Greenland ice sheet under stratospheric aerosol injection

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Stratospheric aerosol injection (SAI) has been proposed as a potential method of mitigating some of the adverse effects of anthropogenic climate change, including sea-level rise from the ice sheets. In this study, we use the SICOPOLIS (www.sicopolis.net) and Elmer/Ice (elmerice.elmerfem.org) dynamic models driven by changes in surface mass balance, surface temperature and ocean temperature (similar to ISMIP6-Greenland; Goelzer et al., 2020, doi: 10.5194/tc-14-3071-2020) to estimate the sea-level-rise contribution from the Greenland ice sheet under the IPCC RCP4.5, RCP8.5 and GeoMIP G4 (Kravitz et al., 2013, doi: 10.1002/2013JD020569) scenarios. The G4 scenario adds 5 Tg/yr sulfate aerosols to the equatorial lower stratosphere to the IPCC RCP4.5 scenario.

We simulate the mass loss of the Greenland ice sheet for the period 2015–2090 under the three scenarios with four earth system models, using SICOPOLIS with hybrid shallow-ice–shelfy stream dynamics and Elmer/Ice in the Elmer/Ice-sheet set-up with shelfy stream dynamics. For atmosphere-only forcing, the results from the two ice-sheet models are very similar. Relative to the constant-climate control simulations, the losses from 2015 to 2090 are 64 [53, 80] mm SLE for RCP8.5, 46 [38, 53] mm SLE for RCP4.5 and 28 [18, 39] mm SLE for G4 (mean and full range). Thus, the mean mass loss under G4 is about 38% smaller than that under RCP4.5. For both models, the accumulated SMB is larger than the actual ice loss because, as the ice sheet recedes further from the coast, the mass loss due to calving is reduced. Inclusion of oceanic forcing changes this picture such that calving becomes a significant contribution to mass loss in all cases. Therefore, absolute numbers of mass losses increase, while the relative contributions in the order RCP8.5 > RCP4.5 > G4 do not change significantly.

Therefore, our results indicate that SAI can be beneficial for limiting the decay of the Greenland ice sheet. We will put this finding into a wider context and briefly discuss some pros and cons of geoengineering approaches to reduce the effects of climate change.

R4-O06

The Impact of Climate Change on the Transformation of Aufeis in the North-East of Russia

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Aufeis (naled, in Russian) is a specific form of seasonal glaciation that is typical for mountainous permafrost environment. The area of aufeis fields can be measured in tens of square kilometers. The dynamic of the aufeis is closely related to the seasonal and long-term climate change. The goal is to assess the impact of climate change on giant spring aufeis (area from 0.01 to 81.1 km^2), which are formed in the North-East of Russia, using historical and current data. The scientific study used the data of the Cadastre of aufeis at the North-East of the USSR (1958) (including the basins of the Yana, Indigirka, Kolyma, Anadyr and other rivers). The Cadastre (1958) is the first data generalization accounting for aufeis and their morphometric characteristics for the study area. The images taken by the Landsat-8 OLI satellite in late spring from 2013 to 2019 were used to determine the number of aufeis fields and their maximum area in the current climate. It was found that the total amount of aufeis increased compared to the data of 1958 from 4642 to 6217. At the same time, the total area has more than halved – from 7,181 to 3,579 km^2. The maximum changes were observed in the Yana River basin where the number of aufeis increased by 1.5 times (from 388 to 583) and in the Chukchi Peninsula where the area of aufeis decreased by 2.4 times (from 2,417 to 955 km^2). Analysis of the data obtained as a result of ground and remote surveys during 1962–2022 revealed significant changes in the seasonal and long-term cycles of the giant aufeis, the maximum size and the ablation period decreased. The results of remote data assessment were confirmed by the field observations obtained at the Anmangynda aufeis (the Magadan region) in 2020–2022. The maximum area and volume of this aufeis field was recorded as high as 6.6 km^2 and 11.7 million m^3 in 1967. In the current climate, the largest sizes of aufeis reached 5.4 km^2 and 8.2 million m^3 in 2000. On average, the maximum size of the Anmangynda aufeis decreased by 25% and 33% in area and volume, respectively, compared to the period 1962–1991. The results suggest that there is a significant increase in air temperature in the North-East of Russia by an average of +2.2°C for the period 1966–2015. The greatest changes are observed in the pre-winter period. In October and November, the air temperature increased by 3.9°C and 5.9°C, respectively. Precipitation increased significantly in August (on average by 45.3 mm, +66%) and a decreased in winter. The pre-winter period is associated with the freezing of the earth's surface, the beginning of aufeis formation. Therefore, the milder the air temperature in October and November, the less the earth's surface will cool, the more water will pass beyond the aufeis valley. The less water will go to the formation of aufeis. The dynamic of morphometric characteristics of aufeis under pressure of climate change can reveal the dynamics of other processes and their transformation, such as permafrost, groundwater. In remote regions, they may serve as an indicator of changes in the cryosphere.

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R4-O07

New Arctic Straits and Islands Appeared due to Glacial Recession from the 1960s to 2021

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Contemporary climate warming led to a progressive recession of glaciers after the Little Ice Age. Since the 1960s, the recession of tidewater glaciers became enough big to result in appearing new straits and islands in some glaciated Arctic coasts. This appearance was first described by Ziaja and Ostafin [1, 2] who compared their own survey with studies on changes of ice coasts published earlier by Pelto and Sharov, and with brief internet notes. The origin and distribution of newest Arctic islands and straits was described by Ziaja and Haska [3]. The formation of new straits and thus islands is determined by the frontal recession of tidewater glaciers that had previously filled these straits' depressions below sea level situated in bedrock and had covered, partly or completely, bedrock elevations situated above sea level, which then became new islands. Of course, such depressions must be open to a marine transgression from at least two sides. The rate of this process was really slow in the 1960s and 1970s, quicker in the 1980s, and accelerated afterwards. To identify newly appeared straits and islands, maps and satellite images of all Arctic coasts were checked, using GIS methods. We also measured the surface area of individual islands and determined their geographic coordinates. Our study focused exclusively on new Arctic islands with an area of at least 0.4 km^2 (40 ha) and ignored smaller islands, which are much more numerous, treating them as islets. The total number of new islands formed in the Arctic due to glacial recession since the 1960s is 44, including 6 of the newest islands appearing since 2018. There is lack of new straits and islands across the American Arctic and there are only two new islands in the Siberian Arctic (in Severnaya Zemlya) which appeared in 2018. The landscape transformation of select Arctic coastal areas into new straits and new islands is continually progressing. The same refers to the size of the biggest new islands. There are numerous new straits and islands in the Arctic at the formation stage and these will continue be form as long as the climate does not cool down. One of these (the Sørkappland peninsula of Spitsbergen, Svalbard) occupies an area of more than 1000 km^2. New islands and especially new straits are subject to intense evolution of new geo- and ecosystems. New straits create the new seaways, some of them may be of a great significance in future.

References

[1] W. Ziaja, K. Ostafin, Origin and location of new Arctic islands and straits due to glacial recession, *Ambio* **48**(1): 25–34 (2019). DOI 10.1007/s13280-018-1041-z

[2] W. Ziaja, K. Ostafin, Morphogenesis of New Straits and Islands Originated in the European Arctic since the 1980s, *Geosciences* **9**, 476, 11 pp. DOI: 10.3390/geosciences9110476

[3] W. Ziaja, W. Haska, The newest Arctic islands and straits: origin and distribution, 1997–2021, *Land Degradation & Development* (submitted in 2022)

Spatiotemporal changes in communities of snow-ice microbes living on Gulkana Glacier, Alaska

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Snow-ice microbes, which adapted to harsh conditions such as low temperature and high dose of UV, inhabit the cryospheric environments. They cause unique phenomena represented by colored snow and ice occurring with blooms of snow and glacier ice algae, and cryoconite holes formed by filamentous cyanobacteria with inorganic matter. These phenomena also darken glacial surface and have a significant effect on the albedo of snow and ice. It is important to understand factors controlling the abundance of all microbes including consumers of algae and cyanobacteria (tardigrades and rotifers) for evaluating the collective influence of biological communities on albedo (biological albedo reduction: BAR). However, most studies have focused only on each taxon (algae, cyanobacteria, fungi or heterotrophic bacteria), and there is a lack of information on whole microbial communities. In this study, we aimed to describe spatiotemporal changes of microbial communities, and discuss the process of their growth and the factors determining their distribution.

The fieldworks were carried out from June to September of 2022 on Gulkana Glacier in the Alaska Range, Alaska. Three different types of samples (snow, bare-ice, cryoconite) were collected spatially at maximum 54 points across the glacier. Microscopic observation and analysis of Chlorophyll *a* concentration, which is a proxy for the total abundance of snow and glacier ice algae, revealed that the algae were most abundant around the snow line and that their maximum occurred in the end of July (1.0×10^3 μg/m^2) and in the middle of August (1.5×10^3 μg/m^2) on the snow and ice surfaces, respectively. Their distribution in the ice area showed a similar spatial pattern throughout the season, higher abundance in the upper right side and lower in the left side. Consumers of algae (tardigrades and rotifers) were found only in the upper parts of the glacier. These results suggest that each microbial species on the glacier have different distribution and that their growth is associated with local characteristics such as microtopography of the glacier surfaces. In this presentation, we will show more data of spatial distribution of chemical composition, total impurities, and concentration of each microbe in all three surface types and discuss the factors of their growth and distribution.

March 6

Breakout Session

R5

Terrestrial Ecosystems

S8

Biogeochemical and hydrological responses to climate and environmental changes in the Arctic

R5-S8-O01

Preliminary result of creating continental-scale, daily water and vegetation maps over Pan-Arctic area using optical and microwave satellite data

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Using various open-free satellite and meteorological data sources, long-term, continental-scale water and vegetation maps over Pan-Arctic area are created. The dataset has daily frequency and 500-m resolution, and over 10-years duration (2003-2017). Through an interdisciplinary research project scheme (Pan-Arctic Water-Carbon Cycles), the created maps will provide fundamental information to water and carbon cycle in the region.

Overall processes of the map creation are shown in Figure 1. First, features sensitive to water and vegetation are extracted from optical (the Moderate Resolution Imaging Spectroradiometer: MODIS) and microwave (Advanced Microwave Scanning Radiometer: AMSR series) satellite data, and pixel-based machine learning (ML) is conducted for each MODIS pixel. Then, water and vegetation indices at MODIS spatial resolution are predicted by the ML, filling observation gaps caused by cloud interruption and any other sensor errors. The basic methodology has been already qualified for water map creation over a limited region (Mizuochi et al., 2021), but we further explored better combinations of the feature values (among 24 explanatory variables) and the regressor (among 25 ML methods) and efficient processing algorithm. On this basis, adopted ML (random forest) predicted normalized difference water and vegetation indices (i.e., NDWI and NDVI) with RMSE = 0.21 and 0.16 in average of four seasons, respectively.

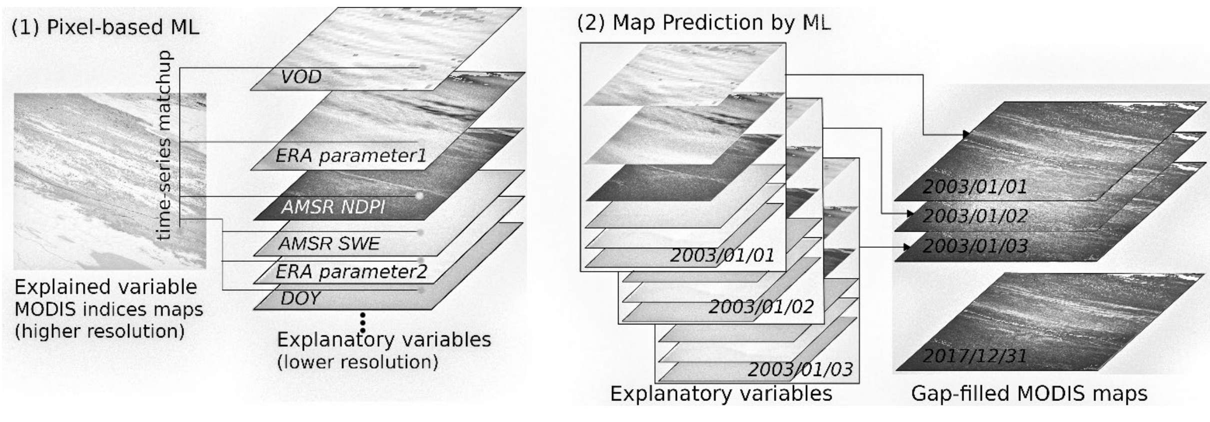

Figure 1. Scheme of (1) learning and (2) prediction of water and vegetation maps based on satellite and meteorological data sources. The example high-resolution maps correspond to MODIS tile h23v02.

References

[1] H. Mizuochi, Y. Iijima, H. Nagano, A. Kotani, T. Hiyama., Dynamic mapping of subarctic surface water by fusion of microwave and optical satellite data using conditional adversarial networks. *Remote Sensing* **12(2)**, 175 (2021)

Inclusion of a Site Specific, Variable Aerodynamic Roughness Length (z_0) in the SNOWPACK Model

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Terrestrial and airborne based LiDAR and other three-dimensional scans of the earth's surface are becoming more readily available. These data are cover a range of resolutions and at varying scales, which can yield different geometric aerodynamic roughness length (z_0). Inclusion of site specific z_0 values into hydrologic and meteorological models as a dynamic, instead of a static parameter, is critical to represent energy processes, and can be observed when simulating the snowpack surface, such as using the SNOWPACK model. Results indicate that as the resolution increased, the z_0 value decreased. When these values were applied to the SNOWPACK model, smaller z_0 values (<0.002 meters) produced smaller sublimation and latent heat fluxes, and larger peak SWE, cumulative snow depths compared to larger (>0.02 meters) z_0 values. Similar patterns were observed when a dynamic z_0 was applied to the SNOWPACK model, although output variables differed when comparing a static versus a dynamic z_0 value (Figure 1).

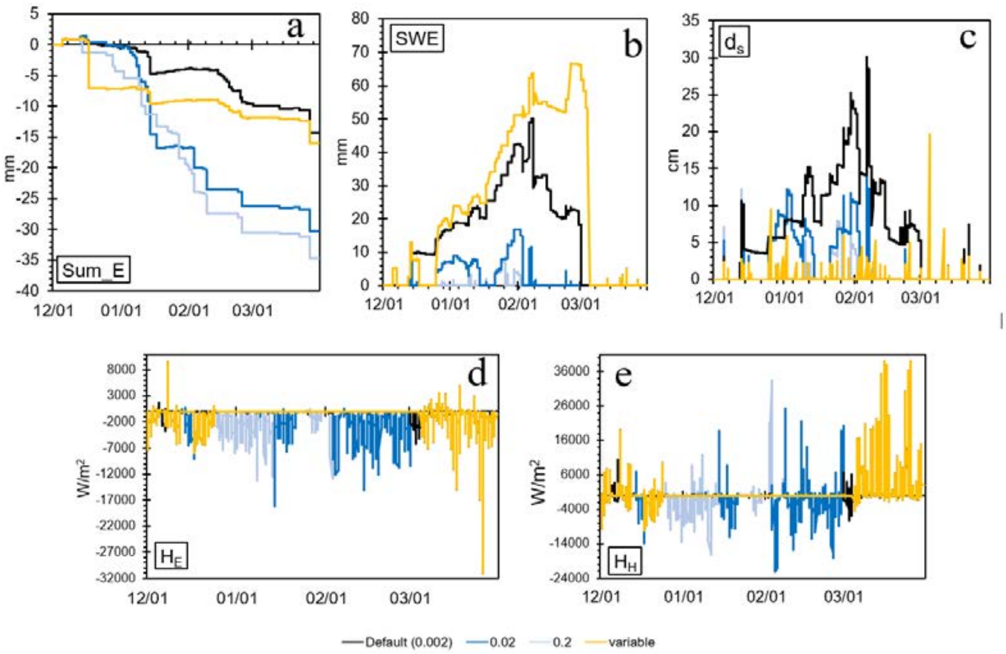

Figure 1. SNOWPACK results from the Trout Farm site using 0.002, 0.02, 0.2 meters, and a dynamic z_0 values from the outputs of a) sum of sublimation, b) SWE, c) snow depth, d) latent heat flux, and e) sensible heat flux.

Long-term degradation of petroleum in Arctic tundra soils

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Petrochemical contamination of soils is a challenging issue, especially for subpolar regions where bio- and chemical degradation rate of pollutants is low [1]. Several compounds are less degradable and, thus, may affect the soil even many years after pollution termination.

In this study, changes of oil fractions composition in upper horizons of contaminated Arctic tundra soils near the Yareiyskoe oilfield (Yamalo-Nenets Autonomous Okrug, Russia) were investigated. Samples were taken from areas near suspended wells. We assumed that the date of suspension could be considered as a date of intensive pollution termination.

An analytical method of extraction and fractionation of petroleum from contaminated soils is proposed. It successfully implements the separation of soil extracts into 3 fractions. F1 (non-polar), and F2 (slightly polar) were analyzed by GC-MS; F3 (polar) – by LC-MS.

Fraction composition shows changes for F1 and F2: relative abundance of easily degradable compounds decreased, whereas substances with rigid structure or oxidized derivatives start to prevail. Alkanes/isoprenoids ratio, which is considered as a petroleum biodegradation proxy, decreased in F1 (fig. 1) [3].

F3 analysis shows similarity of compounds' molecular weights and molecular formulae in samples with different period after pollution. The possible interpretation of these data is that total degradation of maltenes fraction in Arctic tundra soils requires more than 30 years.

We greatly acknowledge As. Prof. Yu. Zavgorodnyaya (Moscow State University) for her invaluable advisory and consultation on the sampling, method development and sampling analysis stages.

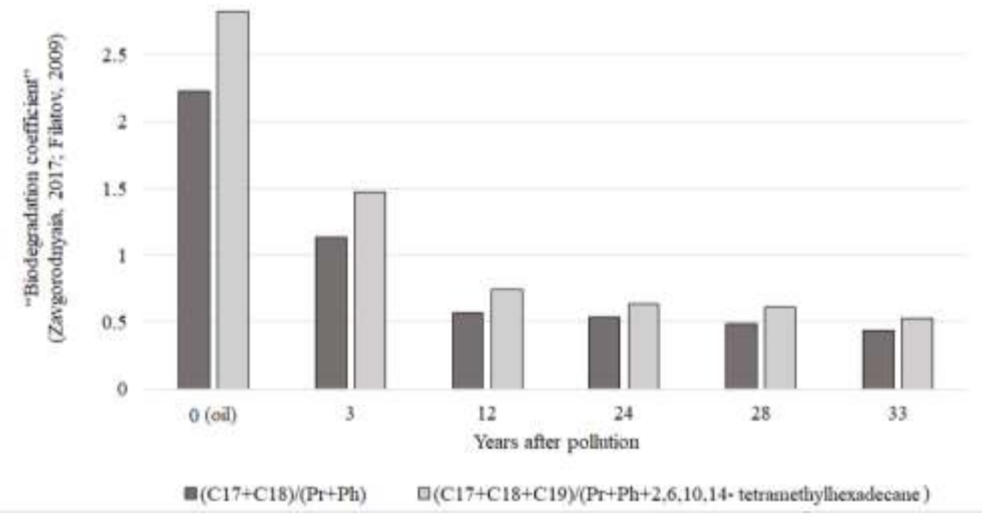

Figure 1. Ratio of linear alkanes and isoprenoids in F1

References

[1] Bento, F.M., Camargo, F.A.O., Okeke, B.C., Frankenberger, W.T., 2005. Comparative bioremediation of soils contaminated with diesel oil by natural attenuation, biostimulation and bioaugmentation. Bioresour. Technol. 96, 1049–1055.

[2] Zavgorodnyaya, Y.A., Stepanov, A.A., Trofimov, S.Y. et al. Effect of introduction of clays, mineral fertilizers, and soil ameliorants on decomposition of organic pollutants in oil-polluted sand under conditions of model experiment. Moscow Univ. Soil Sci. Bull. 72, 35–41 (2017).

Groundwater inputs of mercury to Arctic coastal lagoons

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The transport of mercury via groundwater in the Arctic has been largely ignored due to the presence of permafrost, which limits water flow through seasonally thawed, shallow soil layers. However, as warming temperatures deepen the seasonal thaw of soils, groundwater mercury contributions to the Arctic Ocean may become increasingly important, especially since recent studies indicate that large amounts of mercury are stored in permafrost [1,2]. This study investigated seasonal groundwater discharge into Simpson Lagoon, selected to represent the lagoon-groundwater systems along the Beaufort Sea coast. In August 2021 and June, July, and October 2022, Arctic coastal groundwater was sampled along a salinity gradient, capturing the chemical gradients present within the subterranean estuary of Simpson Lagoon. Differences in redox chemistry and salinity were observed to influence the discharge or retention of chemical species within the shallow supra-permafrost aquifer. We will present seasonal groundwater concentrations of total dissolved mercury and methylmercury, as well as flux estimates calculated by combining radium isotopes with traditional hydrological methods. To the best of our knowledge, these estimates represent the first groundwater discharge estimates of mercury into Arctic coastal waters informed by direct hydrologic and chemical measurements.

References

[1] Obrist, D., Agnan, Y., Jiskra, M., Olson, C. L., Colegrove, D. P., Hueber, J., Helmig, D., Tundra uptake of atmospheric elemental mercury drives Arctic mercury pollution, *Nature,* **547** (2017)
[2] Schuster, P. F., Schaefer, K. M., Aiken, G. R., Antweiler, R. C., Dewild, J. F., Gryziec, J. D., Zhang, T., Permafrost stores a globally significant amount of mercury, *Geophysical Research Letters*, **45** (2018)

R5-S8-O05

Long-term insight into the changes of plant populations in Arctic Alaska over the last 2000 years.

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Peatland ecosystems in the Arctic are important archives for palaeoenvironmental reconstruction owing to their sensitivity to climatic and hydrological change. We carried out palaeoecological studies on eight peat monoliths sampled in various types of peatlands (rich fens, poor fens, string fens) in Arctic Alaska along N-S gradient from the northern slope of Brooks Mts. range to Prudhoe Bay. We applied high-resolution analysis: plant macrofossils, pollen, macro and microcharcoal, testate amoebae, and elemental analysis and stoichiometry, supported by radiocarbon and lead dating to: i) reconstruct local, especially moss population and regional vegetation changes during the late Holocene (mainly the last 2000 years); ii) evaluate the influence of climate change, fire and dust deposition and autogenous succession in the development of arctic plant communities. We address the following hypotheses: i) due to past climate changes, especially noted during the last decades, some of the moss and shrub (e.g. *Betula nana*) populations spread into Arctic areas; ii) minerotrophic plant populations were dominant in the past, in wetland ecosystems; iii) the responses of the herbaceous and moss populations vary between types of peatlands due to local conditions such as geomorphological relief and water level depth. Based on our studies we documented: i) the strongest changes in plant populations after Little Ice Ages, and especially over the last decades; ii) an increased abundance of macrofossils and pollen of shrubs, e.g. Ericaceae, *Betula nana*, *Salix* sp. in peat cores linked to warming stages of climate and this pattern was repeatedly observed; iii) an expansion of *Sphagnum* species and brown mosses (*Tomentypnum nitens, Aulacomnium turgidum, Loeskypnum badium*) that grow in relatively dry habitat over last decades; iv) some of the plant populations composed of *Carex* ssp. and brown mosses (*Scorpidium scorpioides* and *Drepanocladus trifarius*) showed resilience to climate changes over the last 2,000 years.

R5-S8-O06

Winter extreme precipitation event in interior Alaska in December 2021

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A record-breaking precipitation event was observed in interior Alaska in December 2021, with daily maximum precipitation of nearly 100 mm in both Fairbanks and Poker Flat, located farther north in the near Arctic Circle, on December 26. Monthly precipitation in December exceeded 200 mm at both locations, with Poker Flat recording the higher precipitation. The Japan Agency for Marine-Earth Science and Technology (JAMSTEC), in collaboration with the University of Alaska, has set up a tower at the Poker Flat supersite to intensively observe the water and carbon cycles of the boreal forest, and is simultaneously conducting meteorological and subsurface observations. In this study, we will clarify the contribution of rainfall and snowfall to precipitation events exceeding summer precipitation in the Arctic in late December using a snow model, in-situ observation and reanalysis dataset. In addition, the effects of record-breaking precipitation events on the snowpack layer and the water and energy balance were analyzed from the snowpack model. Snowpack model simulations and data analysis revealed that the December precipitation event included significant amounts of rainfall. And the rainfall affected not only the snowpack but also the underlying soil freezing. In the end, we will also discuss how record-breaking precipitation events are related to long-term climate change such as global warming.

Carbon cycle of permafrost transects: representative terrestrial and hydrological ecosystems of Eastern Siberia

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Almost 65% of Siberian forests and 23% of tundra vegetation grow in permafrost zone. According to our estimate, carbon stocks in the soils of forest and tundra ecosystems of Yakutia (Eastern Siberia, Russia) amount to 17 billion tons (125.5 million hectares of forest and 37 million hectares of tundra in total) that is about 25% of total carbon resource in the forest soils of the Russian Federation.

Our observation network SakhaFluxNet in Eastern Siberia has no world analogue and we are ahead of all Russian regions by the number of scientific stations in the North-East of Russia. This applies to the instrumental bases of the stations and the range of parameters studied. At present, SakhaFluxNet research stations are compact mini-scientific institutes researching global climate change at the world level. With almost 20 years of data series, we are on the verge of catching the trends of large-scale changes in permafrost ecosystems, and further continuation of these monitoring studies will make it possible to predict global climate change and solve some issues of human adaptation to today's global challenges.

Long-term experimental data on the carbon of the Arctic tundra and boreal forests of the North-East of Russia will be presented. A number of specific results have been obtained: 1) micrometeorological estimates of the carbon balance have been identified; 2) the quantitative dependence of the concentration of five types of greenhouse gases (CO_2, CH_4, N_2O, SF_6 and H_2) and black carbon on weather conditions and the intensity of forest fires is shown; 3) the carbon parameters of forest, forest-tundra and tundra ecosystems have been studied; 4) attention is drawn to the short vegetation period of plant development. This feature contributes to the enrichment of the atmosphere of northern latitudes with carbon dioxide; 5) a positive dependence of the release of biogenic volatile organic compounds on the area of the assimilating surface and climate warming has been established.

According to our long-term eddy-correlation data, the annual uptake of carbon flux (NEE) in the high productivity larch forest of South eastern Yakutia, 60N – 2.43±0.23 t C ha^{-1} yr^{-1}, in the moderate productivity larch forest of the Central Yakutia, 62N makes 2.12±0.34 t C ha^{-1} yr^{-1} and in the tundra zone, 70N – 0.75±0.14 t C ha^{-1} yr^{-1}.

Interannual variation of carbon fluxes in permafrost forests and tundra in Northeastern Russia (Yakutia) makes 1.7-2.4 and 0.5-0.7 t C ha^{-1} yr^{-1} that results in the upper limit of annual sequestering capacity of 450-617 and 18.5-25.7 Mt C yr^{-1}, respectively.

According our biogeochemical investigation annual flux of carbon from main in Eastern Siberia Lena river basin is almost 6.2 Mt C yr^{-1} including 28% at Aldan and 14% at Viluy rivers.

Due to climate warming, there is a trend towards an increase in carbon sequestration by the tundra as a result of a lengthening of the growing season and changing plant successions, in contrast to a decrease in the forest ecosystem uptakes due to the old age of main of trees species and by unpredictable degradation of permafrost during climate warming and after forest fires and insect disturbances as well.

R5-S8-O08

Permafrost landscapes as cultural landscapes? On the interaction of pastoral and agricultural life-ways in different permafrost regions of North and Inner Asia

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Indigenous and local communities of the Arctic are widely considered as potential victims of climate change and permafrost degradation; however, the complex interaction of pastoral/agricultural livelihoods and permafrost landscapes in North and Inner Asia is not sufficiently understood. Drawing on transdisciplinary studies in the central part of Sakha (Yakutia), the northern Urals, and northern Mongolia, this presentation will explicate the diversity of economic and ecological processes that shape permafrost landscapes. It is relevant to ask: to what degree can we speak of permafrost landscapes as cultural landscapes – and how will permafrost-based livelihoods develop in the future?

The author draws on collaborative research within the IPA Action Groups "Permafrost and Culture" (2014-2019), "Permafrost Agroecosystems" (ongoing) and the EU-funded research project "Drivers and Feedbacks of Changes in Arctic Terrestrial Biodiversity" (2020-2024).

R5-S8-O09

Successional development of soil fungal community on a glacier foreland in The high Arctic

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Temperatures in the Arctic areas have been increasing approximately twice as fast as in temperate regions during the last century. Glacier retreat is accelerating in response to global warming and affecting Arctic ecosystems and the global carbon cycle. Providing a better understanding of how Arctic ecosystems have changed is crucial for predicting the impact of global warming. Although soil fungi play a vital role in regulating multiple ecosystem functions such as nutrient cycles, plant growth and carbon budget, the evidence is still limited for shifts in soil fungal community structure in this region. Our study addressed this knowledge gap by investigating soil fungal communities undergoing primary succession on a well-vegetated glacier foreland on Ellesmere Island in the Canadian high Arctic (Fig. 1a). To assess the fungal succession trajectory, we established two plots near the edge of the glacier and five plots on glacier moraines differing in time after deglaciation along the Arklio Glacier foreland ecosystem (chronosequence approach) (Fig. 1b). In each plot, soil samples were collected, then the fungal ITS1 region was sequenced using DNA metabarcoding. Plant community composition and several potential abiotic drivers (e.g., soil thickness, soil pH, etc.) were also surveyed. Fungal OTU richness showed nonlinear variation during primary succession, with the greatest in the mid-successional stage. *Ascomycota* and *Basidiomycota* were the most abundant fungal phyla, but these two phyla showed different dynamics during primary succession. The richness of the *Basidiomycota* significantly increased along the primary succession, while the *Ascomycota* was stable in the late successional stage. In addition, the significant factors for the structure of soil fungal communities were different at each successional stage. Especially, it was revealed that the soil fungal communities were influenced by the plant communities in the late successional stages. These results imply that changes in vegetation distribution with global warming could change the fungal community structure in the high Arctic area.

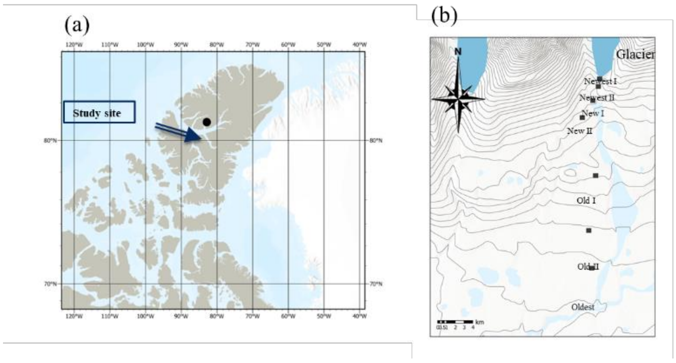

Fig. 1 Site description
(a) The study site of Ellesmere Island, Nunavut, Canada (80°50–52′N, 82°49–51′W)
(b) Location of sampling plots along the Arklio Glacier foreland.

March 9

Breakout Session

R6

Marine Ecosystems

R6-O01

Diatoms Contributing to New Production in Surface Waters of the Northern Bering and Chukchi Seas During Summer with Reference to Water Column Stratification

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Intensive phytoplankton blooms, which mainly consist of diatoms, take place in the northern Bering and Chukchi Seas from spring to summer. Little is known, however, about the diatoms contributing to new production in these waters during summer when the water column is often stratified. In this study, using a ^{13}C, ^{15}N dual isotope tracer technique plus scanning electron microscopy, we assessed the diatom genera or species contributing to new production in surface waters of the northern Bering and Chukchi Seas in July 2013. Relatively high concentrations of nitrate, nitrite, phosphate, and silicate were observed at Bering Strait and Chukchi Shelf stations. In contrast, at the other stations, surface nitrate was generally depleted, but ammonium levels were relatively high (0.05–1.52 μM), suggesting the increased activity of heterotrophic organisms. In surface waters, hourly nitrate uptake rates ranged from 0.03 to 3.73 mg N m^{-3} h^{-1}, whereas the ammonium uptake rates varied between 0.04 and 0.43 mg N m^{-3} h^{-1}. As a result, the mean *f*-ratio was computed as 0.62 ± 0.23 during observation. We found that the nitrate uptake rates were positively correlated with ambient nitrate levels, indicating that the activity was mainly regulated by the physical process of nitrate supply. Small *Chaetoceros socialis/gelidus* cells numerically dominated the surface phytoplankton assemblages in stratified waters, whereas the contribution of *Thalassiosira* to the total abundance declined with an increase in water column stratification. On the other hand, owing to the large cell size of *Thalassiosira*, the contributions of this genus to the total carbon biomass became relatively high in surface waters. Also, the carbon biomass of *Thalassiosira* significantly increased with *f*-ratio, indicating the importance of this diatom genus to new production in surface waters. Implications of these results are relevant for predicting changes over time in export production in the study area, assuming the new production and export production are identical at a steady state condition [1]. Spatiotemporal changes in phytoplankton assemblages contributing to new production may have significant ramifications for biogeochemical processes in the study area and ultimately impact carbon flows to higher trophic organisms, including benthic heterotrophs [2].

References

[1] E.A. Laws, P.G. Falkowski, W.O. Smith, H. Ducklow, J.J. McCarthy, Temperature effects on export production in the open ocean, *Global Biogeochemical Cycles* **14** (2000)

[2] J.M. Grebmeier, B.A. Bluhm, L.W. Cooper, S.L. Danielson, K.R. Arrigo, A.L. Blanchard, J.T. Clarke, R.H. Day, K.E. Frey, R.R. Gradinger, M. Kędra, B. Konar, K.J. Kuletz, S.H. Lee, J.R. Lovvorn, B.L. Norcross, S.R. Okkonen, Ecosystem characteristics and processes facilitating persistent macrobenthic biomass hotspots and associated benthivory in the Pacific Arctic, *Progress in Oceanography* **136** (2015)

R6-O02

Characteristics of autumn diatom communities in the Chukchi Sea unraveled by combined DNA metabarcoding and scanning electron microscope techniques

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The Chukchi Sea displays the highest primary productivity in the Arctic Ocean due to the large diatom blooms occurring from spring to summer. However, there are few taxonomic studies on the autumn microalgal communities, although enhanced productivity was sometimes observed in the season. Diatoms are traditionally investigated using microscopy. Although this technique has the advantage of distinguishing diatom life stages based on their morphological features, the analysis is time-consuming and requires mastery skills to identify diatoms at the genus or species levels. In contrast, the recently emerged DNA metabarcoding (MB) technique allows us to objectively estimate the relative abundance of each algal group based on reliable nucleic acid databases. However, data derived from the two analytical methods have seldom been validated reciprocally in the Arctic. We, therefore, investigated the autumn diatom communities in the Chukchi Sea using scanning electron microscope (SEM) and DNA MB techniques to characterize their community composition with environmental conditions.

Seawater samples were collected from the surface and subsurface layers at 19 stations from October 8–21, 2020, aboard the R/V *Mirai* (JAMSTEC). For the SEM analysis, diatoms were identified and counted with their cell sizes. The abundance of diatoms was also estimated with quantitative PCR [1] and amplicon sequence technologies targeting the V4 region of 18S rRNA gene fragments [2]. Representative sequences were determined following the DADA2 Amplicon Sequence Variant (ASV) pipeline in QIIME2 and annotated using the Protist Ribosomal Reference (PR^2) database (v. 4.14.0) [3]. To evaluate the importance of diatoms in the microalgal communities, chemotaxonomic pigments were also analyzed by ultra-high performance liquid chromatography (UHPLC).

As a result, diatoms were predominant in the microalgal communities, although the phytoplankton abundance was relatively low (0.112–1.06 mg m^{-3} in chlorophyll *a*). The SEM and DNA MB analyses revealed 14 and 21 diatom genera, respectively. The genus *Proboscia* was probably underestimated in the SEM analysis due to its fragile forms. On the other hand, *Chaetoceros* resting spores, which cannot be estimated by the DNA MB technique, were frequently observed with the SEM method. Therefore, we combined the SEM and DNA MB data based on a significant relationship between biovolume and 18S rRNA gene copies in diatoms [4]. Further correlation-based network and cluster analyses using the modified diatom dataset revealed that the *Proboscia* and *Chaetoceros* resting spores were essential in the autumn communities. Comparing the diatom communities with environmental factors indicated that one of the diatom groups was possibly transported from the seafloor.

References [1] Endo, H. et al. (2018). Contrasting biogeography and diversity patterns between diatoms and haptophytes in the central Pacific Ocean. *Sci. Rep.* 8, 10916. [2] Piredda, R. et al. (2017). Diversity and temporal patterns of planktonic protist assemblages at a Mediterranean Long Term Ecological Research site. *FEMS Microbiol. Ecol.* 93, fiw200. [3] Guillou, L. et al. (2013). The Protist Ribosomal Reference database (PR^2): a catalog of unicellular eukaryote Small Sub-Unit rRNA sequences with curated taxonomy. *Nucleic Acids Res.* 41, D597–D604. [4] Godhe, A. et al. (2008). Quantification of Diatom and Dinoflagellate Biomasses in Coastal Marine Seawater Samples by Real-Time PCR. *Appl. Environ. Microbiol.* 74, 7174–7182.

R6-O03

Long-term changes in Arctic Zooplankton communities

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One of the challenges in understand changes in the biological communities of the Arctic it's the limited number of times-series within it given its overall scale and the uniqueness of many regions within the Arctic. Here we examine time-series of the zooplankton communities from sites scattered throughout the Arctic originating from Canada, Greenland, Iceland, Norway, Russia, and the United States. All show changes in community structure, including the phenology of its components, although the magnitude of change varies by location. We illustrate how these are related to changes in sea-ice cover, water temperatures and water masses. We suggest what the future of these ecosystem may look like based on climate projection.

R6-O04

Distribution of Polar cod, *Boreogadus saida*, in the Chukchi Sea inferred from environmental DNA analysis

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Polar cod, *Boreogadus saida*, is regarded as a key species in the Arctic ecosystem due to its circumpolar distribution, abundance, and importance as a prey linking primary producers and higher consumers [1]. Because the ecology of polar cod is closely associated with sea ice, rapid reductions in sea ice have the potential to significantly impact their distribution, survival, reproduction, and biomass [2]. Tracking the distributional shift of polar cod would thus provide critical information about how recent sea ice reduction would affect Arctic fishes and, ultimately, the food web structure and resilience of the Arctic ecosystem.

This study aimed to overview a distribution of polar cod in the Chukchi Sea based on environmental DNA analysis. eDNA, which refers to genetic materials extracted from bulk environmental samples, is a new tool for estimating the presence and abundance of organisms. eDNA samples were collected from surface seawater during the R/V Mirai (JAMSTEC) Arctic cruise, held from September to November 2020. eDNA shed from polar cod was detected and quantified using real-time PCR with newly designed species-specific primers and probe.

Polar cod eDNA was detected primarily in the central part of the Chukchi Sea shelf and in the northernmost observation line, located along the shelf slope and near the sea-ice-covered area (Figure 1). In contrast, very little eDNA was detected in the Bering Sea. The positive sites had distinct environmental conditions from the negative sites (<5 °C in water temperature and <32 in salinity), suggesting that polar cod prefer cold and low-salinity water. This result was consistent with previous research [e.g., 3]. Therefore, eDNA can be regarded as a reliable tool for replacing or supplementing conventional methods. Continuous eDNA surveys, combined with oceanographic investigation, will improve our understanding of Arctic ecosystem change.

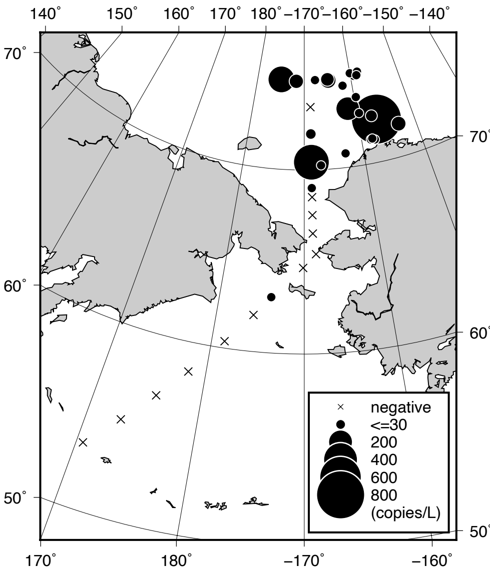

Figure 1. Spatial distribution of polar cod eDNA across the Bering Sea and the Chukchi Sea.

References
[1] Eamer, J. et al. Life Linked to Ice: A guide to sea-ice-associated biodiversity in this time of rapid change. CAFF Assessment Series No. 10. Conservation of Arctic Flora and Fauna. (2013).
[2] Florko, K. R. N. et al. Predicting how climate change threatens the prey base of Arctic marine predators. *Ecol Lett* **24**, 2563–2575 (2021).
[3] Deary, A. L. et al. Seasonal abundance, distribution, and growth of the early life stages of polar cod (*Boreogadus saida*) and saffron cod (*Eleginus gracilis*) in the US Arctic. *Polar Biol* **44**, 2055–2076 (2021).

R6-O05

Balance between human economic activities and the impacts on ecosystem by Atlantic salmon escape into the Pacific Ocean and Pacific salmon invasion of the Atlantic Ocean

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Cooke farmed net pens were destroyed by high tides in Washington State in August of 2017. Farmed Atlantic salmon escaped into Puget Sounds in the Pacific Ocean. Besides, non-native Pink salmon of Pacific salmon whose fries were released by Russia were found in Irish river systems in the Atlantic waters in July of 2017. Bose salmon transported to the different regions from their original habitats. The impacts on ecological disturbance by hybrid creations were concerned by native people and biologists. The destruction of Atlantic salmon cages was caused by insufficient cage cleaning and the invasion of pink salmon was caused by human desire of new fishery resource development. The effects on original ecosystems were concerned by man-made disasters and non-native invasion. Washington State Senate passed a law in February of 2018 banning the farming of Atlantic salmon in the state by 2025 [1]. On the other hand, the Environment Agency of UK was collecting vital data about sighting so officers could monitor the situation to determine any impacts on the local environment and species. Salmon production has been increasing by offshore aquaculture and gigantic farming systems have been constructed. Salmon production needs to supply the global salmon demand. However, it is necessary to keep the balance between human economic activities and sustainability of ecological diversities. Humanity must control farming operation to avoid human error and nature threaten to sustain diversities of ecology, species and genetic.

Figure 1. Atlantic salmon escape [2]

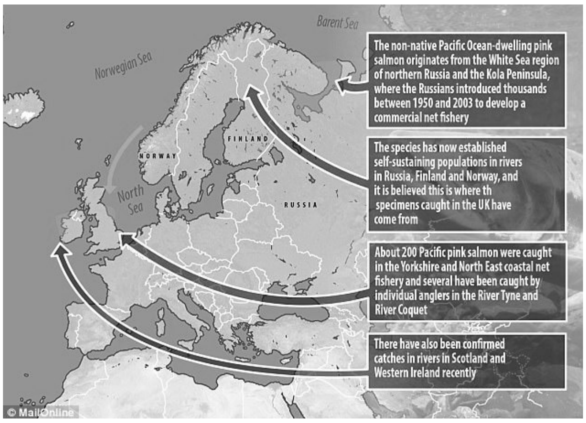

Figure 2. Pink salmon invasion [3]

References

[1] B. Fisher, Washington close to banning Atlantic salmon farming, *Seafoodsource on 21 February* (2018)
[2] L.V. Mapes, Washington state cancels lease for Cooke Aquaculture Atlantic salmon farms near Cypress Island, *The Seattle Times on 5 February* (2018)
[3] Britain's native salmon are under threat from a pink rival that escaped into the sea from Russian farms, *Happy Pettit For MailOnline on 28 August* (2017)

R6-O06

International regulation of fur sealing in the North Pacific : The role of non-state actors in marine living resource management and conservation

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The Northern fur seal (NFS) conservation and management regimes were established by the US, Canada, Russia/USSR and Japan, and existed in 1911–41 and 1957–84. They became the cornerstone of environmental governance in the North Pacific (inclusive of the Bering and Chukchi seas) and a milestone in the development of international law for wildlife conservation and multilateral diplomacy for marine living resource management in general.

So far the NFS regimes have been approached mainly from the state-centric perspective. This paper shifts the focus from the more studied US–Canadian and US–Japan conflict and cooperation in the Northeast Pacific to Japan-Russia interactions in the Northwest Pacific, and from the state-centric / unitary-actor to multi-actor perspective. Applying Putnam's "two-level game" metaphor, it examines the roles played by subnational governments and non-state actors (NSAs; *e. g.* sealing and fishing companies, scientists and environmental activists) in the formation (through agenda-setting, issue-definition and bargaining stages), operation, modification and dismantling of the NFS regimes. The paper outlines and compares SNGs and NSAs' lobbying strategies and channels vis-a-vis their respective central governments, and highlights the instances of multi-actor cooperation.

The study also explores the normative and institutional legacy of the NFS regimes in terms of NSAs' representation and involvement in regional environmental governance (such as the subsequent salmon and walleye pollock regimes in the North Pacific). In conclusion, implications for the future of Japan-Russia cross-border environmental cooperation are discussed, in light of the dramatic impact that Russia's invasion of Ukraine has had on bilateral and multilateral cooperation arrangements in the North Pacific.

References

[1] P.S. Chasek, D.L. Downie, *Global Environmental Politics*. 8th ed. (2021)
[2] P.G. Harris (ed.), *Routledge Handbook of Global Environmental Politics*. 2nd ed. (2022)
[3] V.E. Sokolov et al., *The Northern Fur Seal : Systematics, Morphology, Ecology, Behaviour*. In 2 parts (1998) [In Russian : Соколов В. Е. [и др.] (ред.), *Северный морской котик : Систематика, морфология, экология, поведение*. В 2-х частях. – М. : 1998].
[4] R.D. Putnam, Diplomacy and Domestic Politics : The Logic of Two-Level Games, *International Organization*, 43 (3) (1988), pp. 427–460.
[5] K. Wada, *The Sea Beasts of the North : Sea lions, seals and the fur seals* (2010) [In Japanese : 和田一雄『 北の海獣たち : トド・アザラシ・オットセイと共存する未来へ』 彩流社, 2010.5]

R6-O07

Seasonal movement and habitat use of ringed seals in northwestern Greenland

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Recent global warming accelerates the melting of tidewater glaciers in Greenland and will impact marine ecosystems in the Arctic. The Arctic ringed seals (*Pusa hispida hispida*) are keystone circumpolar Arctic endemic species and are important to the subsistence economy of the Inuit. Information on the interaction between seals and environment is important to predict future ecological changes [1]. To understand the characteristic of habitat selection in ringed seals, four seals (RS2101: adolescent, RS2102: juvenile, RS2103-04: adult) were equipped with CTD-Satellite Relay Data Loggers in Inglefield Bredning, northwestern Greenland. In total, the four seals were tracked for 546 days, sent 6453 positions, 9278 dives and 1756 CTD profiles between August 2021 and April 2022. All seals preferred using shallow and coastal areas. From August to September, all seals stayed inside of the fjord and closer to the front of tidewater glaciers. RS2102 and 03 moved out of the fjord from October to November and remained outside the fjord after December. Diving was generally shallow (52.1 ± 53.7 m, max: 631 m) and short duration (4.1 ± 3.1 min, max: 28.5 min), and some dives in the shallow area (< 200 m) appeared to reach the bottom. CTD profile data showed that seals encountered very low salinity water at 100 m depth between August and November, which suggest that seals dove into subglacial discharge plume areas. Our results show a tight connection between all the seals and tidewater glaciers during summer and fall. Two tags (RS2102 and 03) transmitted into the winter and both swam out into lighter ice conditions in the North Water Polynya. Our results give insight to the habitat use of ringed seals in the inhabited part of the north water area.

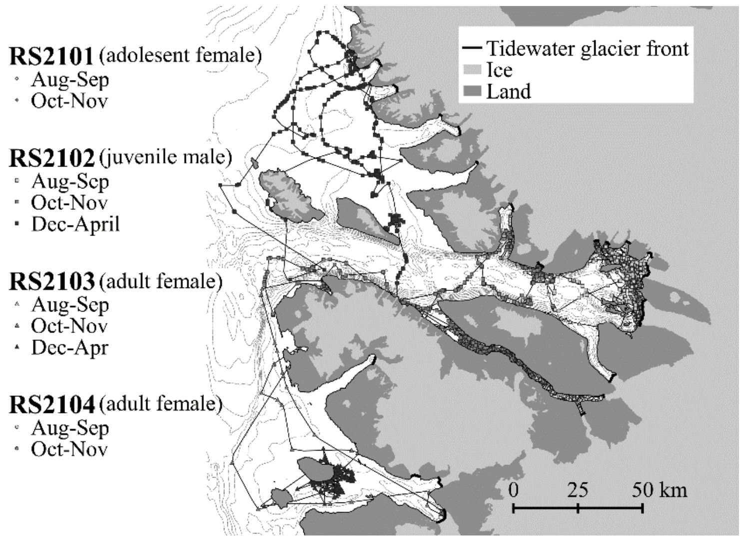

Figure 1. Seasonal movements of four ringed seals

References
[1] C.D. Hamilton et al. Marine mammal hotspots across the circumpolar Arctic, *Diversity and Distributions* (2022)

Diet of seals in northwest Greenland determined by stomach contents analysis

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Northwest Greenland, which has one of the largest polynya in Greenland, is an important feeding ground for pagophilic seals [1]. Within this region, three species of seals can be found: the ringed seal *Pusa hispida*, bearded seal *Erignathus barbatus* and harp seal *Pagophilus groenlandicus*. It is suggested that their feeding ecology has a strong influence on their habitat use [2]. However, there is limited information on their diet in northwest Greenland and the interaction of these three species is unknown. To determine prey selection patterns of the species, we conducted stomach content analyses in Qeqertat and Siorapaluk, northwest Greenland. In July and August 2022, we sampled 11 ringed seals, 3 bearded seals and 1 harp seal during subsistence harvest. Identifiable prey items such as beaks, otoliths, as well as whole and undigested prey were collected from the stomach contents and counted. The importance of each prey was determined by using the frequency of occurrence (FO_i) as follows: $FO_i\ (\%) = (S_i\ /\ S_t) \times 100$, where S_i represents the number of seals that consumed prey type i, and S_t represents the total number of seals sampled. Our results revealed that fish were the most important prey for all species. At the same time, however, there were differences in the composition of prey species among the species (Table 1). This is the first report of comparing the diet preference of three seal species in this area, and the first study to clarify the diet of bearded seals in Greenland. Although these results provide direct quantification of prey consumption, it takes into account only those consumed during the most recent feeding event. Therefore, we will also conduct a stable isotope analysis to further investigate their long-term feeding ecology.

Table 1. Frequency of occurrence (FO_i) of prey identified from stomachs of three seal species

Species	N	Prey type	FO_i (%)
Ringed seal	11	Fish	85.7 %
		Amphipods	28.6 %
		Mysids	57.1 %
Bearded seal	3	Fish	100.0 %
		Shrimps	33.3 %
		Mollusca	66.6 %
Harp seal	1	Fish	100.0 %

References

[1] I. Stirling, The importance of polynyas, ice bergs, and leads to marine mammals and birds, *Journal of Marine System* **10**:9-21 (1997)

[2] G.W. Thiemann, S.J. Iverson, I. Stirling and M.E. Obbard, Individual patterns of prey selection and dietary specialization on an Arctic marine carnivore, Oikos **120** (2011)

Seabird community response to contrasting levels of subglacial meltwater plume activity in NW Greenland

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Tidewater glaciers discharge subglacial freshwater into fjords, forming turbid water plumes surfacing near the calving fronts. This localized and intermittent hydrographic activity with its associated gradient of water turbidity is one of the key mechanisms spatially structuring functional seabird communities in this environment [1]. The upwelling of food-laden turbid meltwater may indeed provide an important foraging habitat for surface-feeding Arctic seabirds near the glacier front, whereas pursuit-diving feeders tend to forage away from this plume, in higher-visibility waters closer to the fjord mouth. However, when this hydrographic activity is reduced or inexistent (under the influence of climate or glacier dynamics, for example), how the surface-feeding seabirds may access food near the surface is poorly understood, and the existence of other mechanisms structuring the different seabird functional communities is unclear. In this study, we collected boat-based data on the distribution and activity of seabirds concomitant with oceanographic measures along fjords in the Qaanaaq region of NW Greenland during the summer of 2022. The subglacial meltwater plume was weak and few surface-feeding seabirds (i.e., black-legged kittiwakes *Rissa tridactyla*, glaucous gulls *Larus hyperboreus*) were seen foraging near the glaciers. These surface feeders were rather seen foraging only occasionally, notably near icebergs flipping over. Pursuit-diving species such as little auks *Alle alle* and black guillemots *Cepphus grylle* were generally more abundant away from the glaciers, foraging at the fjord mouth; however, they were also unexpectedly observed feeding in large numbers at the glacier front, notably when their breeding colonies were located nearby. Under the current Arctic warming and glaciers' mass loss, which are particularly pronounced in Greenland, weakened levels of subglacial meltwater plume activity may become more frequent. Such reduced activity may in turn threaten the ability of surface-feeding Arctic seabirds to forage at predictable suitable locations during the breeding season, in the future.

Figure 1. Boat-based census of seabirds and concomitant oceanographic measures conducted along fjords near Qaanaaq in NW Greenland

References

[1] Nishizawa, B., Kanna, N., Abe, Y., Ohashi, Y., Sakakibara, D., Asaji, I., Sugiyama, S., Yamaguchi, A., Watanuki, Y. Contrasting assemblages of seabirds in the subglacial meltwater plume and oceanic water of Bowdoin Fjord, northwestern Greenland. *ICES Journal of Marine Science* **77**(2), 711-720 (2020)

Bird-colony dynamics revealed by sound monitoring (Siorapaluk, Greenland)

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Records of animal sounds are important behavioral and ecological indicators. Today, compact, autonomous, and affordable sensors allow prolonged sound collection outdoors and thus can be helpful for various research tasks. One such task, continuous observation of a bird-colony attendance, can be laborious, as it requires noting the presence of marked individuals round-the-clock or to investigate hard-gained biologging data. Notably, the former activity is observer-biased, and the latter is invasive and limited to a few individuals. Here, to examine the overall activity of a Little Auk colony during chick rearing, we collected continuous records of sound near Siorapaluk in Northwest Greenland. Such records are also needed to document the vocalization repertoire of this species, which is underrepresented in acoustic literature. In July and August 2022, an audio recorder (Song Meter sampling at 44.2 kHz) was deployed at two locations for at least three days each time. The first experiment aimed to record background noise away from the colony; the second recorded sounds directly in the colony, during the peak chick-fledging period. Automatic analysis of noise emitted by the colony shows a clear diel pattern, with acoustically intense nights and quiet afternoons, which is consistent with previous reports on the highest Little-Auk attendance at low sun (Fig. 1). In addition, manual inspection of audio data reveals that most Little-Auk vocalizations have a frequency below 10 kHz, whereas wing flaps have a characteristic frequency of ~7 kHz. Our non-invasive approach is cheap, observer-independent, and time efficient; it is potentially interesting to be used long-term.

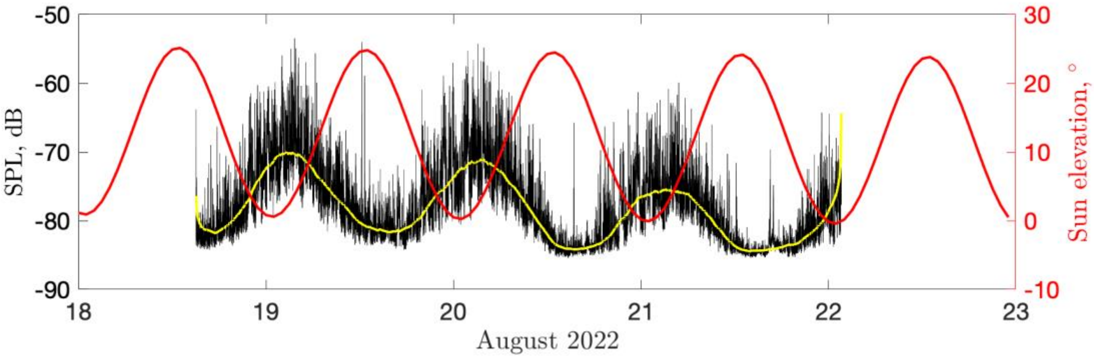

Figure 1. Median Sound Pressure Levels (black) at a Little-Auk colony in Siorapaluk, Greenland compared to sun elevation (red). Yellow color corresponds to SPL time-series median-filtered with a 5-h-long sliding window. (All is in Local Time)

Assessing Vulnerability of the Arctic Marine Ecosystems Under the Multiple Environmental and Anthropogenic Stressors

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Recent changes in the Arctic marine environment, as represented by the drastic decrease of sea ice for example, may increase socio-economic opportunities in natural resource exploitation and northern sea route shipping etc. On the other hand, both the environmental changes themselves and the subsequent human activities have potentials to deteriorate the present marine ecosystems or ecological services, directly or indirectly. Towards a sustainable use of the Arctic region under Anthropocene, ecosystem vulnerability against natural environmental changes and subsequent human activities expected needs to be assessed to evaluate how much stress is still allowed to impose on the Arctic ecosystems without causing irreversible and unmanageable changes of the present ecosystem services. On the other hand, metrics for the assessment of the marine ecosystem vulnerability is not necessarily well-established. Therefore, the objective of this work is to develop the metrics and assess the Arctic marine ecosystem vulnerability using the metrics. Given the fact that human is also a part of the ecosystems, the concept of Planetary Boundaries is introduced in the metrics. The metrics is based on statistical analysis that identifies geographical regions where (1) larger amplitude of environmental forcing, (2) larger response of marine ecosystems to the environmental forcing and (3) smaller adaptive capacity of the ecosystems, are found. Our results show that ecosystems including more coastlines and more ice edges may be more vulnerable than others. Our work is expected to contribute to marine ecosystem management and conservation in the Arctic, including establishment of marine protected areas for example.

(a) natural forcing　　　　(b) anthropogenic forcing

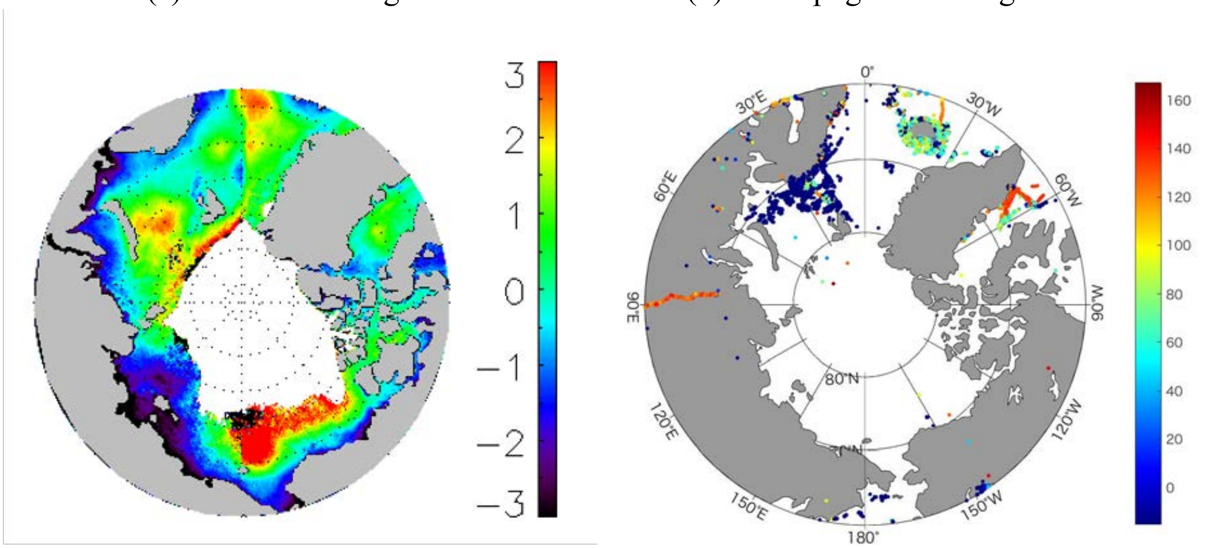

Figure 1. Example of (a) natural and (b) anthropogenic forcings

R6-O12

Activities of the ICES-PICES-PAME working group on Integrated Ecosystem Assessment for the Central Arctic Ocean (WGICA)

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WGICA aims to provide a holistic analysis of the present and future status of the Central Arctic Ocean (CAO) ecosystem and human activities therein. Climate change reduces sea ice, increases light penetration, causes regionally variable trends in stratification and mixing of the water column, increases inflow in both the Atlantic and Pacific sectors, and enlarges heating of waters at the surface and extending deeper. These changes in turn affect primary production and cascade through the foodweb to ice-associated fauna, zooplankton, fish, benthos, seabirds, and marine mammals. They may be exacerbated by increasing human activities in and around the CAO, including increasing pollution from ship traffic and from the transport of contaminants to the ecoregion by rivers and ocean currents. During this past year, WGICA has studied and described human activities in and around the CAO and resulting pressures. In the next three years, WGICA planned to identify ecological, economic, social, and institutional research questions, to enable further stakeholder involvement, and to identify integrated assessment methods that can help evaluate ecosystem conditions and changes. In this presentation we present the main results from the ongoing reporting of the main human activities (global sources, shipping, military and tourism), pressures (contaminants, garbage, noise, etc) and the work on describing the vulnerability of the ecosystem. We will present the plans on how to use this information into a method for Integrated Ecosystem Assessment as used in ICES.

March 6

Breakout Session

R7

Geospace

Abrupt Change in the Lower Thermospheric Mean Meridional Circulation during Sudden Stratospheric Warmings and its Impact on Trace Species

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Our understanding of the vertical coupling between the lower atmosphere and the upper atmosphere has significantly advanced in recent years, spurred by the large amount of new space-borne and ground-based observations and the extension of atmospheric models into the mesosphere and thermosphere. Observational and model studies have revealed that the mesosphere-lower thermosphere (MLT) region is the nexus where the forcings by gravity waves (GWs), atmospheric tides and planetary waves (PWs) contribute to driving the mean meridional circulation (MMC). It is widely recognized that the breaking of GWs propagating from below drives a mesospheric pole-to-pole MMC with ascent at the summer pole and descent at the winter pole. Aloft, in the lower thermosphere (LT), the MMC reverses with ascent in the winter mid-to-high latitudes and descent in the summer high latitudes, accompanied by a winter-to-summer meridional flow.

Based on the hourly output from the 2000–2014 simulations of the National Center for Atmospheric Research's vertically extended version of the Whole Atmosphere Community Climate Model (WACCM-X) in specified dynamics configuration, we examine the roles of planetary waves, gravity waves and atmospheric tides in driving the mean meridional circulation in the lower thermosphere and its response to the sudden stratospheric warming phenomenon with an elevated stratopause in the northern hemisphere. Sandwiched between the two summer-to-winter overturning circulations in the mesosphere and the upper thermosphere, the climatological lower thermosphere mean meridional circulation is a narrow gyre that is characterized by upwelling in the middle winter latitudes, equatorward flow near 120 km, and downwelling in the middle and high summer latitudes.

Following the onset of the sudden stratospheric warmings, this gyre reverses its climatological direction, resulting in a "chimney-like" feature of un-interrupted polar descent from the altitude of 150 km down to the upper mesosphere. This reversal is driven by the westward-propagating planetary waves, which exert a brief but significant westward forcing between 70 and 125 km, exceeding gravity wave and tidal forcings in that altitude range. The attendant polar descent potentially leads to a short-lived enhanced transport of nitric oxide into the mesosphere (with excess in the order of 1. parts per million), while carbon dioxide is decreased.

R7-O02

Progress in high latitude ionospheric specification through diverse data integration

D.R. Themens[1,2*], B. Reid[2,1], P.T. Jayachandran[2], S. Elvidge[1], A.M. McCaffrey[2], J. Bernard[2], N. Rogers[3], F. Honary[3], and J. Ruck[1]

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The Empirical Canadian High Arctic Ionospheric Model (E-CHAIM) is a 3D empirical model of the high latitude electron density designed as an alternative to the use of the International Reference Ionosphere (IRI) at high latitudes. The model was initially developed through Themens et al. [2017, 2018, and 2019] with climatological representations of the F2 peak, topside, and bottomside ionosphere, respectively. The model also includes a storm peak density model to accommodate the high latitude negative ionospheric response to storm-driven changes in thermospheric composition. Since the initial release of the model, auroral electron precipitation was added in v3.1 to account for enhancements in the auroral E-Region [Watson et al., 2021] and a climatological D-Region was added in v3.2 through the integration of the Faraday IRI-2018 [Friedrich and Torkar, 2018]. Here we will discuss the inclusion of solar energetic proton precipitation in the model and compare the resulting electron density enhancements with corresponding increases in riometer absorption and the electron density structures observed through Incoherent Scatter Radar (ISR). We will also conduct a validation of the performance of the auroral electron precipitation module and examine the integration of data assimilation with E-CHAIM via a particle filter approach.

References:

Friedrich, M., C. Pock, and K. Torkar (2018). FIRI-2018, an updated empirical model of the lower ionosphere. *Journal of Geophysical Research: Space Physics*, 123, 6737– 6751. https://doi.org/10.1029/2018JA025437

Themens, D.R., P.T. Jayachandran, A.M. McCaffrey, B. Reid, and R.H. Varney (2019). A bottomside parameterization for the Empirical Canadian High Artic Ionospheric Model (E-CHAIM), *Radio Sci.*, doi: 10.1029/2018RS006748

Themens, D.R., et al. (2018). Topside Electron Density Representations for Middle and High Latitudes: A Topside Parameterization for E-CHAIM based on the NeQuick, *J. Geophys. Res. Space Physics*, 123, doi: 10.1002/2017JA024817

Themens, D.R., P.T. Jayachandran, I. Galkin, and C. Hall (2017). The Empirical Canadian High Arctic Ionospheric Model (E-CHAIM): NmF2 and hmF2, *J. Geophys. Res. Space Physics*, doi: 10.1002/2017JA024398

Watson, C., D.R. Themens, and P.T. Jayachandran (2021), Development and validation of precipitation enhanced densities for E-CHAIM, *Space Weather*, doi:10.1029/2021SW002779

R7-O03

Localised three-dimensional current systems at auroral and sub-auroral latitudes and their potential impacts on the arctic upper atmosphere

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Using data from ground-based magnetometer networks in mostly Scandinavia and Canada, and supporting satellite data – when- and wherever possible - we have studied temporal and spatial characteristics of strong localised intensifications of auroral current systems in the arctic ionosphere and upper atmosphere. We have found that most - if not all - such intensifications are related to the onset of large- or small-scale three-dimensional current-wedges (or wedge-lets), which connect the upper atmosphere with the deeper magnetosphere in the nightside tail regions. Potential agents for the initiation of such current systems are bursty bulk flows (BBFs) or dipolarising flux bundles (DFBs), which obviously stem from the existence of remittent or bursty reconnection in the nightside magnetospheric tail.

Such intensifications are therefore parts of the magnetospheric energy cycle, releasing stored energy from the dayside solar wind /magnetosphere coupling processes and reconnection there. We will discuss the characteristics of such current systems, their impacts on the upper arctic atmosphere and potential risks posed by such current systems to ground-based, air- and space-born human infrastructure in the arctic regions, such as geo-magnetically induced currents (GICs) and ionospheric scintillations

R7-O04

Climatology of HF propagation at very high latitudes

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Propagation of high-frequency (HF, 3-30 MHz) radio waves at very high latitudes is strongly affected by the intrinsically unstable ionospheric conditions caused by energetic particle precipitations and strong electric fields. This makes the conventional propagation forecast at these latitudes rather problematic as it relies on model ionosphere and model propagation mode. While recently there has been a substantial progress in modelling the high-latitude ionosphere using ground data from ionosondes and GPS receivers [1], the simplistic propagation model remained unchanged. To improve this situation, we utilised multi-year high-latitude observations of ionospheric HF backscatter by Super Dual Auroral Radar Network (SuperDARN). Qualitative identification and quantitative characterisation of the propagation modes require an accurate knowledge of the vertical angle of arrival (elevation angle). The accurate calibration of this parameter has become possible only in recent years facilitated by the development of reliable data-based calibration techniques for SuperDARN interferometry [2]. In this talk we present initial results on a solar-cycle/seasonal/diurnal climatology of the HF propagation characteristics at the very high latitudes derived directly from observations by the Canadian SuperDARN radars.

References

[1] D.R. Themens et al, The Empirical Canadian High Arctic Ionospheric Model (E-CHAIM): NmF2 and hmF2, *Journal of Geophysical Research: Space Physics* ***122*** (8), (2017)
[2] G. Chisham et al, Comparison of interferometer calibration techniques for improved SuperDARN elevation angles, *Polar Science* **28** (2021)

R7-O05

SuperDARN Hokkaido Pair of (HOP) radars – studying the ionosphere, thermosphere and upper atmosphere in the Antarctic region

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Super Dual Auroral Radar Network (SuperDARN) is a network of high-frequency radars operated under the international cooperation of about 10 countries. At present, there are a total of more than 35 SuperDARN radars located in both the northern and southern hemispheres, ranging from the polar cap, auroral latitude to the sub-auroral and mid-latitude regions. Among them, the SuperDARN Hokkaido Pair of (HOP) radars, operated by Institute for Space-Earth Environmental Research (ISEE), Nagoya University, are the radars at the lowest geomagnetic latitude among the SuperDARN radars. Using this unique geographic characteristic, we have published a number of scientific achievements (see [1] for details of the accomplishments of the HOP radars, as well as the other, mainly mid-latitude, SuperDARN radars). In this presentation, the past achievements, present status, and the prospect of future studies of the HOP radars, especially in the aspect of the contribution to the study of the Antarctic region, will be presented.

References

[1] Nishitani, N., J.M. Ruohoniemi, M. Lester, et al., Review of the accomplishments of Mid-latitude Super Dual Auroral Radar Network (SuperDARN) HF Radars, Progress in Earth and Planetary Science, https://doi.org/10.1186/s40645-019-0270-5, 6:27, 2019.

R7-O06

Thermospheric Radiative Cooling during Northward Interplanetary Magnetic Fields: A case study

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The southward interplanetary magnetic field (IMF) sustaining longer time in the dayside magnetosphere results in the phenomenon of geomagnetic storm. The northward IMF can also (rarely) create the “anomalous geomagnetic storm”. Both the phenomena transfer huge amount of solar wind energy into the magnetosphere creating strong perturbations in the whole magnetosphere-ionosphere-thermosphere system. This energy is effectively dissipated by different chemical and dynamical processes including the infrared radiative cooling by Nitric Oxide (NO) at 5.3 μm. By combining the SABER observations onboard the TIMED satellite and results from the TIEGCM model simulation, we investigate the response of the NO cooling emission to the anomalous geomagnetic storm event of January 21-22, 2005. The main phase of this storm (minimum Dst = 105 nT) developed during northward IMF Bz condition. A strong discrepancy is noticed between the observations and model simulation results for both the daily and orbital averaged cooling emission. The TIMED/SABER satellite observations exhibit significant enhancement in the NO cooling emission during the storm period and are in-accordance with the observed hemispheric and Joule heating power. On the contrary, the TIEGCM model simulation, although shows a slight increment, it highly underestimates the NO cooling emission. We suggest that the inadequacy of the TIEGCM and the strong discrepancies between the model simulation results and observations could be due to the input parameters used in the model. In this context, we will also discuss the latitudinal differences in the thermospheric cooling between the Arctic and Mid-low latitudes.

Insights into the Dynamics of the Polar Mesopause Region

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The Polar Environment Atmospheric Research Laboratory (PEARL), established in 2005 at Eureka, Nunavut, Canada on Ellesmere Island (80N 85W), provides observations of the polar atmosphere from the ground to the lower thermosphere. Instruments providing observations of the polar mesopause region include an all-sky imager (PEARL All Sky Imager (PASI), irradiance images), a meteor radar (MR, wind), a Spectral Airglow Temperature Imager (SATI, temperature and irradiance) and a field-widened Michelson interferometer (E-Region Wind Interferometer (ERWIN) - wind and irradiance). Thermospheric observations are taken with a Fabry-Perot interferometer (wind, temperature, irradiance: Q. Wu, P.I.) and PASI using oxygen red line observations. Over a decade of observations are now available and provide information on the character of the dynamics near the northern polar upper atmosphere.

In this paper, insights gathered from the observations from three of these instruments (PASI, MR, and ERWIN), on the polar mesopause region are described. Horizontal winds observed with the MR and ERWIN are in good agreement though the meteor wind amplitudes are generally larger. The variability of the wind time series from the two instruments differ implying that there is significant structure in the vertical. Horizontal wind amplitude spectra peak in the 6 – 12 hour period region but this peak is not seen in the vertical and airglow brightness spectra. There is significant intermittency in the horizontal wind. Annual and solar cycle variability of airglow examined. Some solar cycle dependence appears present and there are several significant peaks in the average annual winter sodium airglow. Analysis of individual gravity wave events are discussed. The vertical wind variations and airglow irradiance are generally found to be in quadrature although there are exceptions. There is evidence that waves with periods close to 12 hours are not tides but are inertial gravity waves. These results indicate the complexity of the wave field propagating upward into the polar thermosphere.

R7-O08

Energetics of Arctic Stratospheric and Mesospheric Coupling Due to Small-scale Gravity Waves

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Small-scale gravity waves play a major role in energy transfer throughout the atmosphere and near-space environment, and therefore are essential to include on both weather and climate model studies. However, due to their small structure, they are difficult to implement into these models. Instead, they are often parameterized through an ensemble effect of energy transfer, with the assumption that the energy transported from the source is deposited at the wave breaking level. It is this assumption that is one of the obstacles in the models, as we know from observations that waves are not depositing energy at a single altitude level, but instead deposit energy throughout their propagation as they undergo dispersion. In essence, we currently do not have clear understandings of energy transfer distributions as the waves propagate through the upper atmosphere. The goal of this project through multiple objectives is to help advance our understanding of how energy is transported from the Arctic stratosphere into the upper mesosphere and near-space environment by small atmospheric waves using a suite of instruments situated in Tromsoe, Norway, specifically, the ISEE Na lidar and Na airglow imager. In this presentation, we present the results on the first objective regarding energetics of gravity waves in the MLT region utilizing derived temperature and winds from the Na LiDAR.

R7-O09

AGW-TID detection with EISCAT and meteor radar and application for background neutral wind measurements

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[4]North West Research Associates, Boulder, Colorado, USA
[5]EISCAT Scientific Association, Kiruna, Sweden

Atmospheric gravity waves (AGWs) and their ionospheric component, traveling ionospheric disturbances (TIDs), can be described via dispersion relations. The wave parameters are thereby linked to local density gradient and scale height of the neutral atmosphere as well as the background wind velocity. The relevant wave parameters (wave period, vertical and horizontal wavelength) are difficult to determine since there is no single instrument that sufficiently resolves both vertical and horizontal direction. We show that AGW-TID observations with the EISCAT VHF radar and the co-located Nordic Meteor Radar Cluster [1, 2] can be combined where by all important properties of the wave can be inferred. The EISCAT measurements are used to determine vertical wave properties and the period while the meteor radar cluster are used to determine horizontal wavelength and propagation direction. Different types of Fourier filters are applied to separate multiple wave modes that can be normally seen in measurements from both instruments. The pure wave modes are then fitted with respect to the relevant parameters. High-resolution meteor radar data with 10 min timesteps allows us to filter the detected waves by period. Since the wave period of a single wave is constant in altitude, and because the measurements are only separated by a 10 km vertical gap, we can assume to measure the same AGW-TIDs in both instruments. The measured wave properties are combined with a background neutral atmosphere model to infer the neutral wind velocity along the propagation direction of the wave. For this, we apply a dissipative anelastic gravity wave dispersion relation [3]. The wind velocity profiles obtained by this method show a reasonable range of values. Such investigations may open up a new method for wind measurements, which have been difficult in the thermosphere so far.

References

[1] G. Stober *et al.*, Atmospheric tomography using the Nordic Meteor Radar Cluster and Chilean Observation Network De Meteor Radars: network details and 3D-Var retrieval, *Atmospheric Measurement Techniques* **14** (2021)

[2] G. Stober *et al.*, Meteor radar vertical wind observation biases and mathematical debiasing strategies including the 3DVAR+DIV algorithm, *Atmospheric Measurement Techniques* **15** (2022)

[3] S. L. Vadas and D. C. Fritts, Thermospheric responses to gravity waves: Influences of increasing viscosity and thermal diffusivity, *Journal of Geophysical Research: Atmospheres* **110** (2005)

Effect of Arctic Stratospheric Warming Events on the Antarctic Middle Atmosphere

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The British Antarctic Survey meteor radar located at Rothera station on the Antarctic Peninsula (68ºS, 68ºW), has been used to measure hourly winds from 82 km to 98 km with 2 km vertical resolution from February 2005 to August 2019. The mean winds, as well as the 24- 12- and 8-hour tidal amplitudes were fitted to these winds using a 4-day running window, and daily anomalies relative to a seasonal climatology of each component were calculated. A superposed-epoch analysis quantified the behaviour of the wind and tidal amplitude anomalies in the Antarctic during 5, Northern Hemisphere Sudden Stratospheric Warming (SSW) events occurring between 2005-2013. All these major events were accompanied by an elevated stratopause in the Arctic. The Antarctic wind and wave anomalies show that the Northern Hemisphere SSW events did not cause any significant change in the Southern Hemisphere mean winds or the 24- and 8-hour wave amplitudes. However, the semidiurnal 12-hour wave amplitude at Rothera showed a decrease of between 1 m/s at 84km, and 11 m/s at 92 km, significant between 2- and 8-sigma, occurring 12 to 15 days after the event. Preliminary results using the WACCM-X-SD model show similar southern hemisphere behaviour, and the cause of these anomalies is investigated using a primitive-equation tidal model incorporating mean wind fields derived from the NAVGEM-HA reanalysis. We will present the data, analysis, and model results showing the response of Antarctic winds and tides winds to Arctic stratospheric warming events.

First Campaign Results of LODEWAVE (LOng-Duration balloon Experiment of gravity WAVE over Antarctica)

Yoshihiro Tomikawa[1,2,3*], Kaoru Sato[4], Yoshitaka Saito[5], Isao Murata[6], Naohiko Hirasawa[1,2,3], Masashi Kohma[4], Kyoichi Nakashino[7], Daisuke Akita[8], Takuma Matuso[9], Masatomo Fujiwara[10], Takana Kaho[11], and Lihito Yoshida[2]

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[9]*Meiji University, Japan*
[10]*Hokkaido University, Japan*
[11] *Shonan Institute of Technology, Japan*

In order to clarify the roles of atmospheric gravity waves in the Antarctic region in driving the general circulation, we planned a super pressure balloon (SPB) observation of atmospheric gravity waves over Antarctica, which is called LODEWAVE (LOng-Duration balloon Experiment of gravity WAVE over Antarctica). The first campaign observation was carried out at Syowa Station in Antarctica from January to February 2022 (during JARE63 summer period). In this presentation, we report on the purpose of this project, outline of the observation at Syowa Station, the results of data analysis, and its future plan.

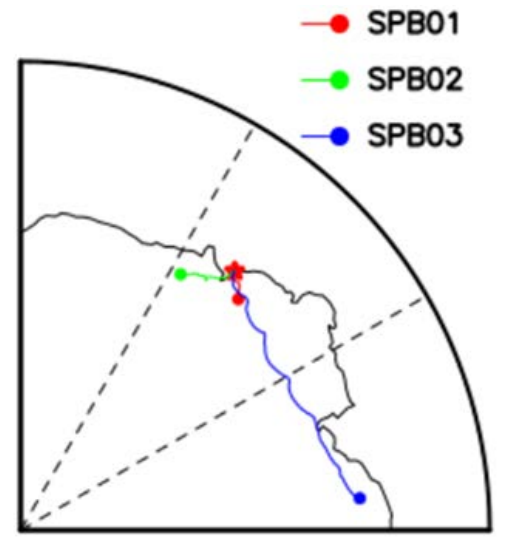

Figure 1. Trajectories of 3 SPBs. A red star denotes Syowa Station (69S, 40E).

March 9

Breakout Session

R8

Laws, Politics and Economy

R8-O01

Arctic law is an academic discipline

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The goal of the law is not just to produce legal rules as prescriptions for behaving in a certain way or facing sanctions because of the behaviour contrary to what has been prescribed. Indeed, the application of legal rules contributes to dispute settlement to serve the objective of the law. Legal practitioners rely on existing rules in juridical processes. Yet, the law is not either to solve disputes only. The presupposed legal rules are often not sufficient to achieve the goal of law – serving society at large to create a better world. Law, therefore, has a mission to accomplish – human flourishing – which often is also jeopardized due to the problems created by legal norms themselves. Therefore, the law is about better understanding a society, its structural contexts and challenges, and integration of relational perspectives by critically studying and examining the pretext and context, and rules' applicability. The law places a greater task to deconstruct presupposed structure and knowledge systems in the face of the dynamic nature of problems and challenges. The ultimate goal is to eradicate governance challenges and promote an understanding of multifaceted challenges with a critical legal mindset toward achieving a fair, just, and equitable society. Hence, legal academics have a role in achieving the law's goal – justice and fairness. Like any other discipline, law, too, is an academic discipline, where the Arctic law suggests an answer to study law for achieving ambitious goals – (environmental and) social justice, human rights, fairness, and equity. Against this background, the presentation explores, among others, the following questions: What is Arctic law for and why? Where does the Arctic stand in the context of an understanding of the law presented herein? Does the existence of international treaties or the signing of new agreements, or even diverse forms of interpretation of treaty rules applicable to the Arctic are sufficient to solve the Arctic problems without examining how such tools operate in the Arctic context?

R8-O03

The Regulation of Black Carbon Emissions in Arctic Shipping: the Role of Actors

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The shipping sector is a major contributor to climate change and is expected to grow in the upcoming years. This poses problems on a global scale, and specifically for the Arctic [1]. As polar shipping routes become more available due to the melting of Arctic sea ice, this creates a special threat to the Arctic, namely in the context of black carbon. Black carbon is a potent climate forcer, emitted when burning heavy fuel oil, which has drastic climate effects accelerating snow and ice-melt and directly contributes to the warming of the atmosphere [2, 3]. This presentation will analyze the international legal framework regulating black carbon emissions in the Arctic, including the regimes of the United Nations Framework Convention on Climate Change (UNFCCC), the International Maritime Organization (IMO) and the Arctic Council. It finds that there is currently a legal gap on this topic. To explain why regulation is lacking, the presentation takes an actor-focused approach, by examining the roles that the different state and non-state actors involved in the regulation play at the different law-making tables (UNFCCC, IMO and Arctic Council). The results will allow a deeper understanding of international law-making, specifically in the context of Arctic shipping. [Please note that this presentation forms part of my ongoing PhD research.]

References

[1] T.W. Smith et al., Third IMO Greenhouse Gas Study 2014. Executive Summary and Final Report, IMO (2014)

[2] J. Bai, The IMO Polar Code: The Emerging Rules of Artic Shipping Governance, 30 International Journal of Marine and Coastal Law **674** (2015)

[3] Y. Yamineva & K. Kulovesi, Keeping the Arctic white: The legal and governance landscape for reducing short-lived climate pollutants in the Arctic region, 7(2) Transnational Environmental Law **201** (2018)

Toward Reducing the Arctic Black Carbon Emissions: Comparative Assessment of Policy Instruments across Arctic and non-Arctic States

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The problem of black carbon (BC), which is a short-lived climate forcer and also a major air pollutant affecting human health, is recognized as a major environmental issue for the Arctic states. Periodic assessments of the status of BC in the Arctic region are conducted under the framework of the Arctic Monitoring and Assessment Programme (AMAP), and also, some comprehensive cost-benefit analyses of BC policies have been attempted at a regional level (e.g., [1]). However, these pan-regional assessments often do not pay close attention to the heterogeneity across countries in terms of the jurisdictions and organizational capacity of the regulatory system, which may inhibit the introduction of certain policy mechanisms and bring about gaps in policy implementation across nations – for example, under federal systems, the national government simply does not have any power for controlling some types of BC emissions that are governed by the regional governments. To draw implications for further reduction of BC emissions for the Arctic region, we review the country-level policy instruments for its main emission sources under domestic regulation – namely, (i) diesel vehicles, (ii) flaring in the oil and gas production, (iii) residential heating stoves and boilers, and (iv) field burning from agriculture – and compare their features source-by-source across the Arctic states and some non-Arctic countries (China and India). We perform a cross-country comparison by classifying the existing policy instruments into three types, (i) command-and-control regulation, (ii) technology-forcing mandates and targets, and (iii) economic instruments, and analyze which types of instruments are used for each source of BC emissions. Key features we find are: (i) the national system of air quality monitoring is markedly weak in Russia in comparison not only to the other Arctic states but also to China and India, which would limit the implementation of even the same levels of air pollution policies as those currently adopted by Asian countries; (ii) policy harmonization in the flaring regulation, while desirable for emission reduction, is missing not only across different Arctic states but also within them, partly as a reflection of the limited power of national regulatory agencies over state or provincial affairs in the US and Canada; (iii) economic instruments, which have been gaining increasing recognition in the context of general air pollution management worldwide, must have a scope for further utilization in the management of Arctic BC emissions, especially for the control of field burning.

References

[1] OECD, *The Economic Benefits of Air Quality Improvements in Arctic Council Countries*, OECD Publishing (2021).

R8-O05

Why Do Non-Arctic States Develop Governmental Arctic Policies?: Motivations and Self-Justifications

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After the Arctic Council opened its door to the observers first time in 1998, the Council has accepted 13 countries as observer states despite of their lack of territory/EEZ on or above of the Arctic circle. Why did the observer states bother to be recognized as observers at an international forum, not a legally binding regime? What did make them to convince their selves that they are eligible to join the Arctic Council as observer? And more importantly, why has a considerable number of countries out of 13 Arctic Council observer states now introduced their governmental Arctic policies? What are their motivations and self-justifications on their Arctic endeavors as non-Arctic states? This presentation analyses these governmental policy documents in addition to the relevant speeches of responsible governmental officials, to compare them to see a pattern in their rationalization in establishing Arctic policies in the governmental level.

R8-O06

The Analysis on Korean Arctic Policy based on the Policy Model and Policy Priorities

HK. SEO[1*]

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After getting the Arctic Council Observer status in 2013, the Korean government established the 1st Masterplan for the Arctic Policy (2013-2017) as a follow-up action in the same year. The 2nd Masterplan (2018-2022) was adopted in July 2018. Then the Ministry of Oceans and Fisheries (MOF) declared a statement during the Arctic Partnership Week in December 2018 on the “2050 Polar Vision” to provide a long-term Arctic Policy direction.

In 2021, Korean government enacted the Act on the Promotion of Activities in the Polar regions to support various activities in the Arctic and Antarctic. The significance of the Act is as follows: (1) Declaration of the government’s formal commitment to support activities in the polar regions, (2) laying the legal basis for activities in the polar region (3) getting synergy effect by collaborating the masterplan for the promotion of research activities in Antarctica (since 2009) and “Masterplan for the Arctic Policy. MOF set the 5 years Masterplan (2023-2027) for promoting activities in the polar regions as a follow up action of this act Dec, 2022.

This study reviewed Korea’s Artic policies in terms of historical perspectives from 2013 to 2022, and analyzed the differences & commonalities among 3 Masterplans (2013, 2018 and 2022) and suggested the implications. And it developed the Korean Arctic Policy Model based on the outputs of analysis. As the next step, through expert-questionaire analysis, the study set the priorities on the polar 20 challenges including Climate Change, Ecosystem Change, Arctic Shipping (issues) which were selected by KOPRI and KMI experts. And then the study proposed the policy directions reflecting the output of questionnaire output was suggested.

The study will introduce the summary of the history of Korea’s Arctic strategies (Masterplans and Visions) by the period & each masterplan’s policy components, and the Act on the Promotion of Activities in the Polar regions on detail. Lastly the policy direction of 2022 Masterplan by reflecting the expert-questionaire will be showed at ISAR-7.

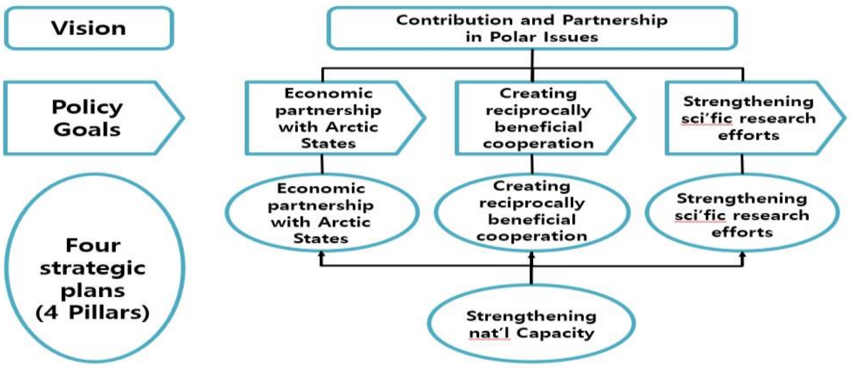

Figure 1. Korea’s Arctic Policy Model

References

[1] HK Seo, Research on Setting the Priority on Polar Challenge, Korean Journal of Siberian Studies 23(1) (2018)

March 9

Breakout Session

R9

Culture, Language, and Environment

Arctic Silences: Avoiding Speech in Siberia

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The aim of this paper is to understand silences as socially and culturally constituted by looking at the boundaries of speech and non-speech, both inside Indigenous communities and during their negotiation with strangers. While in outsiders' accounts Indigenous people are often characterised as silent and taciturn, local communities perceive nonlocals as verbose and noisy. The key ethnographic examples come from the Nenets tundra where reindeer herders meet various kinds of reformers such as state agents and Christian missionaries, who struggle with the reticence of the nomads. I discuss Nenets notions of powerful words which define the social uses of silence and other forms of tacit communication. I also draw examples from elsewhere in the Arctic and ask what it means to fall silent as an act of refusal or to avoid saying things because of a sense that words can create undesirable relations and emotions. I show how these instances are often bound to local concepts of distributed personhood, as well as to wider cosmological assumptions about what kind of agents can understand human speech, and what words can do in animists' relations with animals and predatory spirits. This entails the widespread avoidance of naming illness spirits or the recently dead by their proper names in order not to invoke their unwanted presence or in case of game animals, not to forewarn of a hunt. Instead, a parallel language using euphemisms is the way to manage relations with various nonhumans on the land. The paper suggests that absences of speech in the Arctic form a fruitful arena for developing a wider anthropology of silence, in which the well-established concept of speech act will turn out to be balanced by an equally powerful but so far unexplored concept of silence act.

Naming of meadowlands and their identities in Sakha (Yakutia)

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The salient topography of the lowlands of Central Yakutia is thermokarst, which is called *alaas* in Sakha. Alaas is oval-shaped depressions surrounded by taiga with grassy, level ground at the bottom, often with a lake at its center. There are many such alaases on the right bank of the Lena. They were formed over thousands of years by subsiding land since the underground permafrost began to thaw after the last ice age ended. This extremely longtime process of its formation caused salinification of the soil, and therefore no trees but only grass grows at the bottom. This salt-enriched grass has been highly valued by the Sakha pastoralists as fine-quality fodder.

Such alaases utilized by the Sakha people as meadows are given their own names without exception [1]. Name is regarded as an essential factor of a meadow, so it is quite legitimate to say that a meadow without a name is not a proper meadow [2]. Meanwhile, naming things is in other words segmentalizing things by means of a langue. It is to make a conceptual framing and categorization. Therefore, to name such a place like an alaas that has a clear-cut contour and continuously occupies a particular space means a kind of world-making. And such an act of naming bears comparison with the scientific understanding in making a world in order [3].

Being based on these perspectives, this study brings out an aspect of proper name of land by making investigation into the cadaster of Khayakhsyt nasleg, an administrative division of Churapcha ulus in Yakutia. The cadaster encompasses all names of alaases utilized by the inhabitants of the nasleg. Making a survey of the cadaster will bring the question "what people are doing by naming alaases; whether they indicate an individual thing or provide a literal or a connotative meaning?" into light.

This work was a part of the Arctic Challenge for Sustainability (ArCS) Project (Program Grant Number JPMXD1300000000) and of the Arctic Challenge for Sustainability II (ArCS II), Program Grant Number JPMXD1420318865.

References

[1] H. Takakura, The social and symbolic construction of alaas landscapes in the Siberian forest among the Skaha, *Acta Slavica Iaponica* **28** (2010)

[2] C. Mészáros, The middle world of film: ontological poetics, live landscapes, and sentient beings in the language of movies, *KinoKultura* Special Issue **19** *The cinema of Sakha (Yakutia)* (2022)

[3] S.A. Crate, *Once upon the permafrost: Knowing culture and climate change in Siberia*. Tucson: The University of Arizona Press (2021)

Religious Resurgence among Sakha (Yakuts) in the Context of Muslim Immigration from Central Asia

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Right after the fall of the Soviet Union, the Sakha (Yakut) people attempted to contruct their new post-Soviet identity through the revival of what they perceived to be their native religious beliefs. This became epitomised in the founding of an Association of Folk Medicine in Yakutsk and its hosting of an international conference on shamanism in 1992. As it often happens to identity-building discourses, this religious endeavour soon faded away, giving lead to other projects in the making of Sakha identity, such as the explorations of the genetic origin of Sakha. Today, however, some Sakha are turning back to what their post-Soviet predecessors did in the 1990s, namely the religion of *Aar Aiyy* which principles were laid down by now late Vladimir Kondakov. What struck me in this renewed interest of Sakha in religion is that it appears to have a very palpable gendered dimension. Every Sunday, groups of Sakha men gather for collective prayers and *algys* rituals of purification and blessing. These men claim that Aar Aiyy is their source of empowerment amidst the influx of Others, or labour migrants from Central Asia, whom they imagine to be immensely powerful and hence dangerous to Sakha because of their strong affiliation with Islam. How is this religious contact being made? Is it akin to what is known as 'colonial mimicry'? What is the place of Christianity, claimed to be 'hegemonic', in this oppositional diade? This seems even more interesting given that Sakha are one of few Turkic peoples in the world, who have never adopted Islam. How different or similar do these Sakha imagine these Mulsim and predominantly Turkic-speaking migrants to be from themselves?

Being Komi in the city: identities and belonging

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Syktyvkar, the capital of the Komi Republic (Russia), is the region's largest and allegedly most promising city. A quarter of the city's population (i.e. approximately 62 thousand) is comprised of ethnic Komi people [1]. While not being an Arctic city, but rather a Northern one, Syktyvkar attracts movers from all districts of the Komi Republic, including those incorporated in the officially demarcated Arctic zone of the Russian Federation.

The Komi people are the Finno-Ugric ethnic group that inhabits, apart from the Komi Republic, several other regions of the Russian North and amounts to approximately 230 thousand. The Komi Republic is an ethno-territorial entity with the Komi people being its titular people. Its political and legal status is directly connected to the living of the Komi people [2], and therefore the vitality of Komi communities is directly related to the sustainable development of the region and its population.

The Komi people have experienced drastic urbanization; nowadays, more than 47% of them are urban dwellers [1]. Most relocated to the cities from the rural areas; a small share is born urbanites. Syktyvkar, in this regard, is not only the most Komi-populated city, but it also hosts the biggest share of the region's urban Komi people, i.e., 65%.

This work investigates 1) how urban-dwelling Komi residents perceive themselves in urban space, 2) what meaning they engrain in being Komi urban residents, and 3) how urban area and Komi people interinfluence each other. The present contribution is based on the interviews and field notes collected and recorded during the fieldwork conducted by the author in Syktyvkar in 2021-2022.

Presenting the case of urban Komi people, this work attempts to better understand strategies of identity development and sustenance employed by non-Russian minorities in the continuously restrictive settings of contemporary Russia. Furthermore, bringing urban dwellers to the main focus assists in demystifying and deromanticizing the image of non-Russian ethnic minorities as essentially rural residents.

This presentation is a work in progress; some of its first findings will be presented at the conference.

References

[1] (forthcoming) Fedina, M. (2022). Syktyvkar: the (Komi) capital of the Komi Republic. Analysis of lived experiences of urban Komi people, *Arctic Yearbook 2022*.
[2] Constitution of the Komi Republic. Available at: https://docs.cntd.ru/document/951600634 [accessed 4.11.2022].

Indigenous Well-Being in the Arctic Region of North America: A Theoretical Consideration

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Contemporary Indigenous peoples of the Arctic North America region live in the mixed economic system under the influence of economic globalization and climate change. They face critical challenges pertaining to their political autonomy, economic self-reliance, and food acquisition, in addition to cultural and identity problems, social and health problems, physical safety problems, and environmental problems that may pose a serious threat to their well-being unless adequately addressed. I argue that the well-being of the Arctic peoples of North America is causally correlated with the synergistic effects of these factors [2] (see Figure 1). One of the most serious problems concerning well-being of arctic peoples in North America is a high rate of suicide among young people [1]. I propose to study the suicide problem with use of this theoretical framework and actor network theory to solve it.

Figure 1. A Theoretical Framework for Well-Being

References

[1] Kral, M. J. et al., Unikkaartuit: Meanings of well-being, unhappiness, health, and community change among Inuit in Nunavut, Canada, *American Journal of Community Psychology* 48 (2011), DOI 10.1007/s10464-011-9431-4

[2] Kishigami, N., Cultural security as a key factor for local well-being among the Inupiat in Utqiaġvik, Alaska. A paper read at the 1st Japan-Finland Seminar on the Arctic and East Asia (JAFSAS) (On Line Meeting) (2022)

March 7

Breakout Session

R10

Engineering for Sustainable Development

Examination of urban ZEB envelope performance under sub-Arctic climate condition

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The Paris Agreement of the IPCC and the Glasgow Climate Agreement have prompted carbon neutrality efforts around the world. It is estimated that buildings account for 1/3 of greenhouse gas emissions from human activities. Therefore, in recent years, many developed countries have been trying to convert their buildings to Zero Emission Buildings (ZEB) or Zero Energy Buildings (ZEB). In Japan, measures for decarbonization are being promoted following the declaration in 2019 that the country will be carbon neutral by 2050. Energy conservation standards for office buildings have been strengthened and energy conservation standards for residential buildings have become mandatory by 2025.

This report targets small-scale urban ZEBs in subarctic regions. Originally, energy offsets are difficult to achieve in urban buildings because it is difficult to install PV. In addition, the subarctic region has high heat loss in winter, low sunlight hours, and snow cover, which makes ZEB even more difficult to achieve. However, Norway, Sweden, and Finland have set targets under the EU strategy[1]. Also, the study to reduce the life-cycle carbon footprint to zero by using mainly wood materials was conducted [2].

In Hokkaido, there are already five certified ZEB under the Japanese ZEB certification requirements. In this report, we report on the study of insulation performance, energy-saving equipment, and PV at the design stage, targeting ZEBs built in the area with the most severe sunlight conditions in the city. The actual values after one year of building operation are also reported.

Figure 1. Winter condition of PV panels

References
[1] Ravasio, L.; Sveen, S.-E.; Riise, R. Green Building in the Arctic Region: State-of-the-Art and Future Research Opportunities. Sustainability 2020, 12, 9325. https://doi.org/10.3390/su12229325
[2] https://sdwg.org/what-we-do/projects/zero-arctic-concepts-for-carbon-neutral-arctic-construction-based-on-tradition/

R10-O02

Challenges of sustainable regional development in arctic remote villages

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Qaanaaq is a village in north-west Greenland, one of the most northernmost settlements in the world. Its harsh, cold climate has a significant impact on indoor environment and heating energy consumption [1]. In addition, the remoteness of the community poses challenges for the transport of human resources and goods [2]. This study presents the results of 1) measurements of the indoor environment, 2) a web questionnaire about the indoor environment and ventilation/heating system, and 3) qualitative interviews conducted in October 2022. In addition, a summary, and some suggestions for the challenges in Qaanaaq are provided.

1) Temperature, relative humidity, CO_2 and PM10 were measured in a dwelling built in 2000 (Figure 1). The temperature, CO_2 and PM10 concentration in the living room were generally maintained at appropriate levels. On the other hand, the relative humidity was below 25% through most of the time (Figure 2).

2) 4 survey responses were provided by inhabitants in Qaanaaq. The age of the dwellings varied from before-1960s to the 2000s; three used diesel oil as the heating fuel, but the heating systems were different in each, including heating panels and stoves. While all dwellings opened their windows at least once a day, they also reported from neutral to hot indoor thermal sensations.

3) Interviews were conducted to a local construction company owner. The heating energy consumption is very high due to insufficient insulation in older houses, which most of the people live in. In order to reduce the amount of materials transported, only the cement is imported and local stones and sand are used when pouring concrete. Nevertheless, transportation costs are still high. Furthermore, human resource-shortage is also challenge, as there are only about 10 construction workers in the village and few professional workers.

Summary and suggestion

In order to reduce the use of fuel, the price of which is expected to rise, it will be necessary to rebuild from the current low-performance dwellings to highly insulated ones. In this case, we should consider the issues of human resources and transport of materials at the same time.

Acknowledgements

This work was a part of the Arctic Challenge for Sustainability II (ArCS II), Program Grant Number JPMXD1420318865.

Figure 1. The dwelling

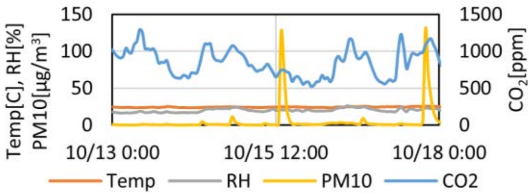

Figure 2. The indoor environment in living room

References

[1] M. Kotol, C. Rode et al., Indoor environment in bedrooms in 79 Greenlandic households, *Building and Environment* **81** (2014)

[2] E. B. Møller, T. Lading, Current building strategies in Greenland, *E3S Web Conferences* **172** (2020)

R10-O03

Prediction of daily leachate generation at dumpsites located in Greenland

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To understand the factor and timing of leachate generation and impact of global warming, numerical calculations were conducted. The calculations utilized a model developed by a previous study. The model is based on water balance in landfill and uses meteorological data (temperature, precipitation, dew point temperature, wind speed, and sunshine duration) from meteorological stations. To calculate evaporation, Penman method was used. Moisture derived from waste was also considered. Since the original model was developed for calculations in low-latitude arid regions, the program was revised to take snow accumulation and snowmelt into account. Meteorological data were obtained from the National Oceanic and Atmospheric Administration's (NOAA) Global Surface Summary of the Day for three sites in Greenland. To take the impact of global warming into account, calculation in which temperature was increased +2°C and +5°C to current data was conducted. As an example, result of THULE AIR BASE in 1997 is indicated in Figure 1. Leachate is generated between April and September, and is mainly influenced by snowmelt, which is shown by the dashed line. In July and August, precipitation directly infiltrates into the waste layer and becomes leachate. The amount of evaporation is low, especially in winter due to the lack of solar radiation during the polar nights. In some years when precipitation (snowfall) is low, leachate is not generated. Similar trends were observed at the other two sites of which latitudes are different, but the amount of leachate generated was higher due to higher precipitation. Although results are not shown, calculations with increased temperatures showed a decrease in leachate generation. Increased evaporation due to warming may be a cause in the decrease in leachate. The increase in evaporation is suggested to be a decrease in albedo due to a decrease in snow cover or an increase in surface water retention due to rainwater intrusion into the surface layer.

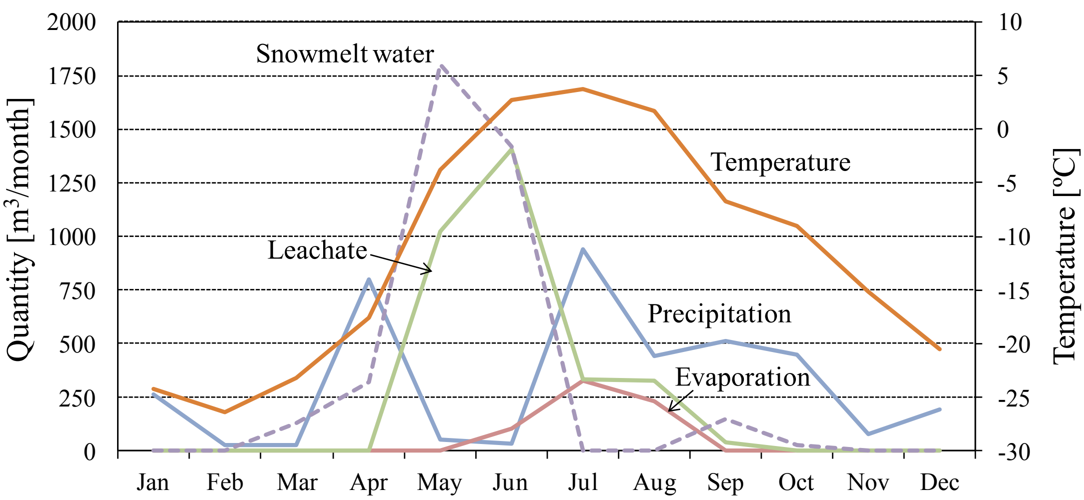

Figure 1. Calculated result at THULE AIR BASE (1997)

References

[1] T. Malmir, H. Nomura, and Y. Tojo, Prediction of long-term leachate generation in a municipal solid waste landfill in an Arid Climate, Journal of JSCE, Ser. G, 71(7), (2015)

Icing process hazards related to the "Lena" highway sustainability for the last 100 years

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Icing (Aufeis) hazards since 1920-th were known, where the "Lena" federal highway has constructed. These hazards relate to damming of a roadway, bridge foundations damaging blurring an embankment. Approaches of icing processes control were proposed by V.G. Petrov (1930). The long-term exploitation of the "Lena" highway and its importance of cargo linkage of the Sakha Republic had been allowing to its multiple reconstruction. The second icing hazards assessment in 1960-th by professor V.R. Alekseev was done. Icings had been going on to develop on previous discovered sites and anti-Icing facilities have not been properly effective. The last round of the "Lena" highway reconstruction has been starting since 2012. In winter 2022 the "Lena" highway was investigated from the south to the north along 600 km. Since previous investigators the embankment of the highway was raised till 10 m. Therefore, some part of small icings either disappeared or already hasn't influenced on embankment sustainability. Anyway, it is 120 Aufeis were detected and 16 from that quantity was assessed as the most hazardous. The criterion of hazard's degree was applied based on subsidence of an embankment, formation of cracks in an asphalt, erosion washouts, ice mounds formation with traces of its explosions, are recorded. Six key monitoring sites for the icing development process and its affecting on embankment sustainability were established.

Figure 1. Icing phenomena along the "Lena" highway and anti-Icing facility on the Banniy creek

The study supported by the grant RSCF #22-27-20118

R10-O05

Engineering Challenge toward Sustainable Use of Arctic Sea Route

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From engineering point of view, safe and efficient navigation are indispensable for the environmental-friendly and sustainable use of the Arctic Sea route. Safety enhances the prevention of oil spill from damaged vessels and efficiency contributes to less GHG emission from vessels. In the present study, a framework for assessing safe and efficient ice navigation by two-step approach is proposed. As a first step, POLARIS[1] proposed by IMO (International Maritime Organization) is adopted in the safety assessment. The system evaluates navigation risks of vessels in Arctic waters using ice class of vessels and sea ice conditions based on WMO sea ice nomenclature. At the second step, a new treatment on navigability assessment is proposed in terms of ship dimensions, hull shape parameters and the same sea ice conditions. Using the same sea ice conditions, it is possible to evaluate safety and efficiency more consistently. Prediction of ice resistance of vessels is one of the key technological issues of navigability assessment. In the present study, the validity of the prediction method proposed by the author is discussed by comparing the field data of ship speed, propeller thrust, and visual observations of sea ice conditions based on WMO sea ice nomenclature.

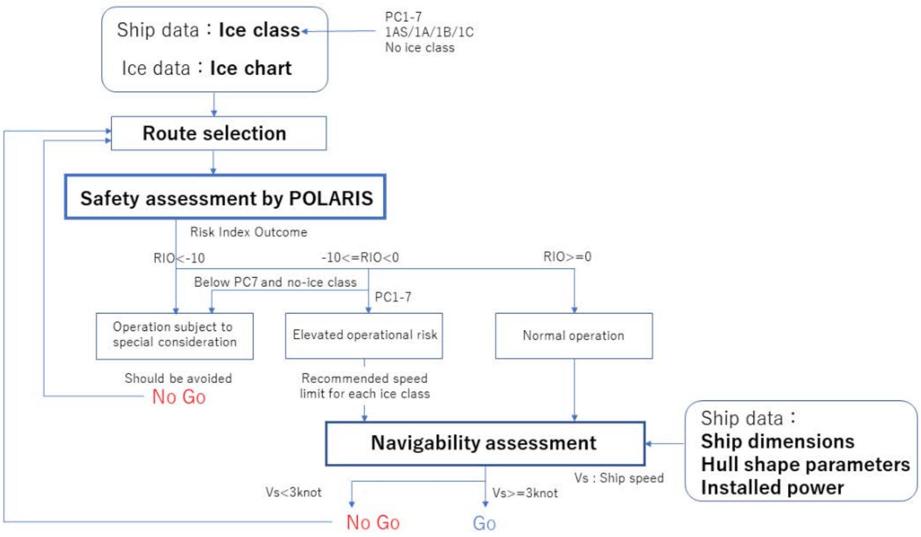

Fig.1 A framework of safety and efficiency assessment of ships independently navigate in Arctic Sea route

References

[1] IMO MSC.1/Circ.1519. Guidance on Methodologies for Assessing Operational Capabilities and Limitations in ice. (2016)

March 9

Breakout Session

S1

High-latitude Fires, Arctic Climate, Environment and health (HiFACE)

Community Vulnerability to Wildfire Risk in the Robson Valley region of British Columbia, Canada

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Climate change has already led to an increase in wildfire season length, wildfire frequency, and burned area across western Canada. This has had both social and ecological consequences. Most research has focused on the drivers and impacts of wildfire, with less known about the capacity of communities to respond to and manage wildfire risk. This research examined community vulnerability to wildfire risk in the Robson Valley region of British Columbia, Canada. An analysis of data collected through semi-structured interviews with key informants (directly involved in forestry, wildfire management, or local governance) and focus groups with community members reveal that communities are largely exposed to the indirect impacts from wildfires in the region such as road closures, and loss of timber resources as well as wildfires elsewhere, through possible damage to power and communications infrastructure along with health impacts due to poor air quality. Residents are sensitive to these impacts due to their isolation, their reliance on the highway to import food and critical goods, and their dependency on regionally managed communications and electricity infrastructure, which is essential for food storage in agricultural communities. Participants expressed frustration over the centralisation and professionalisation of fire suppression services at the expense of local wildfire fighting capacity, both in terms of human-power and local knowledge. Opportunities to strengthen community resilience to wildfire risk include building local capacity and agency in fire management, enhancing food security through a community food cellar, and ensuring redundancy in power and communication networks. This will involve changes to current provincial fire management practices, by enabling a response structure that facilitates local participation and agency when responding to fires within the region and investment in critical infrastructure.

S1-O02

Community Risk and Resilience to High-latitude Wildfires

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In recent years, high-latitude regions are experiencing increasingly extreme wildfire seasons, with parts of Canada, Greenland, Russia and Fennoscandia documenting more intense and destructive wildfires now than in the past 10,000 years [1, 2]. These wildfires are having significant social, economic, and health impacts on high-latitude communities, including, among others, forced evacuations, increased hazardous pollutions levels, and disrupted livelihoods [3, 4, 5]. With climate models predicating an "invasion" of fires to the Arctic and adjacent boreal region [6], it is expected that these impacts will only worsen with time. Although the physical science is considerably improving over the years, there remains little empirical work examining the human/social dimension of high-latitude wildfires. In response, this presentation will introduce a research project focused on understanding how people perceive, experience, and respond to wildfire events in high-latitude communities. First, it will introduce a newly developed conceptual framework to illustrate the factors and dynamics driving risk and resilience to high-latitude wildfires at community levels. This will be followed by a place-based case study applying the framework in Valemount, British Columbia (BC), to examine in greater detail risk and resilience and its drivers. The presentation will demonstrate the importance of considering the social dimensions of wildfire in the evaluation of risk, vulnerability, and resilience; complement the existing wildfire literature; and provide insights that would help practitioners to locate barriers and limits to effectively respond to wildfires in high-latitude contexts.

References

[1] York, A., Bhatt, U.S., Gargulinski, E., Grabinski, Z., Jain, P. and Soja, A., Wildland fire in high Northern latitudes. *NOAA* (2020)
[2] IPCC, Summary for Policymakers. *IPCC Special Report on the Ocean and Cryosphere in a Changing Climate* (2019)
[3] Dodd, W., Scott, P., Howard, C., Scott, C., Rose, C., Cunsolo, A. and Orbinski, J., Lived experience of a record wildfire season in the Northwest Territories, Canada. *Canadian Journal of Public Health* **109(3)** (2018)
[4] Howard, C., Rose, C., Dodd, W., Kohle, K., Scott, C., Scott, P., Cunsolo, A. and Orbinski, J., SOS! Summer of Smoke: a retrospective cohort study examining the cardiorespiratory impacts of a severe and prolonged wildfire season in Canada's high subarctic. *BMJ open* **11(2)** (2021)
[5] Narita, D., Gavrilyeva, T. and Isaev, A., Impacts and management of forest fires in the Republic of Sakha, Russia: A local perspective for a global problem. *Polar Science* (2020)
[6] IPCC. The Physical Science Basis, *Cambridge University Press* (2021).

S1-O03

Health Impacts of Wildfire smoke in Arctic Council Nations

B. Silver[1*], S. Arnold[1], L. Emmons[2], C. Reddington[1] and L. Conibear[1*]

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[*]*Now at Tomorrow.io*

In the Arctic, climate change is making boreal forest and grasslands increasingly vulnerable to wildfires. Arctic wildfire carbon emissions have doubled during the previous two decades, and are predicted to increase even more rapidly in the coming century. Wildfires are causing the annual mean concentrations of $PM_{2.5}$ to increase (Figure 1) across parts of the Arctic. We construct two emissions scenarios, with and without wildfire emissions in Arctic Council (AC) nations. Using the Community Earth System Model, we simulate $PM_{2.5}$ air quality in these two scenarios over the period 2001-2020. Using Arctic in-situ measurement data, we show that the model has a large negative bias in wildfire plumes. We use a high-resolution $PM_{2.5}$ reanalysis dataset [1] to correct the $PM_{2.5}$ bias. We then perform a health impact assessment using the Global Exposure Mortality Model [2] to estimate the health impacts of long-term exposure to fire-sourced $PM_{2.5}$. During 2001-2020, our results attribute 60,000–140,000 premature deaths per year to Arctic Council wildfire emissions. We show that the largest fire-sourced $PM_{2.5}$ health burdens fall on non-Arctic Council nations, such as China, due to their high population density and long-range transport of wildfire emission plumes.

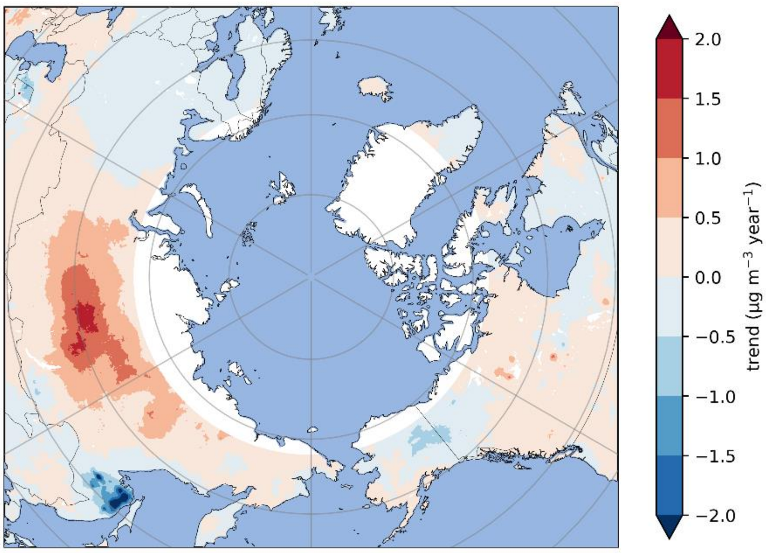

Figure 1. Trend in mean summer (JJA) $PM_{2.5}$ concentrations in Arctic region [1]

References

[1] A. van Donkelaar *et al*., Regional Estimates of Chemical Composition of Fine Particulate Matter Using a Combined Geoscience-Statistical Method with Information from Satellites, Models, and Monitors, Environ. Sci. Technol. 53 (2019) 2595–2611

[2] R. Burnett *et al*., Global estimates of mortality associated with longterm exposure to outdoor fine particulate matter, Proc. Natl. Acad. Sci. U. S. A. 115 (2018) 9592–9597

Fire Regimes in the Arctic Region

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Fire activity in 288 areas (2.5° N × 10° E) in the Arctic region (50°–70° N, 0°–360° E) was analyzed using satellite hotspot data (number of HSs = about 4.4 million) from 2002 to 2021. A total of 21 high fire density areas were selected and their fire–weather conditions during each active fire period were analyzed using weather and temperature maps at upper and lower air (over 1820 maps in all). Analysis results of fire–weather conditions for high fire density areas in the Arctic region (North Eurasia and North America) are: Active fires in central and eastern Siberia started by LWM (large westerly meandering) caused by COL (cut-off low) detached from Arctic low-pressure systems over the continent (west and central Siberia). Very active fires on HS peak days in central and eastern Siberia occurred under COH (cut-off high) detached from a ridge extending from the Tibet plateau and Arabia. In North America, active fires also started by LWM caused by COL detached from Arctic low- pressure systems over the Bering Sea and the Gulf of Alaska. However, fires were not so active until high-pressure systems (COH and ridge) extended from the Great Basin. Analysis results may suggest there are six major fire regimes in the Arctic region: (1) Eastern Europe, (2) Central and East Siberia (Sakha), (3) Far east high-latitude Siberia (northern Sakha), (4) Far east low-latitude Siberia (southern Khabarovsk), (5) Alaska, and (6) Western Canada. Lastly, we should prepare for the next large-scale fires due to climate change by applying the fire–weather analysis approach described in this report. Since we can predict occurrence of active fires, we could prevent active fires by making fire breaks, prescribed fires, and so on. Our fight against wildland fires is one of the executable ways to mitigate global warming.

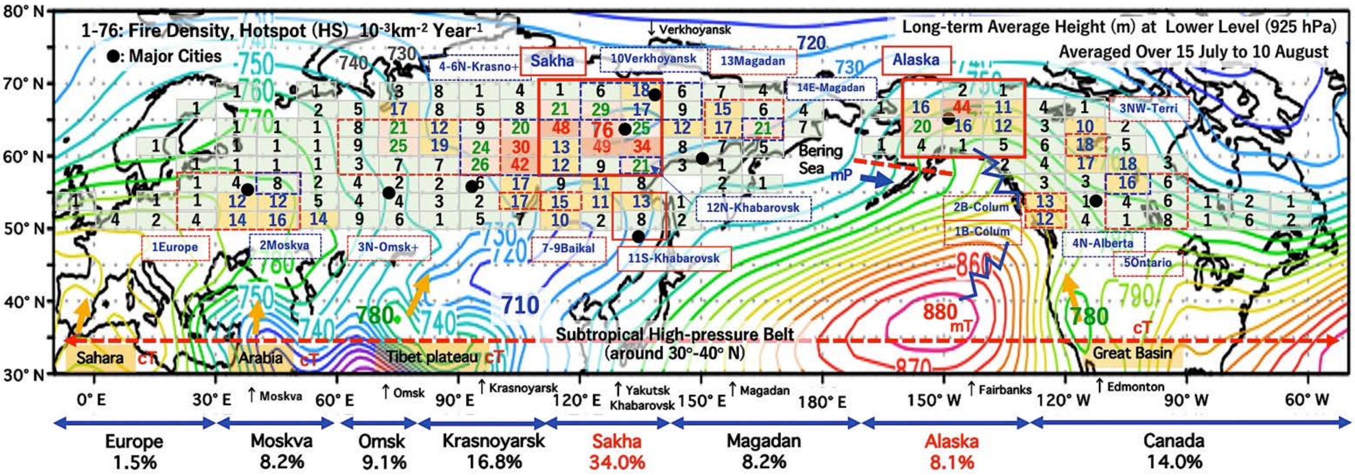

Figure 1. Map of part of the northern hemisphere (30°–80° N, -10°–310° E).
The Arctic study region (50°–70° N, 0°–360° E) was divided into 288 areas (2.5° N×10° E), showing their fire density (hotspot (HS) 10^{-3} km^{-2} $Year^{-1}$).

References

[1] H. Hayasaka, Fire Weather Conditions in Boreal and Polar Regions in 2002–2021, *Atmosphere* **13(7)**, 1117 (2022)

S1-O05

Develop an INtegrated Fire Risk mAnagement (INFRA) Pilot Service for Arctic Wildfires

V. Vitale[1*], E. Brugnoli[2], G. Bernardi[3], O.Drofa[4], O. Gavrichkova[2], M. Sarti[2], E. Nestola[2], A. Tiesi[4], L. Giandomenico[3], N. Tramarin[3], M. Mazzola[1], A.Lupi[1], F. Becherini[1], and D. Mastrangelo[4]

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The past few years have seen a dramatic increase in the frequency and intensity of extreme wildfire events in the Arctic. Despite the numerous well-documented events that occurred in the last 3 years across Fennoscandia, Alaska, Canada, Greenland, and the Russian Federation, the long-term picture is less obvious, but their impacts on ecosystems and communities are clear. Wildfires are a key topic of the new EU Arctic PASSION project. A pilot service called "Integrated Fire Risk Management" (INFRA) is being developed to improve provision of information for first responders and communities in the Arctic. Aim is to develop an integrated web-based system that, through collecting data and coupling physical and parametric models, will support the prevention and evaluation of the risk of wildfire; the sighting and monitoring of wildfires; emergency management of shutdown operations; post-event management and damage assessment. Information layers and outputs will include: risk maps, vegetation stress map, fire weather forecasts, fuel map, early identification of outbreaks, and short-term evolution of the fire event. The service will pay great attention to convey information and alarms towards citizens and communities taking into account their needs and capacities and the limitations of communication infrastructures. To promote full co-design and co-development approach, INFRA will be structured according to well-identified and separate functional blocks, making possible to modulate and reorganize the service in a relatively simple way according to the specific needs of those who must use it and above all of the recipients of the service. The development of tools capable of providing support both in the prevention phase and in the management of the emergency both to the category of professional and non-professional users, aims to give maximum attention to the need to maintain a continuous flow of information, giving the itself the right form and the right comprehensibility, overcoming the problem that often finds itself of little attention to the difference in the levels of understanding and handling information that an unprofessional user usually has. This approach has the advantage of being able to tackle the co-design and co-development phase starting from a base that at the same time has (i) a degree of solidity and completeness such as to be able to base and finalize the discussion and dialogue with users. and users on concrete / reachable elements and (ii) that degree of flexibility necessary to be able to listen first and then receive in the appropriate way the requests, requests, and also the feeling of the final recipients of this service. The presentation will provide details of this approach, as well as information layers, tools and actions to develop and test the service.

S1-O06

Predicting seasonal wildfire patterns with machine learning for the circumpolar and Alaska boreal and Arctic regions

Christine Waigl[1*], Elizabeth Fischer[1], Thomas Ballinger[1], Peter Bieniek[1], Cecilia Borries-Strigle[1], Mitchell Burgard[1], Joshua Hostler[1], Rick Lader[1], Eric Stevens[3], Heidi Strader[3], Alison York[1], and Uma Bhatt[1,2]

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With accelerated climate warming in the high northern latitudes, wildfire activity has increased in recent years across the circumpolar boreal and Arctic regions. Fire activity is driven by fire weather conditions (e.g., hot, dry, and windy) during the wildfire season as well as the presence of suitable dry fuels and ignitions from lightning strikes. Fire management agencies have a need for seasonal predictions of wildfire activity and potential. Our research investigates the predictability of wildfire activity using a machine learning approach. We operate in two spatial domains: a global circumpolar boreal-and-Arctic domain, and a domain centered on Alaska. We have assembled a dataset of predictor variables and fire activity related variables, which are being assembled into a machine learning framework that uses ensembles of regression trees (Random Forest Regressors and Boosted Regression Trees). Additionally, Empirical Orthogonal Functions are used for dimensionality reduction and pattern detection. Target variables for fire conditions are Fire Weather Indices from the Canadian Forest Fire Danger Rating System (CFFDRS), in particular the Build-Up Index, which is a widely used indicator of fire weather conditions. Additionally, we use satellite-based fire detections (from MODIS TERRA) and fire perimeters provided by the Alaska Interagency Coordination Center (AICC). These datasets are gridded to the 0.25° grid of the ERA5 climate reanalysis, which is used to calculate the CFFDRS indices. Predictor variables include the annual snow-off date (gridded, from ERA5), sea ice concentration, atmospheric variables, sea surface temperature, various teleconnection indices as well as lightning activity over Alaska. In Alaska, sub-seasonal divisions of the fire season and the Predictive Service Areas used by fire managers form the basis of the spatiotemporal analysis.

This research is coproduced by a team comprised of researchers from the University of Alaska Fairbanks and fire behavior and fire weather experts from the Alaska interagency fire management community. It is supported by the National Science Foundation (USA) under award #OIA-1753748 and by the State of Alaska.

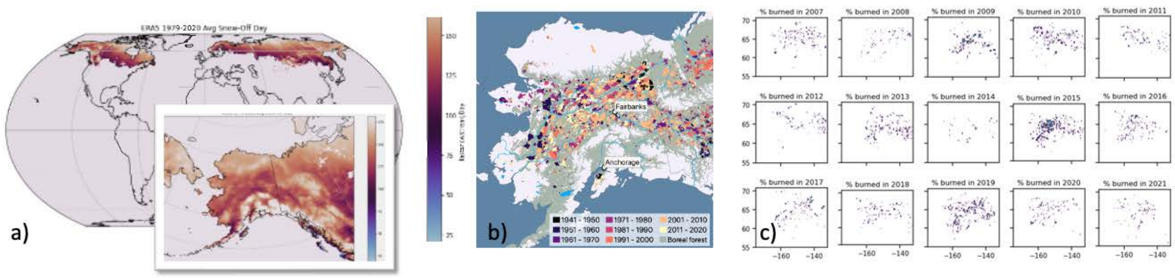

Figure 1. a) Average snow-off Julian day across the circumpolar and Alaska domains (source: ERA5). b) Wildfire activity by decade in Alaska domain, 1940s-present (source: AICC, Environment Canada). c) Gridded annual fire activity for Alaska domain in selected years (source: AICC)

S1-O07

Arctic fire representations in the latest-generation Earth System Models

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The Arctic is experiencing climate change faster than any other region on the planet. This has alarming consequences for high-latitude fire risk: climate models predict further, substantial increases in high latitude fire seasons and lightning strikes that have driven recent record wildfire activity [1-2]. The environmental consequences of increasing future fire risk for this sensitive ecoregion are less robustly known. Impacts on regional air quality are likely as well as feedbacks on Arctic climate though aerosol radiative forcing; moreover the Arctic comprises a vast store of carbon in both forests and peatland which stands to amplify climate change worldwide if burnt [3]. The latest generation of earth system models (ESMs) include interactive vegetation and carbon cycle schemes, and a good representation of high-latitude fires is essential if we want to properly simulate changing fire emissions and the consequences both for the Arctic region and globally. However, the characteristics of high-latitude fires pose unique challenges for our models. For instance, very few ESMs currently simulate peat fires, despite peatlands making up a significant component of high latitude soils. Limited observations of high-latitude peat fires make it difficult to constrain and validate the few models which do. The Arctic is also characterized by highly variable weather conditions and predominantly lightning-driven fire activity [4], contrasting with much of the rest of the world where models often assume a substantial human-driven component to fire ignitions. We present an assessment of the current state-of-the art in modelling high-latitude vegetation, wildfire burnt area, and emissions in fire-enabled ESMs and land-surface models, comparing against a range of observational products and time periods. As well as assessing the range of uncertainty in current models and remote sensing observations, we also seek to explore the drivers of model diversity in how well high-latitude fire amount and variability are simulated, to highlight the key processes to focus on in further improving our representation of this crucial earth system feedback.

References

[1] M. W. Jones *et al.*, Global and regional trends and drivers of fire under climate change, *Reviews of Geophysics* **60** (2022)
[2] A. Krause *et al.*, The sensitivity of global wildfires to simulated past, present, and future lightning frequency, *J. Geophys. Res. Biogeosci.* **119** (2014)
[3] C. Phillips *et al.*, Escalating carbon emissions from North American boreal forest wildfires and the climate mitigation potential of fire management, *Science Advances* **8** (2022)
[4] S. Veraverbeke *et al.*, Lightning as a major driver of recent large fire years in North American boreal forests, *Nature Clim Change* **7** (2017)

S1-O08

INFERNO-peat: A Representation of High Latitude Peat Fires in the JULES-INFERNO Fire Model

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High latitude peatlands are an important store of carbon. However, due to anthropogenic activities and climate change they are becoming increasingly vulnerable to wildfires [1]. Peat fires are among the largest and most persistent wildfire phenomena and are dominated by smouldering combustion [2]. In the high latitudes, peat fires have the potential to release vast amounts of long term stored carbon and other greenhouse gases and aerosols. Consequently, peat fires can have huge implications on the carbon cycle and result in a positive feedback effect on the climate system. Peat fires also impact air quality and can lead to haze events, with major impacts on human health. Despite the importance of peat fires they are currently not represented in most fire models, leading to large underestimations of burnt area and carbon emissions in the high latitudes. Here, I present a representation of peat fires in the JULES-INFERNO fire model (INFERNO-peat). INFERNO-peat improves the representation of burnt area across the high latitudes, with notable areas of improvement in Canada and Siberia. INFERNO-peat also highlights a large amount of interannual variability in carbon emissions from peat fires. The inclusion of peat fires into JULES-INFERNO demonstrates the importance of representing peat fires in models, and not doing so may heavily restrict our ability to model present day fires, and future changes to fire regimes across the high latitudes.

References

[1] Turetsky, M. R. et al., Global vulnerability of peatlands to fire and carbon loss, *Nature Geoscience* **8** (2015)
[2] Rein, G., Smouldering Fires and Natural Fuels. In Belcher, C., Fire Phenomena and the Earth System: An Interdisciplinary Guide to Fire Science, *Wiley and Sons* (2013)

March 6 / March 7

Breakout Session

S2 (Part1 / Part2)

Extratropical teleconnections and predictability of weather and climate related with the Arctic environmental changes

A new proposed scheme for seamless detection of cutoff lows and preexisting troughs

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We propose a new scheme based on geopotential height fields to detect cutoff lows starting in the preexisting trough stage [1]. The intensity and scale derived from the proposed scheme will allow for a better understanding of the cutoff low life cycle. These cutoff lows often accompany mesoscale disturbances, causing adverse weather-related events, such as intense torrential rainfall and/or tornadoes (Fig. 1: left). The proposed scheme quantifies the geometric features of a depression from its horizontal height profile. The height slope of a line intersecting the depression bottom and the nearest tangential point (optimal slope) locally indicates the intensity and scale of an isolated depression. The strength of the proposed scheme is that, by removing a local background height slope from a geopotential height field, the cutoff low and its preexisting trough are seamlessly detected as an identical depression. (Fig. 1: right) The distribution maps for the detected cutoff lows and preexisting troughs are illustrated along with their intensities, sizes, and local background flows estimated from snapshot height fields. We conducted climatological comparisons of cutoff lows to determine the utility of the proposed scheme.

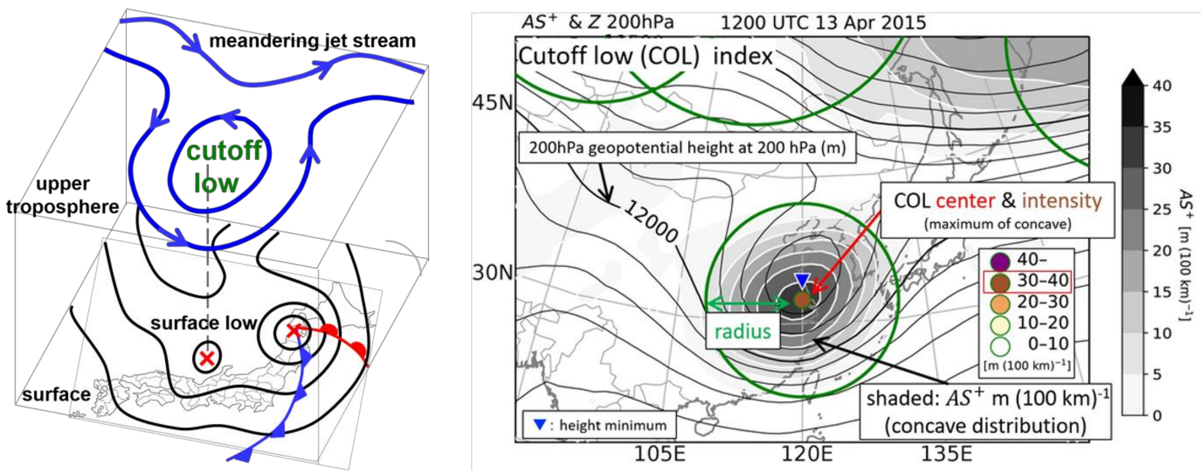

Figure 1. (Left) Schematic of cutoff low (COL), (Right) COL center, intensity, size and concave distribution detected based on a new   scheme.

References
[1] S. Kasuga, M. Honda, J. Ukita, S. Yamane, H. Kawase, A. Yamazaki, Seamless detection of cutoff lows and preexisting troughs, *Mon. Wea. Rev.* **149** (2021)

S2-O02

Cutoff Low Approaching Routes to the Japan Islands

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Cutoff lows (COLs) are mid-latitude cyclones appear at the upper troposphere. They contain cold air mass derived from the polar region. Since they decrease atmospheric stability at the lower troposphere and often accompany severe weathers, investigating COLs that approach regions with a large population, such as the Japan Island is important to forecast/mitigate disasters and clarify remote influences of polar atmosphere to its peripheral region. Besides, the approaching routes of COLs to the Japan Islands and their seasonal cycles have not been investigated with objective method. In this study, we attempt to elucidate them by utilizing depression detection scheme of Kasuga et al. (2021; K21), which can detect COLs from their early stage (pre-existing trough stage). We have implemented a tracking scheme of COLs by simply searching overlapping of area of COLs, which is also defined in K21. Merge and split of COLs are also recorded to investigate variations of the generation/dissipation of COLs

Figure 1 shows that tracked COLs at 200 hPa and 500 hPa. Generally, COLs tend to approach the Japan Islands from northwest. Only JJA and SON at 200 hPa, they approach from southeast. These two routes were reported in different studies; however, we successfully show them with a consistent criterion. The most frequent COL approaching season is JJA at 200 hPa, but MAM at 500 hPa. And, we have found that strong class of COLs are most frequent in MAM for each level. We are investigating these seasonal variations of COLs and planning to introduce some results at the conference.

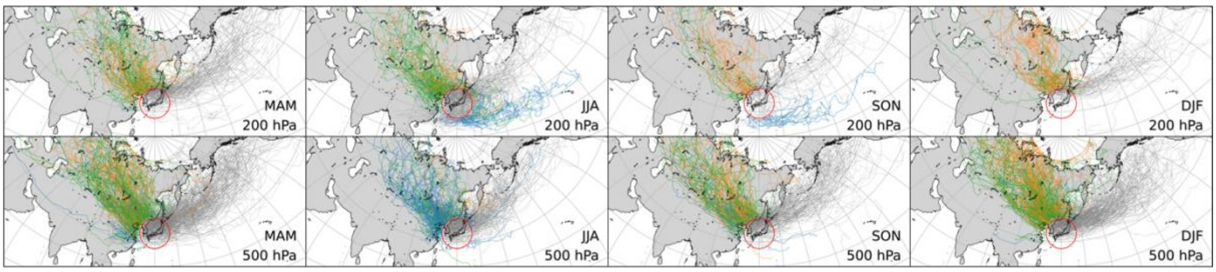

Figure 1. Seasonal change of cutoff lows (COLs) tracks approaching the Japan Islands during 1979–2021 using JRA-55. All track pass the red circle over the Japan Islands. Orange, green, and blue lines indicate, strong, intermediate, weak COLs, defined by their intensity on the red circle. Grey lines indicate tracks after reaching the red circle.

References

[1] S. Kasuga, M. Honda, J. Ukita, S. Yamane, H. Kawase, A. Yamazaki, Seamless detection of cutoff lows and preexisting troughs, *Mon. Wea. Rev.* **149** (2021)

S2-O03

Distinct seasonality in the frequency of migratory cyclones and anticyclones over the North Pacific

S. Okajima[1*], H. Nakamura[1] and Y. Kaspi[2]

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[2]*Department of Earth and Planetary Sciences, Weizmann Institute of Science, Israel*

The North Pacific storm-track activity measured by Eulerian eddy statistics is suppressed substantially under the excessively strong westerly to form a distinct minimum in midwinter, which seems inconsistent with linear baroclinic instability theory [1]. This "midwinter minimum" of the storm-track activity has been intensively investigated for decades as a test case for the storm-track dynamics [2-4]. However, the mechanisms controlling it are yet to be fully unveiled and are still under debate. Here we investigate the detailed seasonal evolution of the climatological density of surface migratory anticyclones over the North Pacific, in comparison with its counterpart for cyclones, based on a Lagrangian tracking algorithm. We demonstrate that the frequency of surface cyclones over the North Pacific maximizes in midwinter, whereas that of anticyclones exhibits a distinct midwinter minimum under the upstream influence, especially from the Japan Sea. In midwinter, it is only on such a rare occasion that prominent weakening of the East Asian winter monsoon allows a migratory anticyclone to form over the Japan Sea, despite the unfavorable climatological-mean conditions due to persistent monsoonal cold-air outbreaks and excessively strong upper-tropospheric westerlies. The midwinter minimum of the North Pacific anticyclone density suggests that anticyclones are the key to understanding the midwinter minimum of the North Pacific storm-track activity as measured by Eulerian eddy statistics.

References

[1] H. Nakamura, Midwinter suppression of baroclinic wave activity in the Pacific, *J. Atmos. Sci.* **49(17)** (2007)
[2] E. K. Chang, GCM and observational diagnoses of the seasonal and interannual variations of the Pacific storm track during the cool season, *J. Atmos. Sci.* **58(13)** (2001)
[3] H. Nakamura, T. Izumi, and T. Sampe, Interannual and decadal modulations recently observed in the Pacific storm track activity and East Asian winter monsoon. *J. Climate* **15(14)** (2002)
[4] S. Okajima, H. Nakamura, and Y. Kaspi, Energetics of transient eddies related to the midwinter minimum of the North Pacific storm-track activity, *J. Climate* **35(4)** (2022)

S2-O04

Remote influence of the interannual variability of the Australian summer monsoon on wintertime climate in East Asia and the western North Pacific

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In northern Australia, mean rainfall during the Australian summer monsoon (AUSM) season exhibits distinct interannual variability, which is unlikely forced by sea surface temperature anomalies but essentially a manifestation of the internal variability of the AUSM system. This study reveals its significant remote influence on the wintertime climate in East Asia and the western North Pacific [1]. The stronger AUSM excites a positive Western Pacific (WP) pattern with strengthening of the East Asian winter monsoon (Figure 1), leading to a colder winter over the Korean Peninsula and western Japan as well as reduced precipitation over southern China. Meanwhile, the Okhotsk sea-ice extent tends to decrease under warm anomalies and weakened offshore winds.

The mechanisms for this cross-equatorial teleconnection are investigated based on observational data and numerical experiments. The WP-like anomalies are excited by the propagation of stationary Rossby waves generated by upper-level divergent wind anomalies from the Southern Hemisphere that extends into the subtropical Asian jet. The climatological Hadley cell has an essential role in this process. Anomalous diabatic heating over East Asia and feedback forcing by transient eddies along the Pacific stormtrack act to further amplify the WP-like response.

The reproducibility of this remote influence in climate models and the remote influence in intraseasonal timescales may also be discussed in the presentation.

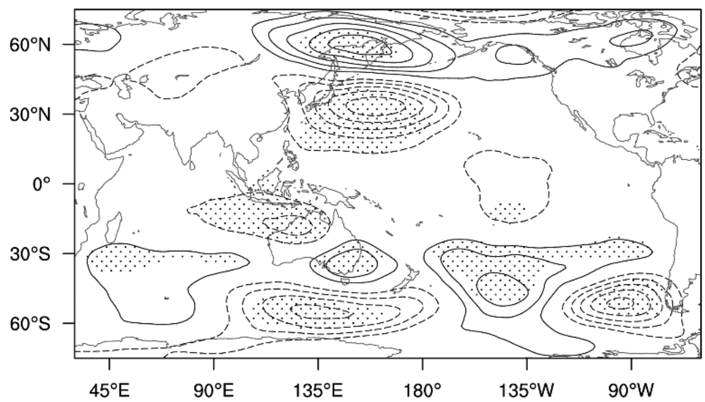

Figure 1. January-February mean 500-hPa geopotential height anomalies regressed onto the AUSM index. Solid and dashed contours denote positive and negative anomalies, respectively, with intervals of 3 m. Stippling indicates anomalies exceeding the 95% confidence level.

References

[1] S. Sekizawa, H. Nakamura, Y. Kosaka (2021): Remote influence of the interannual variability of the Australian summer monsoon on wintertime climate in East Asia and the western North Pacific. *Journal of Climate*, **34**(23), 9551–9570. doi:10.1175/JCLI-D-21-0202.1

S2-O05

Reconciling conflicting evidence for the cause of the observed early 21st century Eurasian Cooling

Stephen Outten[1,2,*], Camille Li[3,2], Martin P. King[3,4,2], Lingling Suo[1,2], Peter Y. F. Siew[3,2], Hoffman Cheung[5,6,2], Richard Davy[1,2], Etienne Dunn-Sigouin[3,2], Tore Furevik[1,2], Shengping He[3,2], Erica Madonna[3,2], Stefan Sobolowski[4,2], Thomas Spengler[3,2], and Tim Woollings[7]

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Arctic amplification of global warming is accompanied by a dramatic decline in sea ice. Over a decade ago, researchers noted that this sea ice loss was accompanied by an apparent cooling over the Eurasian subcontinent, most dramatically during the period 1998-2012. This is a counterintuitive impact under global warming and many studies suggested that changes in wintertime sea-ice were linked to this observed cooling through some hereto unknown teleconnection, whilst other studies argued that Eurasian cooling is mainly driven by internal variability. The ongoing debate regarding Arctic to mid-latitude teleconnections over the Eurasian sector has divided the scientific community, as highlighted by the work of Cohen et al. [1], giving the impression of strong disagreement between those holding the “ice-driven” versus “internal variability” viewpoints.

Here we present a new synthesis study into Eurasian cooling [2] which breaks down the debate into a simple structure by first examining the results of the observational and modelling studies separately, before reconciling some of the apparently conflicting results from the literature. While this study does not present a new mechanistic understanding of the processes underlying Eurasian cooling, it does present an alternative framing of the problem that shows how sea ice and internal variability perspectives can be compatible. Key to this is viewing Eurasian cooling through the lens of dynamics (linked primarily to internal variability with a small contribution from sea ice; cools Eurasia) and thermodynamics (linked to sea ice retreat; warms Eurasia). This approach, combined with recognition that there is uncertainty in the hypothesized mechanisms themselves, allows both viewpoints to co-exist and contribute to our understanding of Eurasian cooling. Rather than posit a “yes-or-no” causal relationship between sea ice and Eurasian cooling, a more constructive way forward is to consider whether the cooling trend was more likely given the observed sea ice loss, and a simple autoregressive model is employed to explore this question. Taken in this way both sea ice and internal variability are factors that affect the likelihood of strong regional cooling in the presence of ongoing global warming.

References

[1] Cohen, J., et al.: Divergent consensuses on Arctic amplification influence on midlatitude severe winter weather, *Nature Climate Change*, **10** (2020)
[2] Outten, S., Li, C., et al..: Reconciling conflicting evidence for the cause of the observed early 21st century Eurasian cooling, *Weather Climate Dynamics Discussions*, doi: 10.5194/wcd-2022-32 (preprint)

S2-O06

Barents-Kara sea-ice decline attributed to surface warming in the Gulf Stream

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Decline in winter sea-ice concentrations (SICs) in the Barents-Kara Sea significantly affects Arctic climate through changing heat exchange between the warm ocean and cold atmosphere. The winter SIC anomalies also remotely influence the mid-latitude surface air temperature in the Northern Hemisphere. However, the sea-ice decrease trend is underestimated in the multi-model mean of CMIP6 historical simulations. In this study, we show that climate model (MIROC6) simulations can reproduce the Barents-Kara SICs trend for 1970–2017 when sea surface temperature (SST) variations over the Gulf Stream region is constrained by observational data (Fig. 1). The constrained SST warming in the Gulf Stream enhances oceanic heat transports to the Barents-Kara Sea that strengthens the SIC decline. Furthermore, the linear trends between the Barents-Kara SIC and Gulf Stream SST are highly correlated in the CMIP6 ensemble (r=-0.75), suggesting that the externally forced component of the SST trend explains 56% of the forced Barents-Kara SIC trend. Our results suggests that the surface warming trend in the Gulf Stream region is an important pacemaker of the Barents-Kara SIC decrease over the past five decades and also imply that reducing uncertainty of the future SST response may be crucial for simulating the Arctic sea-ice change.

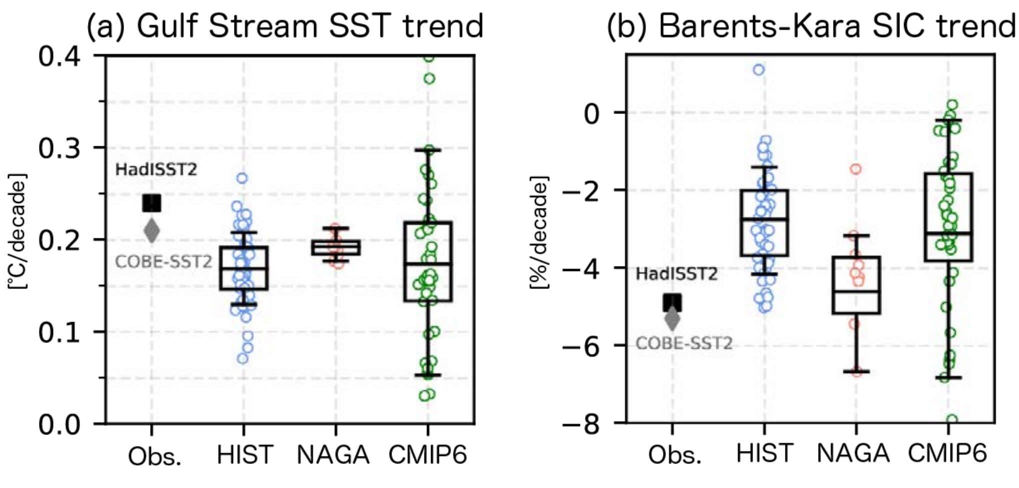

Figure 1. Observed and simulated linear trends of DJF SST in the Gulf Stream and SIC in the Barents-Kara Sea (1970–2017) for the observation (HadISST2; black, COBE-SST2; gray), MIROC6 historical experiments (HIST; blue), MIROC6 SST-nudging experiments (NAGA; red), and CMIP6 (green).

References

[1] Yamagami, Y., Watanabe, M., Mori, M., & Ono, J. (2022). Barents-Kara sea-ice decline attributed to surface warming in the Gulf Stream. *Nature Communications*, *13*(1), 1-10.

S2-O07

Atmospheric circulation-constrained model sensitivity delays timing of ice-free Arctic

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The Arctic climate system has been suggested to be 'en route' to a new state. Here we show that while the observed Arctic warming contains a substantial contribution from large-scale atmospheric circulation in reanalyses, it is not reflected in the modelled forced response. This suggests prospect of delayed emergence of a seasonally ice-free Arctic under future global warming scenarios. Hence a recalibration, comparing the warming signals free of these circulation impacts in observations and models, is proposed to constrain the models' Arctic sea-ice and Greenland ice sheet response to cumulative CO_2 forcing over 1979-2020. This manifests in an approximately decade delay in the projected timing of the first seasonally sea-ice free Arctic and widespread Greenland melting compared to the unconstrained projections for both moderate and high emissions scenarios. Accounting for the role of large-scale atmospheric forcing in Arctic climate change offers new perspectives of estimating regional Arctic climate sensitivity to anthropogenic forcing.

References

[1] D. Topál, Q. Ding, TJ. Ballinger, E. Hanna, X. Fettweis, Z. Li & I. Pieczka (2022): Discrepancies between observations and climate models of large-scale circulation driven Greenland melt impact sea-level rise projections, *Nature Communications* **in Press** doi: 10.1038/s41467-022-34414-2

[2] D. Topál & Q. Ding: Constrained model sensitivity recalibrates projected Arctic climate change, in revision

S2-O08

Energetics of Atmospheric Meridional Teleconnections of Internal/External Variability over the North Pacific in Winter

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The PNA pattern, the WP pattern, and the NPO are known as the dominant teleconnection patterns in the North Pacific in winter, all of which feature meridional dipoles of atmospheric circulation anomalies over the basin. In addition to tropical SST forcing, barotropic energy conversion from the background zonally asymmetric jet, and feedback forcing from transient eddies, recent studies have pointed out baroclinic energy conversion from the background state with strong horizontal temperature gradient for their formation and maintenance [1][2]. However, most studies have analyzed a specific pattern of their interest, and role of individual processes for the dominance of those patterns over other, non-dominant patterns has not been assessed. Besides the atmospheric internal processes, the extent to which external forcing such as SST variability contributes to the pattern dominance remains uncertain. In this study, we systematically extract 286 meridional dipole patterns centered at various locations in the wintertime North Pacific from the atmospheric internal variability (i.e., intrinsic variability without external forcing) and external variability (i.e., response to external forcing), which are separated by using a large ensemble AGCM simulation dataset. Then we discuss their dominance by evaluating their respective energy conversion efficiencies.

For all meridional dipoles, the net energy conversion efficiency is positive with the largest contribution from baroclinic energy conversion from the background state, indicating that all the meridional dipoles gain energy through atmospheric internal processes. For dipole patterns of internal variability, the net efficiency distribution exhibits geographical dependence (Fig. 1a), mainly determined by the barotropic and baroclinic conversion from the background state. There are two efficiency maxima, which correspond to the PNA-like pattern and NPO/WP-like pattern. Dipole patterns of the external variability have overall lower net energy conversion efficiency (Fig. 1b) due to reduced efficiency of baroclinic conversion.

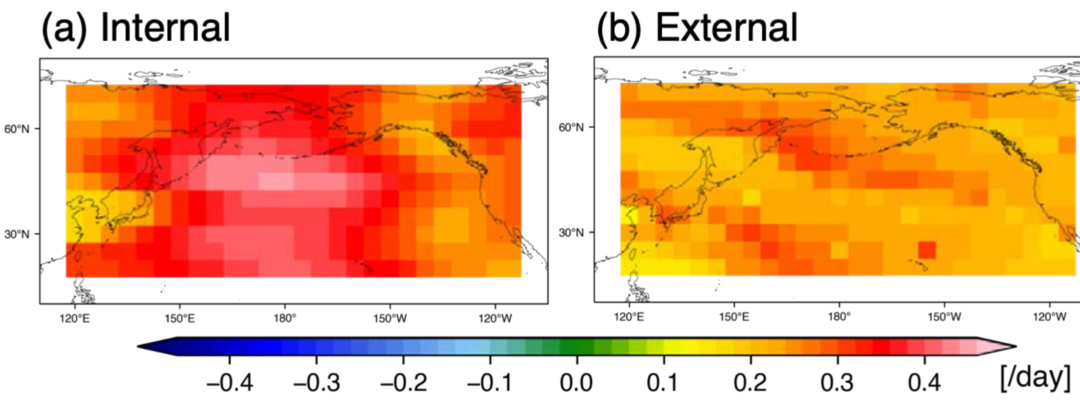

Figure 1. The net energy conversion efficiency for 286 dipoles over the wintertime North Pacific extracted from (a) internal variability and (b) external variability.

References
[1] S. Tanaka, K. Nishii, H. Nakamura, Vertical Structure and Energetics of the Western Pacific Teleconnection Pattern, *J. Climate* **29** (2016)
[2] M. Kim, C. Yoo, M. Sung, S. Lee, Classification of Wintertime Atmospheric Teleconnection Patterns in the Northern Hemisphere, *J. Climate* **34** (2021)

Changing Role of Atmospheric Temperature Advection and Water Vapor Advection under Arctic Amplification using a Large-scale Ensemble Model Dataset

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Under elevated concentration of greenhouse gases, the Arctic undergoes an increased amount of warming compared to the global average in a phenomenon known as Arctic Amplification (AA). One of the leading topics of debate concerning AA is the importance of remote transport of heat into the Arctic from the midlatitudes via advection of temperature and water vapor. Here, we investigate the role of temperature and moisture advection in the lower troposphere under changing level of global warming using the Database for Policy Decision-Making for Future Climate Change (d4PDF; Mizuta et al. 2017[1]) dataset which consist of a large ensemble AGCM dataset designed to quantify the response in atmospheric processes under changing state of greenhouse gasses and sea surface temperature as well as sea-ice boundaries. We also utilize the modified formulation of Wang et al. (2019) [2] to decompose the advection into terms related to dynamical changes, thermodynamical changes and their covariances. Using the non-warming experiment (HPB-NAT) as a baseline, we applied this method to the temperature and water vapor in the lower tropospheric level of 925hPa and compared the difference between the historical experiment (HPB) and 2K/4K elevated global warming experiments (HFB-2K / HFB-4K, respectively).

Analysis over the northern winter season of DJF shows that the total advection in HPB experiment undergoes a positive change in temperature advection over the Arctic driven by a stronger dynamical component of advection along the sea-ice boundary in the North Atlantic and the Northern coastline of the Eurasian continent. This feature drastically changes under HFB-2K and HFB-4K where the total advection turns negative due to the contribution of both the thermodynamical term and the eddy term. The thermodynamical term becomes increasingly negative under weaker temperature gradient and the negative contribution of the eddy term which is related to the effect of sub-monthly transient eddies dissipating the heat released from the ocean dominates over the region where sea ice diminishes. Region along the Eurasian continent where sea ice is reduced shows a large release in sensible heat which is consistent with the negative eddy term.

Similar result can be seen for water vapor where increase in water vapor advection is seen over the North Atlantic due to the dynamical term. The thermodynamical term shows a north/south dipole pattern where the advection of water vapor in the northern Barents Sea increases while there is a marked decrease along the Scandinavian coast. In our presentation, we will further explore the regionality and seasonality of the water vapor advection.

References

[1] R. Mizuta, A. Murata, M. Ishii et al, Over 5,000 Years of Ensemble Future Climate Simulations by 60-km Global and 20-km Regional Atmospheric Models, *Bull Am Meteorol Soc*, **98**, 1383–1398 (2017)

[2] F. Wang, S. J. Vavrus, J. A. Francis, J. E. Martin, The role of horizontal thermal advection in regulating wintertime mean and extreme temperatures over interior North America during the past and future, *Clim. Dyn*. **53**, 6125–6144 (2019)

Exchange of atmospheric moisture between Arctic Ocean and Eurasian continent investigated by moisture transport model experiment

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Persistent abnormal weather events can cause considerable damage to human society and natural environments. In northern Eurasia, such abnormal weather events in the warm season have been enhanced as a result of natural variability and global warming (Sato and Nakamura, 2019). The heatwave over Siberia and associated blocking high helped maintain the abnormal rainfall over East Asia in summer 2020, suggesting Arctic to mid-latitude teleconnection (Nakamura and Sato, 2022). To understand the contribution of hydrological cyclone, this study investigates the exchange of atmospheric moisture between Arctic Ocean and Eurasian continent considering the source of atmospheric moisture. The analysis was performed by the tagged moisture transport model driven by reanalysis data as described in Sato et al. (2022). It is found that the transport of atmospheric moisture to Siberia that originated from Arctic Ocean evaporation has increased substantially in autumn to early winter during 1981–2019 when substantial sea ice retreat was observed. The enhanced Arctic moisture content is found in western Siberia in September, consistent with the observed increase in snow cover investigated in earlier studies. Meanwhile, the annual maximum daily amount of Arctic moisture shows a sharp increase in eastern Siberia during October–December associated with cyclonic activities along coastal regions.

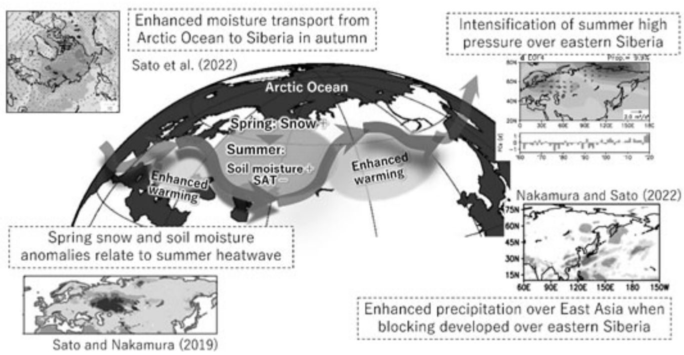

Figure 1. Illustration of the land-atmosphere interaction and hydrological cycle over Arctic ocean and northern Eurasia.

References

[1] Sato T., and T. Nakamura, Intensification of hot Eurasian summers by climate change and land-atmosphere interactions. *Scientific Reports*, 9, 10866, DOI: 10.1038/s41598-019-47291-5 (2019)
[2] Nakamura, T., and T. Sato, 2022: A Possible Linkage of Eurasian Heat Wave and East Asian Heavy Rainfall in Relation to the Rapid Arctic Warming. *Environmental Research*, 209, 112881, DOI:10.1016/j.envres.2022.112881
[3] Sato, T., T. Nakamura, Y. Iijima, and T. Hiyama, 2022: Enhanced Arctic moisture transport toward Siberia in autumn revealed by tagged moisture transport model experiment, *npj Climate and Atmospheric Science*, DOI: 10.1038/s41612-022-00310-1, in press.

Climatological Characteristics of Atmospheric Rivers over Northern Eurasia during Summer

Y. Fukutomi[1*], H. Kanamori[1], and T. Hiyama[1]

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Atmospheric rivers (ARs) have been regarded as a synoptic precipitation producing system which forms a sharp and narrow band structure of strong moisture transport. They tend to be accompanied by development of extratropical cyclones, fronts, and cloud bands which produce heavy precipitation and flooding in the mid-latitude continental coastal regions. It might be expected that ARs induce high-impact weather events also in the higher-latitude continental inland regions. This study examines structure and characteristics of ARs over northern Eurasia during the 43 summer seasons (JJA 1979−2021). Main focus is on the characterization of the continental ARs that are responsible for hydrometeorological impacts in Siberia. The AR events are objectively detected by applying a hierarchical cluster analysis to vertically integrated water vapor transport whose intensity exceeds a specific criterion. The resulting AR patterns are classified into five distinct types over northern Eurasia. Relationships between the AR types, extratropical cyclones, frontal activity, and cloudiness are investigated with composite analysis using JRA-55-based atmospheric variables, gridded precipitation analysis (MSWEPv2.8), and satellite-based cloud amount data (ISCCP-H). The ARs are further characterized as an inland type and an Arctic coastal type. The inland-type ARs tend to penetrate eastward and northeastward into the warm frontal zone accompanied by the extratropical cyclone development in the western and northwestern side of the ARs. Intense precipitation bands are aligned to the warm frontal zones associate with the inland ARs. The coastal-type ARs are more zonally oriented and their axis is almost parallel to warm frontal zones. A zonally elongated warm frontal zone occurs associated with extratropical cyclone activity over the Arctic coastal region. An enhanced precipitation band is collocated with the warm frontal zone whose axis is located to the north of the AR axis. Activities of deep convective cloud and nimbostratus cloud are enhanced within the precipitation band. They can be main precipitating clouds in the well-developed AR precipitation band over northern Eurasia.

Interdecadal Variations of Monthly Water Budget Comportments in Warm Season over Siberia

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Precipitation variability in warm season (from May to September) over Siberia significantly impacts river discharges into the Arctic Ocean from the three major Siberian River basins (Ob, Yenisei, and Lena). Summer precipitation (rainfall) is derived mainly from evapotranspiration from the land surface, whereas large-scale moisture flux convergence is relatively small in summer. The boreal forest plays an essential role in the hydrological cycle through evapotranspiration over Siberia. It has been reported that boreal forests in eastern Siberia were severely damaged by permafrost degradation and waterlogging owing to continuous high summer rainfalls from 2005 to 2008. It is, therefore, essential to reveal the spatial and temporal variability of Siberian summer rainfall for understanding hydroclimate and the responses of boreal forest ecosystem in the northern high-latitude regions. Interdecadal variation in summer rainfall associated with that in stationary waves was predominant over Siberia. However, interdecadal variation of the hydrological cycle in the region remains unclear. In this study, we investigate interdecadal variations in the atmospheric water budget components from 1980–2021 in order to further understand the atmospheric-land surface interaction over Siberia.

Persistent wet years in the late 2000s and dry years in the late 2010s related to the decadal variability in summer, particularly over eastern Siberia (Lena River basin), were detected in the MSWEP (Multi-Source Weighted-Ensemble Precipitation) dataset. The increasing rainfall trends in July and August contributed mainly to the wet period. However, the rainfall in June has not increased considerably compared to the other warm months in this period. In contrast, the decreasing rainfall trends in June and August were dominant in the recent dry years of the late 2010s. Interestingly, interdecadal rainfall variation was weak in July, with persistently high rainfall since 2000s, while exhibiting notable interannual rainfall variability. The southerly water vapor transport anomalies evaluated with the ERA5 reanalysis data showed distinct decreases during the dry period, associated with the interdecadal variation of stationary wave train along the 65–75N° in June and August. And the evapotranspiration from June to August obtained from the GLEAM (Global Land Evaporation Amsterdam Model) data showed an increase with decadal change from the wet to dry periods. These results imply that the seasonal cycle of the atmospheric water budget and the hydrological cycle over Siberia were modulated with interdecadal variability.

March 6

Breakout Session

S3

Atmospheric composition and Arctic environment/climate:

New assessment reports and original studies

S3-O01

Size Distribution and Depolarization Properties of Aerosol Particles over the Northwest Pacific and Arctic Ocean

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Atmospheric aerosols over polar regions have attracted considerable attention for their pivotal effects on climate change. Temporospatial variations in single-particle-based depolarization ratios (δ: s-polarized component divided by the total backward scattering intensity) were studied over the Northwest Pacific and the Arctic Ocean using an optical particle counter with a depolarization module. The δ value of aerosols was 0.06 ± 0.01 for the entire observation period, 61 ± 10% lower than the observations for coastal Japan (0.12 ± 0.02) and inland China (0.19 ± 0.02) in summer. The volume concentration showed two dominant size modes at 0.9 and 2 μm. The super-micrometer particles were mostly related to sea-salt aerosols with a δ value of 0.09 over marine polar areas, ~22% larger than in the low-latitude region because of differences in chemical composition and dry air conditions. The δ values for fine particles (<1 μm) were 0.05 ± 0.1, 50% lower than inland anthropogenic pollutants, mainly because of the complex mixtures of sub-micrometer sea salts. High particle concentrations in the Arctic Ocean could mostly be attributed to the strong marine emission of sea salt associated with deep oceanic cyclones, whereas long-range transport pollutants from the continent were among the primary causes of high particle concentrations in the Northwest Pacific region.

S3-O02

Concentrations and physical properties of refractory black carbon in the atmosphere over the Pacific and the Antarctic Ocean

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Black carbon (BC), emitted by combustion processes of fossil-fuel and biomass, in the Arctic atmosphere has attracted considerable interest due to its significant impact on snow and glacial melting, particularly in the Arctic region. However, little is known about its chemical and physical properties and the histories of its emissions and transport over the Antarctic ocean. In this study, we will measure refractory black carbon (rBC) including its number and mass concentration, size distributions, and mixing state using an extended-range single particle soot photometer (SP2-XR, DMT) on the Korean R/V Araon through the Pacific and the Antarctic ocean, focusing on the Terra Nova Bay over the Ross Sea during November to December 2022.

SP2 has recently been used in the Arctic region as it provides high-resolution data based on a single particle approach. In detail, this field measurement aims to provide spatial distributions of the rBC properties and explore its emission sources and aging processes in the atmosphere of the Pacific and the Antarctic ocean. Detailed results will be presented in the meeting.

Acknowledgement

This work was supported by Korea Polar Research Institute (KOPRI) grant funded by the Ministry of Oceans and Fisheries (KOPRI PE22900)

S3-O03

Observations of the Central Arctic Atmosphere and Surface Using Uncrewed Aircraft Systems

G. de Boer[1,2,3*], R. Calmer[1], G. Jozef[1], J. Cassano[1], J. Hamilton[1,2], U. Egerer[4], D. Lawrence[5], A. Doddi[5], and B. Argrow[3]

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Over a six-month period, a team from the University of Colorado Boulder operated uncrewed aircraft systems (UAS) or drones alongside the research icebreaker *Polarstern* during its drift through the Central Arctic Ocean as part of the MOSAiC expedition (de Boer et al., 2022). These observations provide high-resolution perspectives on the temporal and spatial variability of atmospheric and surface parameters. This includes nearly 100 flights in the lowest 1 km of the atmosphere using the DataHawk2 UAS, which measures thermodynamic and kinematic properties of the atmosphere. The Datahawk2 was specifically operated in close proximity to small leads to assess the influence of those ice features on the lower atmosphere, and was additionally used to provide frequent profiles in between radiosonde launches. In addition to the DataHawk2, the team also operated the HELiX, a hexacopter equipped to make detailed measurements of ice surface features and the surface albedo. This platform captured information on the evolution of the ice surface during MOSAiC leg 4, including information on melt pond fraction and surface cover. It also provided detailed information on the significant dependence of measured surface albedo on altitude above the surface, helping to bridge gaps between surface based albedo sensors, helicopters and satellites.

Here, we will provide an overview of the flights conducted with these UAS during the MOSAiC campaign. We will provide insight into the evolution of lower atmospheric and boundary layer properties and processes during legs 3 and 4 of MOSAiC. We will additionally provide insight into the evolution of the ice surface, including albedo during the summer melt season, as seen by the HELiX platform. Finally, we will highlight some efforts to understand the ability of numerical weather prediction models to accurately portray these complex Arctic processes in relation to the observations collected by UAS and other platforms during MOSAiC.

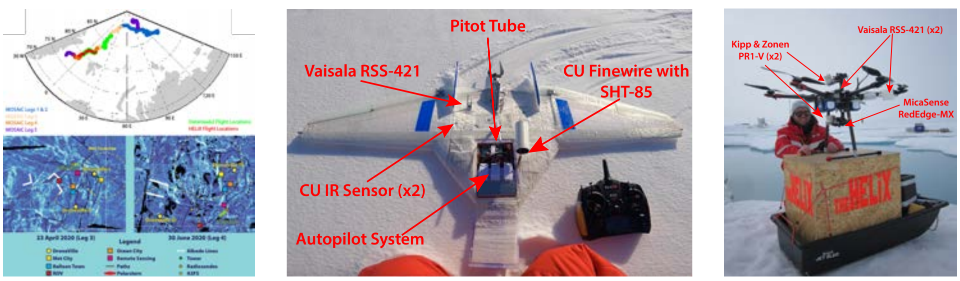

Figure 1. A map showing the flight locations (left), and photographs of the different UAS (center, right).

References

[1] G. de Boer, and co-authors: Observing the Central Arctic Atmosphere and Surface with University of Colorado Uncrewed Aircraft Systems, *Nature Sci. Data.*, **9**, 439, https://doi.org/10.1038/s41597-022-01526-9.

S3-O04

Potential impact of marine biota on the formation of marine bioaerosols, CCN, and INP over the Arctic Ocean

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[2] National Institute of Polar Research, Japan
[3] Graduate School of Integrated Sciences for Life, Hiroshima University, Japan
[4] Yokohama Institute for Earth Sciences, JAMSTEC, Japan

Marine bioaerosols originating from marine biological activities are uplifted from the ocean surface to the atmosphere and they could drive climate change via cloud processes by acting as cloud condensation nuclei (CCN) and ice-nucleating particles (INP). Nevertheless, the abundance and distribution of atmospheric biological particles over the ocean and the potential roles of marine biota in the cloud-forming processes via sea-air exchange are still unknown. To investigate the bioaerosols over the ocean and their relationship with the marine biogenic sources, cruise observation was conducted on R/V MIRAI from 28 Sep to 10 Nov 2019, over the North Pacific, the Bering Sea, and the Arctic Ocean.

Bioaerosol particles in the ambient air were identified with an online waveband integrated bioaerosol sensor (WIBS-4) and categorized based on the fluorescence patterns and particle size. Organic gel particles from marine biota, i.e., the polysaccharides transparent exopolymer particles (TEP) and the proteinaceous Coomassie stainable particles (CSP), were extracted from surface seawater and quantified. Additionally, physicochemical properties of aerosol particles (number-size distribution, number concentration, and chemical composition) and cloud-activation properties as CCN and INP were also obtained by in-situ observations. Using these comprehensive data, we will discuss (1) the geographic distribution and abundance of bioaerosols and their fluorescence pattern with the meteorological condition and sources, (2) the relationship between bioaerosols and oceanic biological activity underlining air-sea interaction, and (3) the roles of bioaerosols for activation in the cloud processes based on the observed CCN and INP.

S3-O05

Arctic marine aerosols observed during R/V Mirai cruise in Autumn, 2021

T. Kinase[1*], F.Taketani[1], T. Miyakawa[1], C. Zhu[1], M. Takigawa[1], and Yugo Knaya[1]

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Arctic climate change is one of the most important issues for the Earth's future. Aerosols contribute to climate change via effects on radiation and cloud properties, but measurements of Arctic aerosols are not sufficient to elucidate the roles, especially in the marine environment. To understand the Arctic climate change, observations of the temporal and spatial distributions and characteristics of diverse aerosol particles are required. Our group conducted online aerosol measurements and samplings throughout the Arctic cruise of R/V Mirai (MR21-05C) in 2021.

The research cruise was conducted between September and October 2021. We observed concentrations of BC (SP2), the size distributions of fine particles (Nano Scan model 3910), CO (48i-TLE), and O_3 (model 205) in the research room. Sample air was introduced to the CO and O_3 instruments using long Teflon tubes from the front of the compass deck and to the SP2 and SMPS using a custom-made concentric tube-type inlet. Aerosol samples for the transmission electron microscopic (TEM) analysis were collected using a two-stage auto impactor with several meters of conductive silicone tube every 1–4 hours. On the compass deck (18m asl), concentrations of coarse mode particles (KR-12A) and fluorescent particles (WIBS-4A) were observed. Aerosol samples were collected on quartz fiber filters using a high-volume air sampler (120SL) equipped with a single-stage impactor (TE-231) for the chemical analysis. The air sampler cooperated with a wind selector to avoid sampling ship plumes from R/V Mirai.

During the reseach cruise, we observed several typical events regarding aerosols' physical and chemical properties, such as the enhancements of fine particle numbers and the changes in particle's chemical features (Figure1). In figure1, we can see the changes of particle fraction of sulfate and sea salt occurring with the fine particle enhancement. In this presentation, we will introduce such results based on online measurements and TEM analysis observed during MR21-05C.

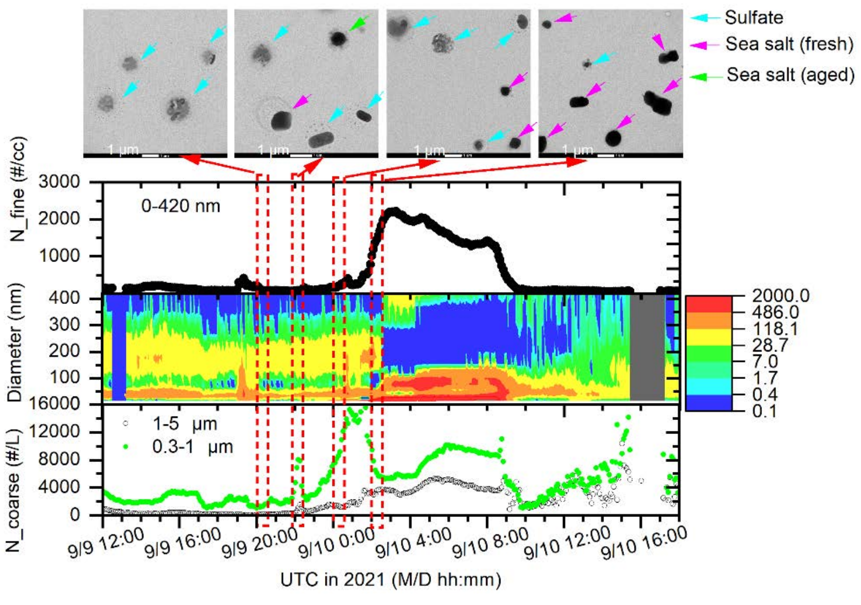

Figure 1. Time series of fine and coarse particle concentration, the size distribution of fine particles, and TEM photos of aerosol particles.

Source attribution of black carbon aerosols at Poker Flat, Alaska using FLEXPART-WRF

M. Takigawa[1*], F. Taketani[1], Y. Kanaya[1], H. Kobayashi[1], T. Kinase[1], C. Zhu[1], Y. Kim[2]

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[2]*University of Alaska Fairbanks, USA*

Black carbon aerosols (BC) are emitted into the atmosphere by incomplete combustion processes of fossil fuels and biomass. Especially in the Arctic region, anthropogenic emissions from mid-latitudes (e.g., China) are transported by large-scale atmospheric circulation. Local emissions, such as forest fires in boreal forests and gas flares in oil fields, are also considered to contribute significantly. In this study, we report on the emission source analysis for Poker Flat, Alaska, mainly focusing on the forest fire emission inventories, which still show large differences among the inventories.

Since April 2016, observations of BC and CO have been conducted at the Poker Flat Research Range (PFRR; 65.12°N, 147.49°W) in cooperation with the University of Alaska Fairbanks. The pathways of air parcels observed at PFRR were estimated using the Lagrangian particle diffusion model FLEXPART-WRF version 3.3. Backward calculations were performed for 20 days using 40,000 particles every 6 hours from April 2016 to December 2020. The meteorological field was calculated by a regional meteorological model (WRF) covering the Northern Hemisphere. The source attribution has been estimated using the residence time calculated by FLEXPART-WRF and emissions at each grid. The ECLIPSEv6 and six different inventories (FINNv1,5 FINNv2.5(MODIS, MODIS+VIIRS), GFEDv4.1a, GFASv1.2, QFEDv2.5r1, FEERv1.0-G1.2) were used as the anthropogenic and biomass burning emissions, respectively.

It was found that there were significant differences in the contribution of biomass burning among inventories in summer when the forest fires were active. Among them, GFEDv4.1 generally succeeded in capturing large fire events, especially in 2017 and 2019. If we assume the 'event period' as observed BC concentration exceeds the 98 percentiles for the whole period (>152.6 ng/m^3-STP), the contribution of biomass burning was estimated to be remarkably higher at the event period (69.4%) than that during the non-event period (22.1%).

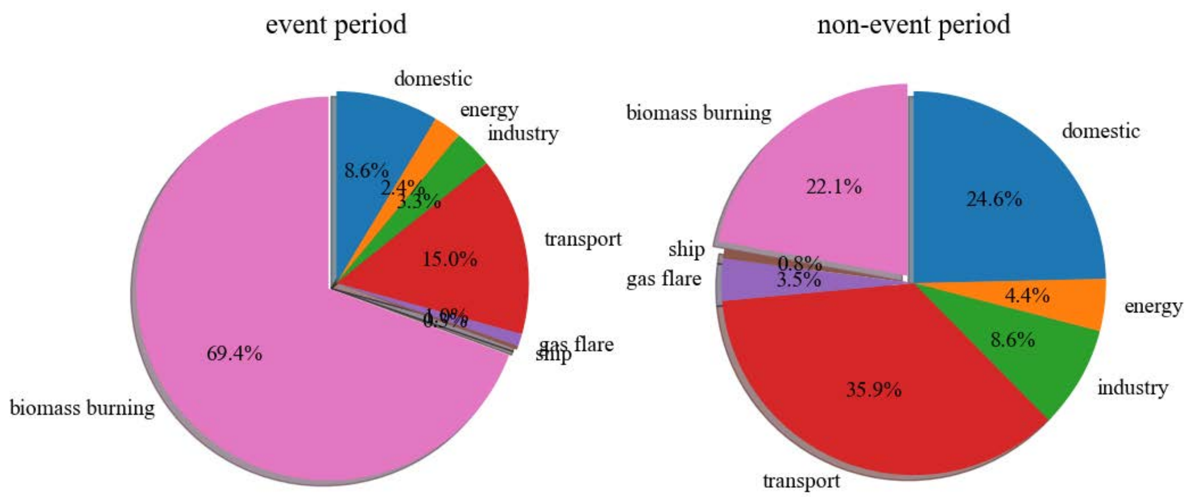

Figure 1. Source sectors estimated using FLEXPART-WRF for 2016-2020.

Ship-borne Observation of Ice Nucleating Particles over the Western North Pacific to the Arctic Ocean by R/V Mirai: Comparison with Composition of Aerosol Particles

F. Taketani[1*], Y. Tobo[2,3], M. Takigawa[1], T. Miyakawa[1], and Y. Kanaya[1]

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[2] National Institute of Polar Research, Japan
[3] The Graduate University for Advanced Studies, Japan

At high latitudes including the Arctic region, mixed-phase clouds consisting of droplets and ice are often present and play an important role in the hydrological cycle and climate of this region. Ice nucleating particles (INPs) present in low abundance in clouds, have a significant influence on the ice formation process and affect the characteristics of mixed-phase clouds by changing cloud radiation properties and lifetimes. Therefore, information on the concentration and source of INPs is important for estimating climate and hydrological cycles. However, information on INPs over the ocean at high latitude is extremely poor. In this study, we investigated the number concentration of INPs and the composition of aerosol particles over the western North Pacific to the Arctic Ocean measured by shipborne observation using the R/V Mirai from 22 August 2016 to 6 October 2016.

The number concentrations of INPs active at -25°C ($N_{\mathrm{INP(T>-25^{\circ}C)}}$) in this cruise varied from 0.03 - 41 L^{-1} (Figure 1). $N_{\mathrm{INP(T>-25^{\circ}C)}}$ over the Arctic Ocean (>70°N) was lower than those over the Bering Sea and the western North Pacific. Comparison of $N_{\mathrm{INP(T>-25^{\circ}C)}}$ with mass concentrations of Fe and Mn by filter analysis indicated that the variation trends were similar, suggesting that particles of terrestrial origin may be influencing observed $N_{\mathrm{INP(T>-25^{\circ}C)}}$. The number concentration of INPs active at -15°C ($N_{\mathrm{INP(T>-15^{\circ}C)}}$) was significantly observed over the Bering Sea and western North Pacific in late September. Comparison of $N_{\mathrm{INP(T>-25^{\circ}C)}}$ and $N_{\mathrm{INP(T>-15^{\circ}C)}}$ with number concentration fluorescent aerosol particles (N_{FAP}) measured by Waveband Integrated Bioaerosol Sensor (WIBS-4) indicated that $N_{\mathrm{INP(T>-15^{\circ}C)}}$ shows a higher correlation with N_{FAP} than $N_{\mathrm{INP(T>-25^{\circ}C)}}$, indicating that $N_{\mathrm{INP(T>-15^{\circ}C)}}$ may be influenced by biological materials. In addition, air masses affected by the Siberian Forest fires were also transported over the Bering Sea in this cruise period, suggesting that soil and biogenic particles from biomass burning had a significant impact on the observed $N_{\mathrm{INP(T>-25^{\circ}C)}}$ and $N_{\mathrm{INP(T>-15^{\circ}C)}}$.

Furthermore, we are planning to introduce the new Japanese icebreaker to be constructed in near future for the Arctic research (https://www.jamstec.go.jp/parv/e/).

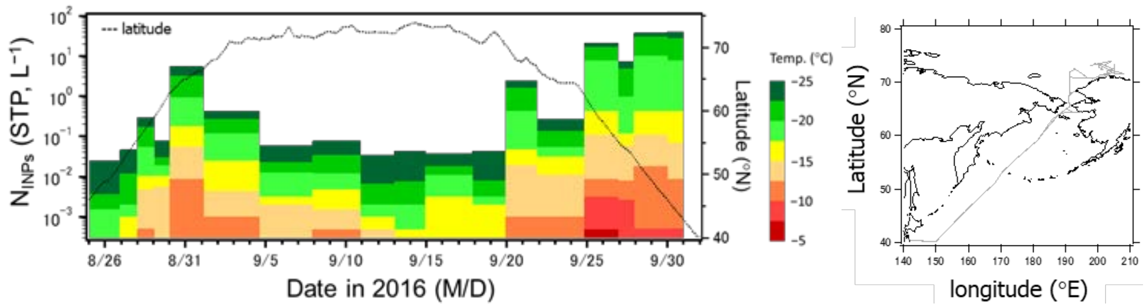

Figure 1. Time series of number concentrations of INPs (left) and cruise track (right) in this study.

S3-O08

Short-lived climate forcers in the Earth system: recent trends, source attribution, and future projections

Marianne Tronstad Lund[1*]

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This talk focuses on the most recent literature and assessments of atmospheric composition, trends, and projections of SLCF abundances, on global and regional scales, including the Arctic. Short-lived climate forcers (SLCFs) - including aerosols, methane, and ozone – play a key role in shaping the regional and global climate and environment. Limiting human-induced global warming and alleviating detrimental air quality requires concurrent reductions in CO_2, and other long-lived greenhouse gases (GHGs), and SLCFs. In contrast to well-mixed GHGs, SLCFs comprises a complex mix of spatially heterogeneous, chemically and radiatively active compounds with both cooling and warming temperature effects, as well as effects on other climate variables. Due to these characteristics and their short lifetime, SLCFs remain challenging to simulate and their climate effects can depend on the location of emissions, making source-specific attribution important for the development of mitigation strategies. Recent decades have also seen rapid shifts in the geographical distribution of anthropogenic emissions of aerosols and precursor gases, and existing scenarios span a wide range of possible future evolutions (Figure 1). The influence of differences in recent emission inventories on simulated aerosol and ozone distributions, and the subsequent radiative forcing will be explored. Finally, knowledge about the climate effects of emissions from different regions and sectors will be discussed, with an outlook for further required research.

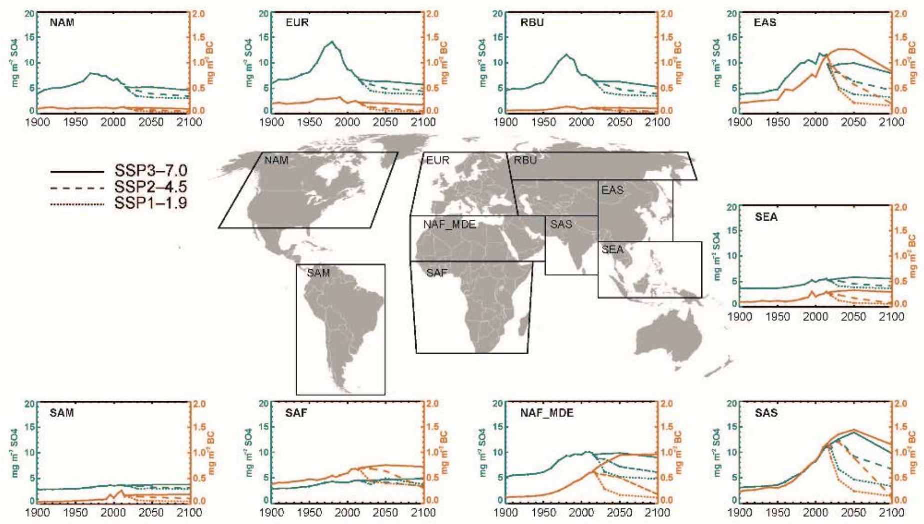

Figure 1: Simulated regionally averaged burdens of BC and sulfate aerosols from 1900 to 2100 using CEDS with the CEDS historical and SSP future emissions (Lund et al. 2019).

References: Lund, M. T., Myhre, G., and Samset, B. H.: Anthropogenic aerosol forcing under the Shared Socioeconomic Pathways, Atmos. Chem. Phys., 19, 13827–13839 (2019).

S3-O09

Impacts of Short-lived Climate Forcers on the Arctic Climate by MRI-ESM2.0 and Multi-model Analyses

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We developed the latest version of the Meteorological Research Institute Earth System Model MRI-ESM2.0 [1], which was one of the models that participated in the Coupled Model Intercomparison Project Phase 6 (CMIP6), contributing to the IPCC sixth assessment report, and the Arctic Monitoring and Assessment Programme (AMAP) short-lived climate forcers (SLCFs) assessment. MRI-ESM2.0 generally displays realistic reproduction in both mean climate and interannual variability. In this presentation, we introduce our recent studies, relevant to the Arctic climate, using MRI-ESM2.0 and multi-model analyses. First, the effective radiative forcing (ERF) of anthropogenic gases and aerosols under present-day conditions relative to preindustrial conditions is estimated using MRI-ESM2.0 as part of the Radiative Forcing Model Intercomparison Project (RFMIP) and Aerosol and Chemistry Model Intercomparison Project (AerChemMIP), endorsed by CMIP6 [2]. The global mean total aerosol ERF at the top of the atmosphere consists of 23% from aerosol-radiation interactions (-0.32 W m^{-2}), 71% from aerosol-cloud interactions (-0.98 W m^{-2}), and slightly from other effects (0.08 W m^{-2}). In the Arctic, black carbon (BC) and methane can provide the second and third largest contributions, respectively, to the positive ERFs after carbon dioxide. The reduction in the surface albedo due to BC deposition on snow over land and sea ice, which leads to a decrease in the snow cover due to snow melting, plays a major role in the Arctic mean shortwave ERFs of BC. This study also suggests the importance of interactions of aerosols with ice clouds, particularly over tropical convective regions. Second, observations showed the Arctic surface cooling during the mid-20th century (1940–1970) followed by ongoing rapid warming since 1970. We conducted a multi-model analysis using the CMIP6 Detection and Attribution Model Intercomparison Project (DAMIP) historical simulations, suggesting that human-related external factors could contribute to the high-latitude surface cooling observed in 1940–1970 [3]. Our analysis shows that both increased anthropogenic aerosols and multidecadal internal variability provide major contributions to the 1940–1970 Arctic surface cooling. Finally, we also introduce our recent activities for the AMAP SLCFs multi-model studies, which contributed to the AMAP SLCFs assessment report.

References

[1] Yukimoto, S., H. Kawai, T. Koshiro, N. Oshima, K. Yoshida, S. Urakawa, H. Tsujino, M. Deushi, T. Tanaka, M. Hosaka, S. Yabu, H. Yoshimura, E. Shindo, R. Mizuta, A. Obata, Y. Adachi, and M. Ishii, The Meteorological Research Institute Earth System Model version 2.0, MRI-ESM2.0: Description and basic evaluation of the physical component, *J. Meteor. Soc. Japan* **97** (2019)

[2] Oshima, N., S. Yukimoto, M. Deushi, T. Koshiro, H. Kawai, T. Y. Tanaka, and K. Yoshida, Global and Arctic effective radiative forcing of anthropogenic gases and aerosols in MRI-ESM2.0, *Prog. Earth. Planet. Sci.* **7** (2020)

[3] Aizawa, T., N. Oshima, and S. Yukimoto, Contributions of anthropogenic aerosol forcing and multidecadal internal variability to mid-20th century Arctic cooling—CMIP6/DAMIP multimodel analysis, *Geophys. Res. Lett.* **49** (2022)

Estimation of the Arctic CH_4 flux based on an ensemble of atmospheric inversions and aircraft observations

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Methane (CH_4) emitted from both natural and anthropogenic sources is the second most important greenhouse gas with poorly known sources located in the Arctic. The significance of studying the dynamics of CH_4 emissions from Arctic sources to the atmosphere has increased sharply in recent years in connection with the degradation of permafrost and subsea methane hydrate thawing. The high CH_4 concentrations in the troposphere over this region were derived from both ground-based measurements and space-borne observations of the total methane column. The recent review on the methane budget in the atmosphere clarifies the orders of magnitude of individual sources for the planet, but it does not answer the question of the reasons for the accelerated increase in the CH_4 concentration over the Arctic compared to other latitudes.

In this study, we have estimated methane sources and sinks using the Japan Agency for Marine-Earth Science and Technology's Model for Interdisciplinary Research on Climate (MIROC, version 4.0) (referred to as MIROC4-ACTM [1]) and atmospheric measurements from ground-based observations with a special focus on the 2000-2021 period. The CH_4 inversion enables the key regions with emission changes to be identified, and the information on emissions from different source sectors from an extensive set of inventories has been used to attribute affecting drivers [2]. Our inversion model system simulations with a set of mandatory and optional runs using various oxidant fields contribute to the global CH_4 budget estimation performed in the frame of the Global Carbon Project.

This MIROC4-ACTM CH_4 was estimated using airborne in-situ measurements of atmospheric CH_4 carried out during the extensive campaign undertaken in the troposphere over the Russian Arctic by means of the Optik Tu-134 [3] aircraft laboratory from 4 to 17 September 2020 [4]. The flight route of the above experiment covered all seas and coastal areas of the Russian sector of the Arctic and the Bering Sea as well. Vertical profiles were measured from the minimum permissible heights (typically 500 m above ground level and 200 m above seas) to the upper troposphere. The methane concentrations recorded over the seas were increased compared to the coastal areas during all time of the experiment. Whether the methane was of the oceanic origin or was transported from terrestrial sources is not clear yet. Clarifying this issue is of special scientific interest.

References

[1] Patra, P. K. et al.: Improved chemical tracer simulation by MIROC4.0-based atmospheric chemistry-transport model (MIROC4-ACTM), *SOLA* **14** (2018).
[2] Chandra, N. et al.: Emissions from the oil and gas sectors, coal mining and ruminant farming drive methane growth over the past three decades, *J. Meteorological Soc. Jpn (*2021).
[3] Anokhin, G. G. et al.: OPTIK Tu-134 aircraft laboratory, *Atmos. Oceanic Opt.* **24** (2011) in Russian.
[4] Belan B. D. et al.: Integrated airborne investigation of the air composition over the Russian sector of the Arctic, *Atmos. Meas. Tech.* **15** (2022)

Quantifying Contributions of Anthropogenic Aerosol Increase and Internal Variability to the Mid-20th Century Arctic Cooling by CMIP6/DAMIP Multimodel Analysis

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Observational Arctic surface air temperature (SAT) around 1970 was −0.95°C–−0.70°C lower than around 1940 (Figure.1). We conducted the multimodel analyses using the state-of-the-art climate models participated in Coupled Model Intercomparison Project Phase 6 (CMIP6) or Detection and Attribution Model Intercomparison Project (DAMIP) to quantify the factors contributing the Arctic cooling. Multimodel ensemble mean using all CMIP6 historical simulations suggested the contribution of external forcings to the Arctic cooling. Multimodel ensemble means using all DAMIP historical simulations exhibited Arctic surface cooling of −0.22°C (±0.24°C) in decadal mean SAT in 1970 versus that in 1940 and showed that anthropogenic aerosol forcings contributed to a cooling of −0.65°C (±0.37°C), which was partially offset by a warming of 0.44°C (±0.22°C) due to well-mixed greenhouse gases. When the multidecadal internal variability was combined with the cooling response to all forcings, its value reached −0.69°C (−0.93°C–−0.45°C), which is comparable to the observed cooling of −0.81°C. The ranges of 30-year Arctic SAT trends for weak and strong cooling fluctuations caused by the internal variability were estimated to be −0.6°C and −1.2°C with reemergence periods of approximately 70 and 2000 years, respectively. The ongoing warming signal will override the fluctuations due to internal variabilities in the Arctic. As anthropogenic sulfur emissions and sulfate aerosols contributing to cooling at Earth's surface will decrease in any future scenarios of shared socioeconomic pathways (SSP) [1], Arctic warming will continue over the near-term future even under strong cooling fluctuations generated by internal variability.

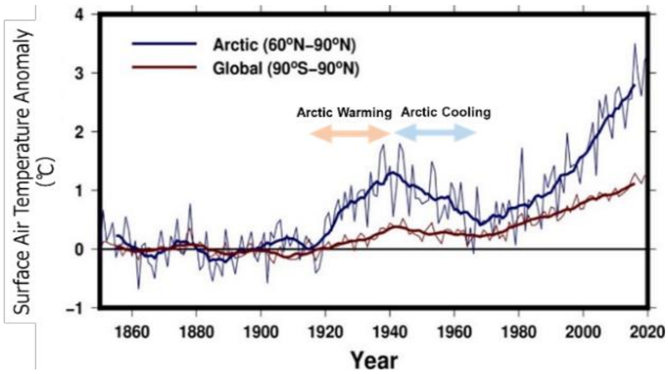

Figure 1. Observed surface air temperature changes in the Arctic (blue line) and Global (red line) relative to the 1850–1900 mean by HadCRUT5. Thick lines indicate 9-year running mean values.

References
[1] M. Gidden, K. Riahi, S. Smith, S. Fujimori, G. Luderer, E. Kriegler et al., Global emissions pathways under different socioeconomic scenarios for use in CMIP6: A dataset of harmonized emissions trajectories through the end of the century, *Geoscientific Model Development* **12(4)** (2019)

S3-O12

Expert Group on Black Carbon and Methane (EGBCM) - A Finnish Perspective on National Reporting

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Arctic States are responsible for 30% of black carbon's warming effects in the Arctic, because of the greater warming impact of local emission sources. Furthermore, methane is a well-mixed greenhouse gas, so reducing global sources will benefit the Arctic, and hence reductions in methane, whether from Arctic or non-Arctic States, is important for the mitigation of near-term warming of the Arctic. Under the **Arctic Council Framework for Action**[2], the Arctic States are committed to take "enhanced, ambitious, national and collective action to accelerate the decline in our overall black carbon emissions and to significantly reduce our overall methane emissions", and to submitting biennial national reports on countries' existing and planned actions to reduce black carbon and methane, national inventories of these pollutants and, when available, projections of future emissions.

To help implement these commitments, the Framework established an Expert Group on Black Carbon and Methane (EGBCM). The Expert Group was tasked with developing a biennial "Summary of Progress and Recommendations" based on the national reports and other relevant information. The 3rd Summary of Progress and Recommendations was ready in 2021, and the 4th Summary report is under preparation. In 2021, the EGBCM assessed that Arctic States have reduced their collective black carbon emissions by 20% in 2018, compared to 2013, and are on track to achieve the collective, aspirational goal to reduce black carbon emissions by 25-33% of 2013 levels by 2025. Collective methane emissions have increased by 2% from 2013 to 2018, and are projected to continue increasing to 2025. Continued efforts are hence required to maintain progress on black carbon emission reductions, and more ambitious efforts are required to reverse the trend of increasing methane emissions.

This presentation would introduce EGBCM work on national reporting and on the preparation of the Summary report as well as share recent experiences from the Finnish perspective.

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[2] Enhanced Black Carbon and Methane Emissions Reductions. An Arctic Council Framework for Action. Annex 4. Iqaluit 2015 SAO Report to Ministers, available at <https://oaarchive.arctic-council.org/handle/11374/610>.

S3-O13

Synthesis of bottom-up and observation-based black carbon emission estimates from China, Japan and Korea as Observer States of Arctic Council

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Reducing black carbon (BC) emissions by 25-33% relative to 2013 levels by 2025 is targeted by the Arctic States to stabilize the climate change. Asian countries including Japan, China and Korea as Observer States of the Arctic Council are invited to the work to reduce emissions and to report on their national progress, as their emissions can be transported for long distances to the Arctic region. However, the information content or accuracy is still limited to fully support the policy. Here our activities are introduced synthesizing recent emission estimates from bottom-up and top-down (atmospheric observation-based) approaches to assist the reporting processes. We aim for a regional assessment during 2024 and call for international collaboration.

China has been regarded as a major emitter and thus chiefly investigated. Our long-term observations of atmospheric BC mass concentrations using MAAP and COSMOS instruments since 2009 at Fukue Island (32.75°N, 128.68°E), western Japan, revealed that Chinese national total emission amount decreased significantly from 1.6 to 1.1 Tg yr^{-1} during 2009–2018 [1]. This evaluation includes correction for the interannual meteorological variability by using regional atmospheric chemistry model (WRF/CMAQ) simulations with constant emissions. Consistency with bottom-up inventories has remarkably improved recently: 1.04 and 1.21 Tg yr^{-1} for 2019 from Multi-resolution Emission Inventory for China (MEIC) [2] and the Community Emissions Data System (CEDS, v2021-04-21), respectively, and 1.15 Tg yr^{-1} for 2016 from ECLIPSE v6b. Based on the atmospheric concentration response to the COVID-19 lockdown, we estimated the dominance of residential sector (64%) for Feb–Apr 2019 [3], which was similar to 57% from MEIC for the same period, and 63% from ECLIPSE v6b for 2015, while other inventories estimated lower fractions. In the presentation, we will summarize information about Japan and Korea as well.

References

[1] Y. Kanaya et al., Rapid reduction in black carbon emissions from China: evidence from 2009–2019 observations on Fukue Island, Japan, *Atmos. Chem. Phys.*, **20**, 6339–6356 (2020)
[2] B. Zheng et al., Changes in China's anthropogenic emissions and air quality during the COVID-19 pandemic in 2020, *Earth Syst. Sci. Data*, **13**, 2895–2907 (2021)
[3] Y. Kanaya et al., Dominance of the residential sector in Chinese black carbon emissions as identified from downwind atmospheric observations during the COVID-19 pandemic, *Sci. Rep.*, **11**, 23378 (2021)

March 8

Breakout Session

S4

Synoptic Arctic Survey – international collaboration for Arctic Ocean transdisciplinary studies

S4-O01

Into the deep Central Arctic Ocean – results from the Nansen Legacy Arctic Basin expedition 2021

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In August-September 2021, the Norwegian icebreaker R/V *Kronprins Haakon* sailed to the Central Arctic Ocean within the Nansen Legacy project, to investigate the deep and ice-covered Nansen and Amundsen basins. The purpose was to provide integrated scientific knowledge on the rapidly changing marine climate and ecosystem of the Nansen and Amundsen basins in order to facilitate sustainable management through the 21st century. The research focus was on physical, chemical and biological processes in the sea ice, water column and at the seafloor in a climate change perspective. The expedition was a Norwegian contribution to the Synoptic Arctic Survey. We will present preliminary results from the water column carbonate chemistry, ocean acidification state and drivers.

S4-O02

AdvanCing knowledge on the present Arctic Ocean by chemical-phySical, biogeochemical and biological obServAtioNs to preDict the futuRe chAnges (CASSANDRA)

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The Arctic and sub-Arctic regions have been warming more than twice as rapidly as the rest of the world for the past 50 years. The Arctic climate has undergone tremendous changes, such as Arctic wetting, reduction of Arctic sea-ice thickness and coverage, decrease of snow cover extent and duration, thawing of permafrost and melting of Greenland ice sheet. The changes in sea-ice conditions in turn accelerate warming, by reduced summer albedo and through the additional heat flux from the ocean as more open water areas are maintained later into the Autumn. This positive feedback effect is among the main processes responsible for the "Arctic Amplification", which is likely to strengthen in the years to come. Arctic and sub-Arctic ecosystems are environmentally sensitive regions, where the impact of global climate change is expected to make marked changes over the next decades and more rapidly than elsewhere. However, many of its consequences have yet to be understood. In this context, the Arctic Ocean and its marginal seas remain profoundly understudied and among the least-known basins in the world ocean, due to their remoteness, hostile weather and the multi-year or seasonal ice-cover. To fill this lack of relevant information, a bottom-up initiative called the Synoptic Arctic Survey (SAS; https://synopticarcticsurvey.w.uib.no), with the aim of developing synoptic-scale observations across the Arctic Ocean and its marginal seas, was organized. SAS consists of regional shelf-to-basin ship-based coordinated surveys to generate a comprehensive dataset of essential ocean variables (atmospheric, chemical-physical, biogeochemical and biological) on a quasi-synoptic, spatially distributed basis. SAS aims to take a "picture" of the Arctic Ocean in as much detail as possible and to answer the main scientific question: what is the current state and major ongoing changes in the Arctic marine system? The CASSANDRA project (granted by the Italian Arctic Research Program, PRA) aims at contributing to the Synoptic Arctic Survey (SAS) effort by studying a historical transect to 75° N (CASSANDRA I: 29 August - 14 September 2021) crossing the Greenland Sea Gyre, and the work plan has been designed to contribute to answer this question. Preliminary results of the CASSANDRA I oceanographic cruise will be presented concerning the hydrography of the 75° N transect, ecosystem functioning and productivity, carbon uptake and ocean acidification.

S4-O03

Overview of the R/V Mirai Arctic Ocean cruise in 2022

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The Arctic Ocean cruise of Research Vessel (R/V) Mirai has been conducted from 12 August to 29 September 2022, under the Arctic Challenge for Sustainability II (ArCS II) project. The Arctic Ocean is the area with the fastest rate of global oceanic warming in the world. The detailed research of the R/V Mirai along with other icebreaking vessels, satellite observation and numerical modeling have documented the impact of inflow of the Pacific origin water We have observed sea ice decrease and marine ecosystem changes associated with Pacific origin waters bringing heat, nutrients, fresh water into the Arctic. Its impact is getting greater and more wide spread into the entire Arctic.

In 2022, we conducted hydrographic, paleoenvironmental and biogeochemical surveys, including plankton, trace-metals, microplastic, eDNA and aerosols in the Chukchi and Beaufort Seas. Three hydrographic moorings and a sediment trap mooring were also recovered and re-deployed on the pathway of the Pacific origin water to monitor transport and impact on marine ecosystem. In the marginal ice area, various drifting buoys were launched to measure the ocean waves and sea ice interaction. Trials of an under-the-ice drone, designed for automated cruise and observations in the sea ice area, were carried out. In addition to observation of present Arctic environments, sediment records have been collected by piston, gravity, multicore and box corers to understand differences between the present environmental changes and past warming events in the Arctic Ocean.

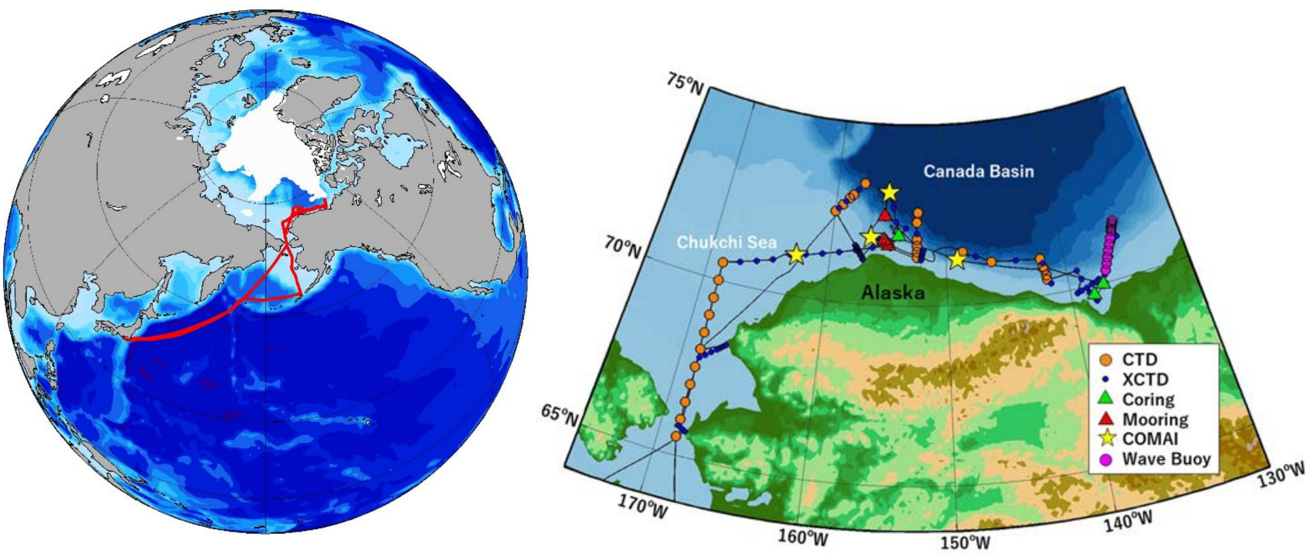

Figure 1. Map of the entire cruise area (left) and enlarged research areas in the Arctic Ocean (right). The cruise track and minimum ice coverage during the observation term from SSM/I (left). Orange and blue dots show CTD/ROS and XCTD stations (right). Green and red circles denote moorings and sediment coring stations. Yellow stars show the locations of under ice drone trials.

S4-O04

Benthic Studies during the 2022 US Synoptic Arctic Survey

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Benthic population and carbon cycling studies were part of the US contribution to the international Synoptic Arctic Survey (SAS), supported by the US National Science Foundation on the USCGC Healy in September-October 2022. Goals of the US SAS included determining the current state of the Pacific Arctic ecosystem from the Chukchi continental shelf into the Canada Basin and up to the North Pole, specifically water masses, the marine ecosystem and carbon cycling. Macrofaunal population and sediment respiration rates were highest on the Chukchi shelf, declining to extremely low levels in the high Arctic, consistent with lower water column chlorophyll biomass in both the water column and surface sediments under more persistent ice cover. However, significant chlorophyll biomass was present on the shelf and slope as late as mid-October. Benthic images showed marine snow on the outer shelf and slope, with little detritus in the deep Arctic Basin. Sediments were collected for total organic carbon and nitrogen content, grain size, and meiofaunal and microbial community studies. We outline here the benthic SAS program details and preliminary results that will be shared with international SAS partners. Overall the SAS will contribute to understanding the present state of the ecosystem on a pan-Arctic basis.

Surface microplastic concentrations and water-column microplastic inventories in the Chukchi Sea, western Arctic Ocean

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The recent influx of microplastics into the Arctic Ocean may increase environmental stress on the marine ecosystem, which is experiencing significant sea-ice loss owing to global warming. Quantitative data on microplastics in the Arctic Ocean on the Pacific side are very limited, and the microplastic budget of the water column is completely unknown.

Therefore, in this study, we observed surface concentrations (number of particles per unit volume of seawater) of microplastics using a neuston net in the Chukchi Sea, Bering Strait, and Bering Sea. From these observations, we estimated the water-column microplastic inventories (total number of microplastics in the entire water column). The mean water-column microplastic inventory in the Chukchi Sea was 5,236 pieces/km^2, which was one-thirtieth of those for the Arctic Ocean on the Atlantic side and less than one-tenth of the average for the global ocean. Because the total area of the Chukchi Sea is 620,000 km^2, the total number of microplastics floating in the entire Chukchi Sea was estimated to be 3.3×10^9 pieces.

However, the annual flux of microplastics from the Pacific Ocean into the Chukchi Sea, estimated from microplastic concentrations in the Bering Strait, was estimated to be 1.8×10^{10} pieces/year. This value was approximately 5.5 times greater than the total amount of microplastic in the seawater of the entire Chukchi Sea. This suggests that microplastic inflows from the Pacific Ocean are accumulating in large amounts in reservoirs other than the Chukchi Sea water-column (e.g., sea ice and seafloor sediments) or in the downstream regions of the Pacific-origin water, such as the Beaufort Sea.

S4-O07

Shrink of an ocean gyre in the Pacific Arctic and Atlantification open a door of shadow zone

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The Arctic Ocean is now facing dramatic environmental and ecosystem changes. In this context, an international multiship survey project was undertaken in 2020 to obtain current baseline data. For the first time, extremely low dissolved oxygen and acidified water were found in a fishable area of the western Arctic Ocean. The data suggested that the Beaufort Gyre shrank to the east of an ocean ridge and formed a front between the water within the gyre and the water expanded from the eastern Arctic. That phenomenon triggered a frontal northward flow that was 2–3 times faster than before. This flow could transport the low oxygen and acidified water, which had ever appeared only in the shelf-slope of the East Siberian Sea, toward the fishable area.

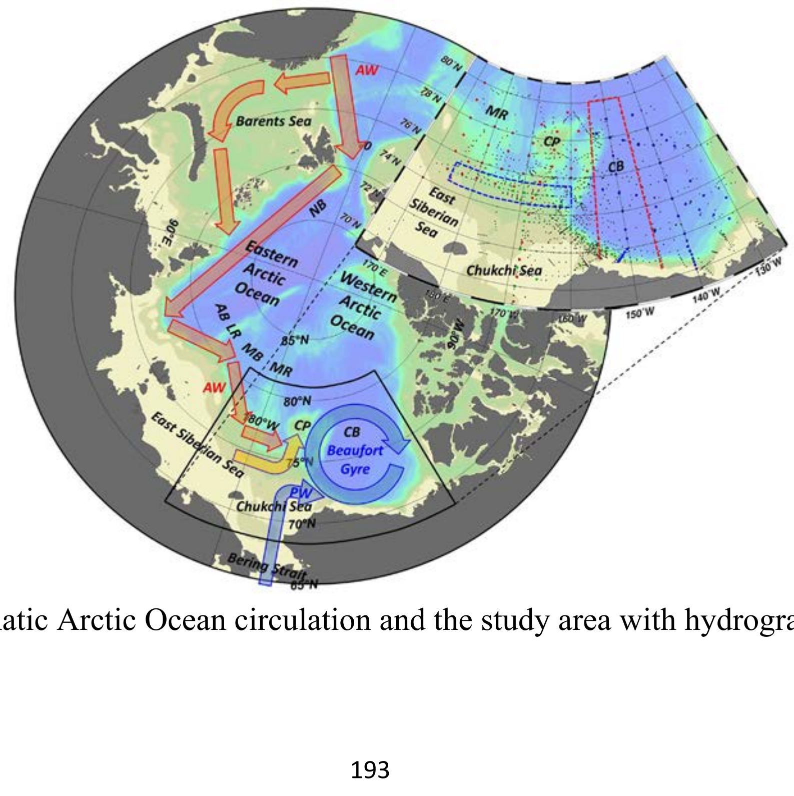

Figure 1. Schematic Arctic Ocean circulation and the study area with hydrographic stations.

S4-O08

Temporal changes in radiocesium in the Arctic Ocean and the northwestern North Pacific Ocean by 2020

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Dissolved radiocesium (^{134}Cs and ^{137}Cs) in the ocean, which was derived from the nuclear weapon testing and nuclear accidents, plays a role as a tracer for studies of water circulation in the ocean. The bomb-derived ^{137}Cs was deposited in the northern hemisphere mostly in the 1950s and 1960s. The ^{137}Cs deposited in the North Atlantic Ocean was transported into the Arctic Ocean although the bomb-derived ^{137}Cs transport from the North Pacific Ocean to the Arctic Ocean was limited because of the narrow Bering Strait between the two basins. In the 1990s, the ^{137}Cs concentration in the Arctic Ocean increased due to the polarward transport of the ^{137}Cs released from nuclear-fuel reprocessing plants in the United Kingdom and France mainly in the 1980s [1]. The ^{137}Cs concentration in the North Pacific Ocean increased in the 2010s due to the ^{137}Cs released from the Fukushima Dai-ichi Nuclear Power Plant (FNPP1) accident in March 2011. In the case of the FNPP1 accident another radioactive isotope, ^{134}Cs was also released. The FNPP1-derived ^{134}Cs had been transported to the Bering Sea and then the Arctic Ocean (Chukchi Sea) by 2017 [2]. We measured vertical profiles of ^{134}Cs and ^{137}Cs activity concentrations in the Canada Basin in the Arctic Ocean and the western subarctic area of the North Pacific Ocean in 2020 and discussed their temporal changes by 2020. The FNPP1-derived ^{134}Cs was not detected in the surface layer from the sea surface to 800 m depth at a station in the Canada Basin (75°N/160°W approx.) between 2012 and 2015. In 2020, ^{134}Cs (about 1.5 Bq/m^3, decay-corrected to the FNPP1 accident date) was observed in the surface layer shallower than 100 m depth, which suggests transport of the FNPP1-derived ^{134}Cs from the Chukchi Sea to the Canada Basin between 2015 and 2020 along with the surface current. At a station in the western subarctic area of the North Pacific Ocean (47°N/160°E approx.), the ^{134}Cs concentration in the surface layer shallower than 100 m depth decreased continuously from about 4 Bq/m^3 (decay-corrected) in 2012 to about 0.4 Bq/m^3 (decay-corrected) in 2017 due to its eastward transport. In 2020, ^{134}Cs concentration in the surface layer increased to about 1 Bq/m^3 (decay-corrected), which suggests a return of the FNPP1-derived ^{134}Cs from the eastern to the western subarctic area along the anti-cyclonic subarctic gyre current about ten years after the accident. In the Canada Basin in the Arctic Ocean, ^{137}Cs concentration in the subsurface layer between 300 and 800 m depth significantly decreased from about 3.5 Bq/m^3 (decay-corrected) in 2012–2015 to about 2.3 Bq/m^3 (decay-corrected) in 2020, which implies a shift of water circulation in the thermocline in the Arctic Ocean between 2015 and 2020.

Reference

[1] J. N. Smith, F. A. McLaughlin, W. M. Smethie, Jr., S. B. Moran, K. Lepore, Iodine–129, ^{137}Cs, and CFC–11 tracer transit time distributions in the Arctic Ocean, *Journal of Geophysical Research* **116** (2011).

[2] Y. Kumamoto, M. Aoyama, Y. Hamajima, M. Inoue, S. Nishino, T. Kikuchi, A. Murata, K. Sato, Fukushima-derived radiocesium in the western subarctic area of the North Pacific Ocean, Bering Sea, and Arctic Ocean in 2019 and 2020, *J. Environmental Radioactivity.* **251-252** (2022).

March 6

Breakout Session

S7

Arctic hydrology in the context of warming climate

River streamflow change in continuous permafrost environment in Eastern Siberian Arctic

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A growing number of studies presents evidence of climate change impacts on hydrological cycle in the Arctic rivers. Our study analyses trends in annual and monthly streamflow in 21 gauges located in four large and poorly studied Arctic river basins in Eastern Siberia, for the period 1967-2017. Trends of precipitation and air temperature in the corresponding catchment areas was also analyzed, The Anabar, Olenek, Yana and Indigirka rivers are fully covered by continuous permafrost. The selected river basins are considered as pristine environment since no dams, intensive landuse or big towns exist there. The climate is distinctly continental. The catchment areas of 21 gauges vary from 16.6 to 198000 sq.km. The mean annual discharge is from 0.09 to 1160 cub.m/s. Time series were evaluated for stationarity in relation to the presence of monotonic trends with Mann–Kendall and Spearman rank correlation tests at the significance level of $p < 0.05$.

Annual discharge increased by 25-85% over the study period in 10 of the river basins, while the remaining 11 basins show no significant change. There is a clear seasonal pattern in monthly flow changes with a higher number of gauges showing positive trends from September to December compared to the rest of the year. Downstream parts of the studied rivers undergo more severe hydrological change than upstream areas. The relative trend magnitudes are higher at the small and middle-sized catchments, while absolute magnitudes are larger at the big rivers. Spatially coherent patterns of significant trends are detected, which are further investigated by stratifying the results into several regions based on topography. Annual air temperature increased significantly in all river basins, with changes ranging between 1 and 3 degrees over the study period. Significant trends in monthly air temperatures were detected in all river basins from March to June. However, a pattern of non-significant trends in monthly air temperature from July to December was detected, correlating in space to the absence of trends in the annual streamflow in the westerly located rivers (Anabar, Olenek, and parts of Yana).

This work was conducted in the HYPE-ERAS project which is funded by FORMAS (project DNR: 2019-02332), RFBR (project No 20-55-71005) and JST (Grant No. JPMJBF2003) through the Belmont Forum Collaborative Research Action: Resilience in the Rapidly Changing Arctic.

S7-O02

WATER FLOW CHANGES IN THE LENA RIVER AT KYUSYUR DURING 1936–2019

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The long-term changes in river water flow of the Arctic rivers, as well as those in other regions, are characterized by contrasting periods or phases, according to the terminology adopted in Russia of their increased and decreased values with various durations. A large amount of long-term variability exists: some long-lasting periods can be distinguished by a duration of 10–15 years, while others last many decades. These contrasting phases are characterized by specific, relatively steady water regimes. This article is devoted to the study of long-lasting periods (phases) of increased and decreased water flow of the Lena River at Kyusyur. The long-term series of the Lena River daily water discharges near the village of Kyusyur have been naturalized after the creation of the Vilyuysky reservoir. The Kalinin-Milyukov flow routing method [1] conceptualizes a relation between the inflow and outflow of a river section as a linear function of water stored within the reach. The parameters of the influence function were determined on the basis of data on average daily water discharges in the Kyusyur and Tabaga on the Lena River, as well as in the Okhotsk Ferry on the Aldan River, for which there were observational data covering periods during which there was no noticeable anthropogenic impact on the flow of the mentioned rivers. This made it possible for the entire observation period (1936-2019) to determine the shift points between the long-term phases of increased/decreased annual and seasonal water flow and investigate their features. The quasi-synchronous nature of the sequence of phase changes of reduced and increased values of annual and seasonal flow was revealed. It is common for rivers within the basins of the Lena and Yenisei rivers. The duration of the contrasting phases varied in a wide range from 10 years (the phase of decreased snow melt flood flow) to 58 years (the phase of decreased annual water flow). At the same time, both for annual and seasonal flow, the phases of decreased flow were longer. At the same time, the most noticeable difference in the flow of contrast phases was observed in the winter and summer-autumn seasons, when it was 48 and 30%, respectively. The smallest difference is typical for snow-melt flood flow and annual flow (11-12%).

References

[1] G.P. Kalinin, P.I. Milyukov. Approximate calculation of unsteady motion of water masses. *Proc. of the Central Institute of Forecasts*. Issue **66**. Leningrad, 72 p. (1958) (In Russian).

S7-O04

Trends in River Water Chemistry Suggest Permafrost Degradation in the Kolyma River Basin

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The Arctic regions are now facing the environmental changes, including water and biogeochemical cycles, mainly due to permafrost degradation in response to the warming climate. To understand the impact of permafrost degradation on arctic river biogeochemistry, it will be beneficial to investigate long-term water chemistry data. In this study, we analyzed the river water chemistry data (Ca, Mg, SO_4^{2-}, and Alkalinity) in the Kolyma River from 1980 to 2020, obtained from the Global Environment Monitoring System for Freshwater (GEMS/Water) and the Arctic Great Rivers Observatory (Arctic GRO). We also analyzed trends of annual/seasonal air temperature and summer (June–August) precipitation in the Kolyma River basin using Climatic Research Unit gridded Time Series v4.05 (CRU) on a 0.5 latitude/longitude grid for 1980−2020. Both long-term datasets (GEMS and Arctic GRO) showed increases in the annual concentrations of Ca, Mg, and SO_4^{2-} during 1980−2020. On the other hand, alkalinity in both datasets did not show any clear trend over this period. We also found that annual/seasonal air temperature increased in the whole Kolyma River basin during 1980−2020, and this trend was stronger in the northern part of the basin. Summer precipitation also exhibited an increasing trend in the whole basin, although regional difference was not obvious. Considering the increased air temperature and summer precipitation in the basin, it is reasonable to assume that increased concentrations of Ca, Mg, and SO_4^{2-} were resulted from promoted mineral weathering in soils due to higher soil temperature and increased rainfall, as indicated in the Yukon and Mackenzie rivers [1,2]. Regarding the alkalinity, an increase over the recent decades was reported in the Ob and Yenisey rivers [3], but there was no increase in the Kolyma river and the concentration is lower than those rivers. This inconsistent result is likely related to the permafrost characteristics in the Kolyma River basin; ice-rich Yedoma is generally distributed in the northern part of the basin where the increase in air temperature was more obvious. Because alkalinity is a proxy of the residence time of the supra-permafrost groundwater flow, the lower concentration of the alkalinity in the Kolyma indicated relatively new water discharge to the main stream. In contrast, higher concentration and increasing trend of alkalinity in the Ob and Yenisey rivers suggested more contribution of old water discharge due to permafrost degradation [3]. In the Kolyma river basin, the relatively shallow active layer helps to discharge new water, and degradation of Yedoma supplies ground ice-melt water with less alkalinity to the Kolyma river.

References

[1] Toohey et al., Multidecadal increases in the Yukon River Basin of chemical fluxes as indicators of changing flowpaths, groundwater, and permafrost. *Geophys. Res. Let.* **43**(12) 120–130 (2016)

[2] Tank, et al., Multi-decadal increases in dissolved organic carbon and alkalinity flux from the Mackenzie drainage basin to the Arctic Ocean. *Environ. Res. Let.* **11**(5) (2016)

[3] Drake et al., Increasing alkalinity export from large Russian Arctic rivers. *Environ. Science and Technol.* **52**(15) (2018)

S7-O05

Indicators of recent hydro-climatic and river temperature change in the Mackenzie River Basin

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Canada's north is warming at more than double the global rate, and causing substantial changes to the region's hydrology and ecology. This study assesses recent (1980-2018) changes in air temperature, precipitation, snowpack, streamflow and water temperature in the Mackenzie River basin. We focus on mean and extreme indicators, including climate extremes (CLIMDEX), and mean, maximum and minimum snow, streamflow and water temperature. We use a machine-learning framework to evaluate the relationships between these variables and their changes. Our initial results indicate mostly increasing annual and seasonal air temperature in the basin, with higher increases in the northern sub-basins than southern sub-basins. Precipitation is also mostly increasing across the basin with higher increases in the northern regions. Annual and seasonal discharge trends in the basins are generally small and non-significant. However, summer water temperature mostly show significant increases, suggesting that the air temperature increase in the main driver of water temperature changes. Further analysis will provide more detailed insights on the controls, sensitivities and interactions of these mean and extreme indicators.

Radium Isotopes as Tracers of Shelf-Basin Exchange Processes in a Changing Arctic Ocean

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The continental margins of the Arctic Ocean play a significant role in Arctic surface water chemistry via inputs of biologically important materials including carbon, nutrients, and trace metals from rivers and shelf sediments. Rapid warming of the Arctic may further amplify these inputs through increases in river discharge, coastal erosion, and permafrost thawing; reductions in sea ice extent may enhance inputs from shelf sediments via increased turbulence near the seabed in shallow shelf seas (Figure 1). Given their ubiquitous sediment production and release from decay of uranium-thorium series radionuclides in marine environments, radium (Ra) isotopes have been proven as useful tracers of these various input processes.

Since 2015, we have been measuring Ra isotopes in the Arctic Ocean water column to test the hypothesis that the net annual flux of shelf-derived materials from eastern Arctic shelves to Arctic surface waters is increasing in response to climate warming. Data from that year indicated a near two-fold increase in radium-228 compared to published data from 2007 and earlier, which suggests that shelf-material fluxes had increased substantially on a sub-decadal time-scale. Levels of ^{228}Ra observed in 2018 and 2021, remained similarly high, but do not appear to have risen further. Circulation modeling results, water mass fractions, and high-resolution radium sampling from 2021 further elucidated the major source of radium isotopes to the central Arctic Ocean as the East Siberian Sea. This work highlights the need for further data on how climate change is affecting shelf-basin exchange of biologically-important materials in the Arctic Ocean.

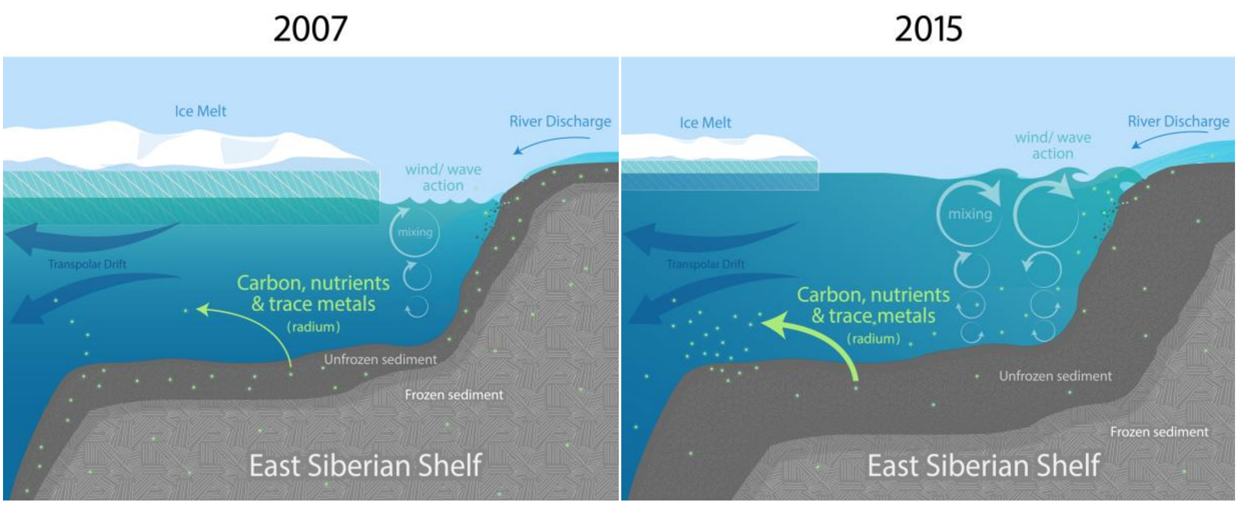

Figure 1. We have hypothesized that the loss of sea ice over Arctic shelves leads to longer open water seasons and increased wind- and wave- driven turbulence. This increased mixing can facilitate the release of shelf-derived materials into the overlying water column. (Graphic by Natalie Renier, WHOI Creative Studio).

Arctic sea ice retreat does not enhance atmospheric hydrological cycle

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Arctic hydrological cycle is increased in the past decade. A driver that induced the increased hydrological cycle is considered to be the Arctic sea ice retreat, which increases local evaporation and enhance heat transportation from mid-latitudes in winter season. While previous studies have investigated the impacts of Arctic sea ice on atmosphere, these included the effect of other factors. Here, we quantified the impacts of Arctic sea ice retreat on atmospheric hydrological cycle using an idealised sea ice retreat experiment simulated by an atmospheric general circulation model[4]. We observed an increase in local evaporation in the area associated with sea ice retreat. However, Arctic became dry condition due to increase surface air temperature, resulting in small impact on terrestrial Arctic precipitation. Additionally, the simulated precipitation isotopes increased as reduced sea ice. These results suggest that Arctic sea ice retreat does not increase hydrological cycle, it alone cannot explain the increased Arctic hydrological cycle.

S7-O08

Permafrost hydrology changes due to expansion, erosion, and merging of thermokarst lakes in Central Yakutia

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The ice-rich permafrost region is subject to local-scale topographic change due to the development of thermokarst associated with arctic climate change. Recently, it has been pointed out that the expansion of thermokarst may significantly alter hydrologic processes through developing a network of channels along the development of polygonal topographic troughs [1]. Once expanded as a thermokarst lake by topographic subsidence, lateral erosion causes collapse runoff, merging with nearby lakes or draining into lower elevation valleys and old alases. These channelization processes are called the lake and drained lake basin systems [2]. The system has been noted as major changes to not only hydrological processes but also the landscape and ecosystems of permafrost regions.

In the central Lena River Basin (Central Yakutia), thermokarst lakes develop within the boreal forest on several river terraces. We compared Planet satellite imagery [3] from 2017-2022 for the Yukechi area on the Tyungyulyu terrace and the Churapcha area on the Abrakh terrace, together with high-resolution AW3D DSM. We assessed how many thermokarst lakes are expanding and merging (Fig. 1). The results showed that more thermokarst lakes are growing within the boreal forest in the Churapucha area than in Yukechi and that the number of combined lakes was increasing. In Yukechi, there had been already combined, and drained thermokarst lakes, and several alases were combined to form one extended watershed.

The merging of thermokarst lakes and their channelization may lead to further runoff and subsequent desiccation of the areas. The spatio-temporal variability and rapidity of the processes should be assessed, as they are likely to be associated with irreversible ecohydrological changes.

The present study is supported by the Arctic Challenge for Sustainability Research Projects II (JPMXD1420318865) funded by MEXT and JSPS KAKENHI (19H00556).

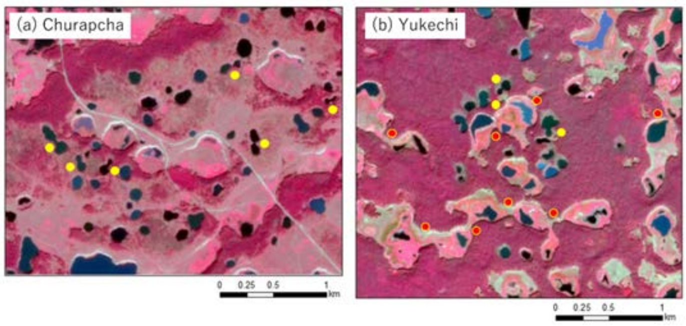

Fig.1 Thermokarst lakes in (a) Churapcha and (b) Yukechi. Yellow dots show merged lakes. Red dots show merged and channelized lakes and alases.

References
[1] Liljedahl, A. K., J. Boike, R.P. Daanen, A. N. Fedorov, et al., Pan-Arctic ice-wedge degradation in warming permafrost and influence on tundra hydrology, *Nature Geoscience* **9**, 312–318 (2016)
[2] Jones, B.M., Grosse, G., Farquharson, L.M. et al. Lake and drained lake basin systems in lowland permafrost regions, *Nat Rev Earth Environ* **3**, 85–98 (2022)
[3] Planet Team. Planet Application Program Interface: In Space for Life on Earth. San Francisco, CA. https://api.planet.com. (2017)

Continued warming of the permafrost regions over the Northern Hemisphere under future climate change

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Abstract:

Surface air temperatures can directly affect the thermal state of permafrost in the permafrost region of the Northern Hemisphere (PRONH). It is necessary to understand the trends in air temperatures and consider actual CMIP future scenario output instead of a linear temperature increase over different permafrost regions. In this study, air temperatures from 23 models of the sixth coupled-model intercomparison project (CMIP6) are evaluated against observational data from the PRONH. It is shown that most of the models reasonably represent the dominant characteristics of air temperature variations. Under three different future scenarios, air temperature and warming trends are examined using an optimal model ensemble. Results show that mean annual air temperature (MAAT) is higher in sporadic-permafrost and isolated-permafrost regions than in continuous-permafrost regions. MAAT warming rates were 0.10 °C/decade and 0.35 °C/decade from 1900 to 2014 and from 1980 to 2014, respectively, and were 0.09 °C/decade, 0.38 °C/decade, and 0.95 °C/decade from 2015 to 2100 under the low- to high-emission scenarios. Air temperature varies considerably between the high-altitude, transitional, and high-latitude permafrost regions, and warming trends are the greatest in high-latitude permafrost regions under future scenarios. Moreover, warming trends in different permafrost classes vary little from the historical values from 1900 to 2014, and with a gradual increase from isolated-permafrost regions to continuous-permafrost regions under future scenarios. The results suggested that air temperatures in the PRONH warmed approximately 1.6 times faster than global air temperatures from 1980 to 2014 and under the three future scenarios.

S7-O10

Contribution of water rejuvenation induced by climate warming to evapotranspiration in subarctic boreal forest

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Current climate warming is enhancing the warming of permafrost in the Arctic. Although permafrost is a crucial component of the Arctic terrestrial water cycle, its influence on processes regulating the fluxes and ages of Arctic terrestrial water, particularly soil water storage and evapotranspiration, is not well understood. In this study, a water age calculation scheme was implemented into the coupled hydrological and biogeochemical model (CHANGE) to assess the mechanisms through which climate warming affects the soil water storage–evapotranspiration–water age feedback cycle in subarctic boreal forests. A previous study (Park et al., 2022) indicated that permafrost warming, characterized by earlier active layer thawing and later freezing, induced higher evapotranspiration, thereby shortening the residence time of precipitation-sourced water in the active layer and further rejuvenating water in soil layers and in evapotranspiration. Based on the result, the similar model simulation is conducted over the pan-Arctic scale, and the analyses are focused on changes in water ages of evapotranspiration and their correlations with warming permafrost. These will increase our understanding for the accelerating Arctic terrestrial water cycle under the climate warming conditions.

References

[1] H. Park, T. Hiyama, K. Suzuki, Contribution of water rejuvenation induced by climate warming to evapotranspiration in a Siberian boreal forest, *Frontiers in Earth Science* doi:10.3389/feart.2022.1037668 (2022)

Snow Surface Roughness across Space, Time, Land Cover, and Scales

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When there is snow on the ground, the snowpack is the interface between the atmosphere and earth's surface. The surface of the snowpack changes due to its interaction with meteorological processes, such as precipitation inputs, wind, humidity, short and long-wave radiation, the underlying terrain characteristics, and land cover. These connections create a dynamic snow surface, yet this surface is considered a constant parameter in many earth system models. Such differences impact the energy and mass balance of the snowpack and the blowing snow potential, and other processes.

The data from the NASA Cold Land Processes Experiment (CLPX) collected in 2002 and 2003 across northern Colorado were used to investigate the spatial and temporal variability of snow surface roughness. The random roughness (RR) and fractal dimension (D) metrics used in this investigated are well correlated (Figure 1). However, roughness is not correlated across scales, here computed from snow roughness boards at a millimeter resolution and airborne lidar at the meter resolution. Process scale differences are found based on land cover at each of the two measurement scales (Figure 1), as appraised through measurements in the forest and alpine.

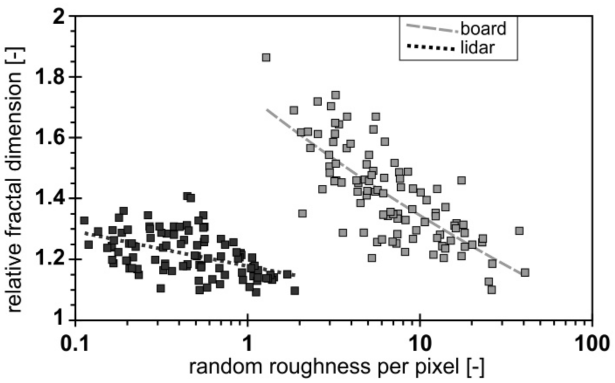

Figure 1. Relative fractal dimension (D) versus standardized random roughness for fine (snow roughness board) and coarse (lidar-based) scales

March 7

Breakout Session

S9

Sustainable, responsible, and resilient Arctic tourism: lip service or concrete actions

Transpolar Tourism: Lessons Learned, Challenges Conquered, and Future Features, from North to South

Dr. Ellen Cressman Frye

William Paterson University of New Jersey, USA

When one contemplates the Polar Regions, whether North or South, the environment and the landscape are strikingly different from all other regions on Earth, whether desert, jungle, tropical, or mountainous. Both the North Pole and the South Pole have their own distinguishing features, which are ennumerated here, but as a whole, the challenges that visiting the Polar Regions are explored, through the specific lens of tourism. Glaciers, ice sheets, icebergs, and unique flora and fauna attract humans' curiosity, and people long to visit the unique polar regions. This presentation opens with by comparing and contrasting the history of polar tourism, including when people began touring the Northern Polar Region versus the Southern; why they wanted to visit these regions; and who these first tourists were, as well as when and how they traveled. Next, the trajectory of tourism to the Polar Regions is explored: how quickly it exploded in popularity and why. Intermingled are challenges faced by tourism in each Polar Region, such as weather, ice, fear of disturbing wildlife and sealife, as well as other region-specific difficulties. How these challenges were overcome, including accompanying lessons learned, will be analyzed. The importance of the history of Polar Region tourism cannot be highlighted enough because it shines a spotlight on current features and challenges, particularly over-tourism, global warming, and overall climate change, among others. We need to get more people excited about and fascinated by the Polar Regions, in order to effectuate positive transformation, such as protecting the environment and decelerating climate change. We cannot underestimate the intrinsic value of polar tourism, and the crucial role it plays, in growing an increased awareness of, concern about, and eventually, passion for the Polar Regions, inciting people to action, which in the case of both the Arctic and Antarctica, is becoming critical.

S9-O02

Pathways to Culturally Sensitive Tourism Policies and Practices

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Market-driven development, outsider operators with little knowledge of Indigenous or other local cultures, stereotypical representations and cultural appropriation are common interrelated problems in Arctic tourism. This paper brings together discussions of social practices and cultural sensitivity in order to gain a better understanding of how more inclusive, legitimate and effective sustainable tourism policies can be formulated. Our research draws on a wide range of stakeholder interviews and benchmarking in Arctic Finland, Sweden, Norway, Greenland and Canada. It focuses on two bundles of culturally sensitive practices that tourism companies utilise, according to our empirical material: reciprocal practices enhancing collaboration and respectful practices related to authenticity. Moreover, we identify local knowledge as the connecting element between these two bundles. The paper suggests cultural sensitivity as a novel framework for tourism policymaking and sustainable tourism practices.

Our research was supported by the Northern Periphery and Arctic Programme 2014–2020, under Project No. 274 – Culturally Sensitive Tourism in the Arctic (ARCTISEN). We would like to acknowledge ARCTISEN project partners for their support and commitment to developing culturally sensitive tourism in the Arctic.

Keywords: Arctic tourism, authenticity, collaboration, cultural sensitivity, Indigenous peoples, local knowledge, practice theory, recognition, respect, reciprocity, tourism policy

In search of the authentic experience:
Case of Sàmi Indigenous Adventure Tourism

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The global warming causes rapid environmental changes and the global COVID-19 pandemic have directly affected the tourism industry as well as the local communities in the Arctic. In northern Finland, for example, traditional reindeer herding practices have suffered from difficult winters and the pandemic prevented the visits of the international tourists. These developments posed a challenge to the sustainable development and community resilience. In the field of indigenous tourism, questions concerning authenticity have attracted attention for long time, not least because of the cases where indigenous cultures (including also Sàmi culture) have been misused when creating improper services to tourists. According to our understanding, the matching desires and expectations of both the supply (indigenous hosts) and demand side (visitors) are at the core of authentic tourism experiences and sustainability of the field.

This study examines the authentic experience through a case study focusing on Sàmi indigenous tourism in Inari region in Finland. We also clarify how the authentic experience relates to the sustainable indigenous tourism, not only economically, but culturally, environmentally, and most significantly, ethically. This research leans on the conceptual framework of Adventure Tourism (AT). AT has recently become a global trend within the huge international tourism market emphasizing visitors' desire for genuine experiences [1]. According to our understanding, the authentic Sàmi cultural experience should not only emphasize tradition but be fused with the contemporary and constantly evolving style of living that is carried on by future generations. Besides paying attention to Sàmi entrepreneurs and their visitors (most of whom come abroad), we are using the theory of value co-creation to understand and analyze the interaction between hosts and guests. [2]. Here, value is not created only from goods and services, but emphasis is in the value created by subjective experiences. Yet, the authentic experience is not simply considered as a subjective feeling of the visitor but as an entity co-created through respectful and open interaction between hosts and guests.

When trying to contribute to the development of sustainable tourism and community resilience, this study also inspects the potential domestic demand for indigenous AT experiences and services in Finland.

References
[1] D. Huddart, T. Stott, Adventure Tourism: Environmental impacts and management (2020)
[2] J.H. Gilmore, B.J. Pine Ⅱ, Authenticity: what consumers really want (2007)

S9-O04

Sustainable Tourism and Climate Change in the Arctic: Women's (Missing) Opportunities and Tourist Motivations

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Tourism plays an increasingly important role in Arctic communities around the world but the impacts of global climate change on the long-term sustainability of Arctic tourism remains an understudied area. This research seeks an understanding of how residents of Arctic towns perceive the role of global climate change in shaping tourism in their communities and how tourists visiting these locations perceive global climate change impacts on the region. Women's perceptions, particularly how indigenous Iñupiat women's perceptions are situated on an axis of difference with women of other ancestries, are largely absent from existing scholarship and this research directly addresses this gap.

The research site for this study was Utqiaġvik (formerly known as Barrow), Alaska in the United States. Utqiaġvik is the largest city in the North Slope Borough region serving as a transportation and commercial hub. The city acts as the primary destination for tourists due to ease of access [1]. The Iñupiat people are the original residents of the North Slope region. Many Iñupiat people continue to practice traditional customs and livelihood strategies including the harvest of bowhead whales. Utqiaġvik is host to major Iñupiat festivals including the Nalukataq whale feast held each year around the summer solstice, which attracts tourists seeking authentic indigenous cultural experiences.

Results from unstructured interviews with residents of Utqiaġvik reveal perceptions regarding the influence of global climate change on the region, how it is shaping daily life, and whether it is affecting local tourism. Residents' perceptions of how tourism impacts privacy and safety in the community were examined. The role of tourism in Utqiaġvik was also investigated to reveal its impacts on local women and the lack of resulting economic opportunities. Results from unstructured interviews with tourists in Utqiaġvik reveal perceptions regarding what, if any, role global climate change played in their visit to the Arctic and other motivating factors. This research addresses questions from the literature around the growth of "last-chance tourism" in the Arctic and whether it is a motivating factor throughout the region. Research gaps on women's perceptions of the role of global climate change in Arctic tourism including a lack of data on women's views of privacy and safety related to tourism are also addressed.

The author would like to acknowledge Amy Quandt, Stuart Aitken, Donatella Zona, and Walter Oechel of San Diego State University, and Vena Chu of the University of California, Santa Barbara for their mentorship and support.

References

[1] North Slope Borough (2014). Soaring to the future: Barrow comprehensive plan 2015-2035. Final Draft. Retrieved April 1, 2022.

S9-O05

Snowmaking as an adaptation strategy in Arctic winter tourism centers – avoiding maladaptation by a climate service

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Reliable snow conditions are the key to economic success in winter tourism industry, particularly ski resorts [1]. Also in the Arctic, snow conditions are decreasing and getting less predictable due to climate change [2]. For instance in Northern Scandinavia, climate change is expected to decrease snow cover days by 20 – 30 %, particularly in the early season.

As winter tourism centers increasingly use snowmaking as means to ensure snow security, it is worth considering snowmaking as an adaptive strategy. There is a strong connection between the costs and emissions of snowmaking and the weather conditions through energy consumption. Energy consumption for snowmaking increases in less favorable weather conditions, which raises issues both on competitiveness [3] and on the environmental impacts, and hence the sustainability of snowmaking as an adaptive strategy. High energy consumption may, in fact, turn snowmaking into maladaptation [1], [4], [5].

Climate services are a diverse set of ways to provide climate and climate change related relevant information to end-users in user-friendly ways [6].They can support both adaptation and mitigation. We co-designed a climate service for winter tourism industry in Northern Finland together with a leading ski resort during a 3-year collaborative process. The resulting service offers reliable 4-week forecast on snowmaking conditions, enabling executive decisions on snowmaking, targeted marketing, and savings in energy and water consumption. The prototype is applicable in Arctic countries and potentially all snowy countries across the world.

The presentation is based on work conducted within the Blue-Action: Arctic Impact on Weather and Climate project (2016-2021), the case study on co-designing a climate service for winter tourism in Northern Finland. The Blue-Action project received funding from the European Union's Horizon 2020 Research and Innovation Programme under Grant Agreement No 727852.

References

[1] Steiger, R., Scott, D., Abegg, B., Pons, M., Aall, C., 2019. A critical review of climate change risk for ski tourism. Current Issues in Tourism 22, 1343–1379. https://doi.org/10.1080/13683500.2017.1410110
[2] Snow, Water, Ice and Permafrost in the Arctic (SWIPA) 2017, 2017. Arctic Monitoring and Assessment Programme, Oslo, Norway:
[3] Damm, A., Greuell, W., Landgren, O., Prettenthaler, F. (2017). Impacts of +2°C global warming on winter tourism demand in Europe, Climate Services 7, pp. 31-46, https://doi.org/10.1016/j.cliser.2016.07.003
[4] Contreras, R., Mettiäinen, I., Toivonen, J., Coath, M. 2018. D5.2 Case Study Nr. 1 Model Information Utilization Report. Blue-Action project. https://doi.org/10.5281/zenodo.1184553
[5] Mettiäinen, I., Coath, M., Contreras, R., Moore, J.C. & Toivonen, J. (forthcoming). Assessment and Evaluation Report. Case Study 1 Winter Tourism in Finland. Blue-Action Deliverable D5.4.
[6] European Commission. 2015. A European research and innovation roadmap for climate services. Luxembourg: Publications Office.

March 6

Breakout Session

S10

Changing Arctic strategic and geopolitical landscapes: the impact of the war in Ukraine

S10-O01

Changing geopolitical landscape in the Arctic after the Russian attack on Ukraine on February 2022

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The war in Ukraine is transforming the geopolitical landscape around the world. The Arctic is no exception. On March 3, 2022, seven members of the Arctic Council (A7), with Russia being the eight, declared to pause all activities, for the first time since 1996, due to the Russian attack on Ukraine. Other Arctic cooperative platforms followed suit. On June 8, the A7 arctic countries Moreover, the war prompted Finland and Sweden to apply for NATO membership, which could bring significant changes for Arctic security. This paper reviews the discussions on changing geopolitical landscapes of the Arctic region in search for common grounds for deepening the understanding of the impacts of the Russian War in Ukraine. In so doing, it highlights the importance of the core principle of sovereignty and territorial integrity as fundamental rule in the Arctic international affairs.

The Arctic: What role for NATO?

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The questions of what place the Arctic should have in the affairs of the North Atlantic Treaty Organisation (NATO), and what role NATO should have in the Arctic, have been regularly addressed in the last decade and a half. While some have urged NATO members to enhance the Alliance's role in the region, including developing an Arctic strategy [1], others have urged restraint [2]. The Russian attack on Ukraine on 24 February 2022 has brought renewed attention also to this issue. In an August 2022 op-ed prior to a visit to Canada, NATO Secretary General Jens Stoltenberg outlined the security challenges allies face in the Arctic in light of the new situation and stated not only that "NATO has a clear interest in preserving security, stability and co-operation in the High North", but also that the Alliance "is already increasing our presence in the High North." [3] Based on research of primary and secondary written sources, and interviews with key stakeholders, this paper critically analyses three perspectives on the NATO-Arctic debate. The first is how has the issue of the Arctic has evolved in NATO since it appeared in earnest in 2008. The second is what views five allies with a specific interest in the Arctic – Canada, the United States, United Kingdom, Denmark and Norway – hold on the issue. Third and finally, the paper addresses what potential roles NATO could have in Arctic affairs – given the likely strong Russian resistance to cooperating with the Alliance in dealing with Arctic issues.

References

[1] A. Wieslander, NATO Must Engage in the Arctic, *Defence One,* 16 September (2019)
[2] David Auerswald, NATO in the Arctic: keep its role limited, for now, *War on the Rocks*, 12 October (2020)
[3] Jens Stoltenberg, In the face of Russian aggression, NATO is beefing up Arctic security, *The Globe and Mail*, 24 August (2022)

S10-O03

The Effect of Finnish and Swedish NATO Membership for the Dynamics in the Arctic

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In May 2022, Finland and Sweden applied for NATO membership, a historical decision for two traditionally non-aligned Arctic countries. Finland and Sweden had cooperated closely with NATO earlier within NATO's Partnership for Peace framework and in major NATO operations at the Balkan's and in Afghanistan, but membership is a quite different thing. It means common defence instead of just coordinated defence. The paper will focus on what that will mean for the dynamics in the Arctic politically economically, and militarily. The main argument in the paper is that it will demand a much more active Finnish and Swedish engagement in the region, and also that NATO will pay more attention to the Arctic when two more Arctic countries become members.

Greenlandic visions of sovereignty and security in the wake of the Russian war in Ukraine

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Most political parties in Greenland have for decades declared independent statehood apart from Denmark to be their goal [1]. Political debates have therefore concentrated on how far removed this goal should be, and what reforms are deemed necessary to inch closer to realizing it [1]. Integral to the independence project has been a political identity as Inuit, including the idea of the inherent peacefulness of this indigenous people [2]. Visions of The Great Arctic Thaw and rebalancing of global power and economy has allowed Greenland to imagine possibilities for diversifying unilateral dependence on Denmark [3; 4]. Most recently, U.S. advances has allowed Greenland increased influence and even independent room for maneuver within the constitutional relation to Denmark, reaching even to the core of foreign, security, and defense policy [5]. Concurrently, however, it is increasingly clear that given Greenland's geopolitical position, the U.S. is and will be leaning hard on, first, the Kingdom of Denmark, but increasingly also directly on the Government of Greenland, to prevent any other great power from engaging Greenland in ways that allow it to gain influence in Nuuk [6]. The paper discusses how the Greenlandic visions of sovereignty and security is currently shaped by the way in which the geopolitical freeze already underway in the Arctic is accelerated by the Russian war in Ukraine. Specifically, it dissects how in the 2022 election campaign before the Danish parliamentary elections, in which Greenland takes part, previous reflex Inuit pacifism has been transformed into an explicit across the board accept of NATO membership, leaving, however, open for debate how membership is to be squared with (current lack of and visions of future) sovereign statehood.

References

[1] Gad U.P., *National Identity Politics and Postcolonial Soverignty Games*, Copenhagen: Museum Tusculanum Publishers [Monographs on Greenland **353,** Man & Society **43]** (2016)
[2] Rasmussen R.K. ‘The desecuritization of Greenland's security’, *Arctic Yearbook* (2019)
[3] Jacobsen M., 'Greenland's Arctic Advantage', *Cooperation & Conflict*, 55(2):170-192 (2020)
[4] Gad U.P. et al., 'Imagining China on Greenland's Road to Independence', *Arctic Yearbook* (2018)
[5] Olsvig S., 'Greenland's aim to move from trilateralism with Denmark and the US, to US-Greenlandic bilateralism', *Danish Foreign Policy Review* (2022)
[6] van Brunnersum S.-J., 'China failed its Arctic ambitions in Greenland', *politico.eu* (22 October 2022)

March 7

Breakout Session

S11

After the Ukraine: The Arctic, International Law, and International Scientific Cooperation

Russia's Invasion of Ukraine and Policy Implications for the Poles: Examination of Post-Invasion Developments

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Russia's unprovoked invasion of Ukraine began on 24 February 2022 while the former was the presiding Member of the United Nations Security Council (UNSC); a main body of the United Nations (the UN) that according to the UN Charter has the 'primary responsibility for the maintenance of international peace and security'.[1] That invasion which continues up until this moment, appears to have altered fundamentally the perception of the security in the Polar regions.[2] With the outset of Russian invasion of Ukraine, both the Arctic and Antarctic have witnessed various patterns of policies that have been put in place through their respective policymaking systems; most of which are mainly by western states in the polar regions triggered by and as a response to Russia's invasion of Ukraine. Within the Arctic, shortly after that invasion, a joint statement is issued by seven member states of the Arctic Council stating that they will not send their representatives to Russia for meetings of the Arctic Council, a forum that is currently chaired by Russia, and will temporarily pause participation in all meetings of the Council and its subsidiary bodies.[3] Following that joint statement, Russia's Ministry of Foreign Affairs issued an announcement that Russia will continue discussion of the current agenda of the Arctic territories in the northern latitudes as part of the upcoming events of the Russian chairmanship of the Arctic Council, but its chairmanship will be reoriented to address national issues of developing its northern territories.[4] This follows by another statement by seven states of the Arctic Council as to limited resumption of their work with projects that do not involve the participation of Russia.[5] Up until the moment of writing this manuscript, it has not yet become clear that how a resumption of the Arctic Council's work without the participation of Russia will look like and whether this has put the work of that forum into an indefinite pause.[6] All the above is taking place within a forum in which international scientific cooperation has constantly been playing a key role in decisions and policies.[7] Within the Antarctic, the situation takes a different trend. Importantly, strong reactions were expressed at the ATCM XLIV Berlin (2022) in view of the Russian invasion of Ukraine, stating that it jeopardizes the atmosphere of mutual trust and support within the Antarctic community. It seems that whilst most western states have a common position vis-à-vis Russia, this is not true of other major decision-making states in the Antarctic fora, therefore making it distinct from that of the Arctic. This paper seeks to examine various patterns of policies put in place in the polar regions triggered by and as a result of Russia's invasion of Ukraine up until present to see what their implications are in either of the poles from legal and policy perspectives.

References

[1] See Article 24 of the UN Charter.

[2] For analogous views see, among others: 'Arctic Cooperation in the Shadow of Russian Aggression: Armchair Discussion with Icelandic Foreign Minister Thórdís K.R. Gylfadóttir', the Wilson Center's Polar Institute, 21 April 2022. Last retrieved on 24 October 2022 from https://www.wilsoncenter.org/event/arctic-cooperation-shadow-russian-aggression-armchair-discussion-icelandic-foreign-minister; and E. Wishnick and C. Carlson 'The Russian Invasion of Ukraine Freezes Moscow's Arctic Ambitions', 3 October 2022, Journal of Indo-Pacific Affairs, published online, last retrieved on 24 October 2022 from https://www.airuniversity.af.edu/JIPA/Display/Article/3172713/the-russian-invasion-of-ukraine-freezes-moscows-arctic-ambitions/

[3] Joint Statement on Arctic Council Cooperation Following Russia's Invasion of Ukraine, March 3, 2022; https://www.state.gov/joint-statement-on-arctic-council-cooperation-following-russias-invasion-of-ukraine/

Arctic governance in light of Ukraine crisis: the important role of the Arctic Council in the overall governance of the region

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Russia's illegal attack on Ukraine caused an immediate reaction from the seven western member states of the Arctic Council. They suspended their own activities in the Council, of which Russia was and is the chairman. However, these same states also stated that it is important to continue the cooperation of the Arctic Council for many reasons. At the beginning of June 2022, they resumed about 70 projects that do not involve Russians. Norway is currently preparing to take over the chairmanship from Russia. One can observe that even in such difficult circumstances, the seven member states of the Council see a need for resuming the Arctic Council co-operation. This presentation will demonstrate why it is that the Arctic Council is so crucial for the future of the Arctic region. In many ways the Council acts as a glue to the multi-level governance environment of the region, without which many important issues will be hard to tackle. Even if there are uncertainties relating to the future of the Council, it is fair to say that no matter what will happen, the Arctic states will need at some point in time to draw from the 25 years of history of the Arctic Council to respond to the challenges of the region.

S11-O03

Analyzing Proposals on "the Necessary Modalities" for the A-7 States to Continue the Arctic Council's Work

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In response to Ukraine invasion by Russia from 24 February 2022, on 3 March, the seven Arctic States (A-7 States) decided temporal pause of their participation of all meetings of the Arctic Council "pending consideration of the necessary modalities that can allow [them] to continue the Council's important work in view of the current circumstances." On 8 June, the A-7 States announced limited resumption of Council's work in the projects that do not involve the participation of the Russian Federation as one of "the necessary modalities". Furthermore, the A-7 States announced that they continue to examine "additional modalities" to allow them to further continue the Council's important work. In face of this crisis of the Arctic Council, world-leading Arctic experts have published number of insightful web articles considering and proposing "the necessary modalities" [1-5]. What is interesting in these articles is that there seem to be some differences of views among these authors especially regarding how to continue the Council's work among the A-7 States and how to address handover of Council's chairmanship. This presentation attempts to identify the real challenges that the Arctic Council and A-7 States are now facing by analyzing these articles, especially the differences of views and where they come from.

References

[1] Timo Koivurova, "The Arctic Council Can Continue without Russia," *Arctic Today* 10 March 2022<https://www.arctictoday.com/the-arctic-council-can-continue-without-russia/>.
[2] Evan T. Bloom, "A New Course for the Arctic Council in Uncertain Times," *Arctic Today*, 18 March 2022 <https://www.arctictoday.com/a-new-course-for-the-arctic-council-in-uncertain-times/>.
[3] Jeremy Greenwood, "Move Forward Without Russia: How the Arctic Council Can Keep Up Its Work?," *High North News*, 4 May 2022 <https://www.highnorthnews.com/en/move-forward-without-russia-how-arctic-council-can-keep-its-work>.
[4] Timo Koivurova, "Is It Possible to Continue Cooperating with Russia in the Arctic Council?," *Georgetown Journal of International Affairs*, 29 June 2022 <https://gjia.georgetown.edu/2022/06/29/is-it-possible-to-continue-cooperating-with-russia-in-the-arctic-council/>.
[5] Evan T. Bloom, "After a 6-month Arctic Council Pause, It's Time to Seek New Paths Forward," *Arctic Today*, 6 September 2022 <https://www.arctictoday.com/after-a-6-month-arctic-council-pause-its-time-to-seek-new-paths-forward/>.

Global governance and the two-category system in the Arctic in relation to Arctic sustainable development

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The Arctic continues to experience aggravating climate and environmental challenges that require profound scientific research and effective policies. This paper identifies the privileged access of Arctic states to their offshore resources based on the Law of the Sea regime. This privilege influences the outcomes of global governance in the Arctic region that may lead to different results as wished upon by non-Arctic states. The High North keeps arousing political and economic interests from non-Arctic states, which often collide with sovereign rights of Arctic states on the Arctic maritime domain. In this regard the eight Arctic States (Canada, Denmark, Finland, Iceland, Norway, Sweden, the Russian Federation, and the United States) signed the Agreement on Enhancing International Arctic Scientific Cooperation (2017). This Agreement creates an improved legal environment for Arctic science. Although it might stimulate scientific involvement of non-Arctic states - such as through joint research projects with Arctic states (Article 17) - it does not provide a legal basis for those states to participate in formal decision-making. In this way the Agreement creates a two-category system dividing Arctic and non-Arctic states. (1) This research seeks to discuss this two-category system by taking a non-state-centric perspective into consideration. On the one hand this requires an analysis of how non-Arctic states and inter-governmental, non-governmental and Indigenous organizations are limited in participating in decision-making processes. On the other this requests a critical examination of how Arctic scientific research incorporates metropolitan interests and how the research itself needs to be decolonized. As a result, this research seeks to attach a significant importance to the interests of the victims of climate injustice in the Arctic region, namely the Arctic communities (both Indigenous People and Arctic non-Indigenous people). (2) Ultimately, this study examines how Arctic scientific and climate research suffers under the current situation in Ukraine. Not only because of the increased tensions in international politics, but also because of Russia's dominant position in the North, both geographically and legally through its chairmanship in the Arctic Council (a platform for enhancing Arctic scientific cooperation) since May 2021. Thus, this study seeks to explore the opportunities of collective action and International Scientific Cooperation without disguising neo-colonialism under the waiver of Arctic sustainable development.

References:

[1] A. Shibata, M. Raita, An Agreement on Enhancing International Arctic Scientific Cooperation: Only for the Eight Arctic States and Their Scientists?, *The Yearbook of Polar Law* **143** (2016); A. Shibata, The Arctic Science Cooperation Agreement: A perspective from non-Arctic actors, *Emerging Legal Orders in the Arctic: The Role of non-Arctic Actors* **217 – 218** (2019)

[2] U. Markussen, Towards an Arctic Awakening: Neocolonalism, Sustainable Development, Emancipatory Research, Collective Action, and Arctic Regional Policymaking, *The Inter-connected Arctic* **306 – 307** (2016)

S11-O05

The Arctic Council Task Force: “Task Force on Improved Connectivity in the Arctic” and the impact of the Ukraine crisis on Arctic connectivity

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The Task Force on Improved Connectivity in the Arctic (TFICA) main goal was to meet the needs in terms of connectivity, new technology and network deployment (mostly through satellite coverage) for research cooperation and safety issues in the Arctic. Funding in new technologies and new partnerships with private or public companies and organizations was necessary. The connectivity issue was something to be dealt with multiple solutions. The task force needed to ensure which regions in the arctic needed the most increase in connectivity improvement and which changes were a priority (increase regulatory frameworks and harmonization, build up more data centers, including indigenous specificities, adapting the adequate devices to the arctic environment…). The invasion of Ukraine by Russia has put on hold cooperation between the Arctic States as five of them (maybe six with Finland’s candidature) are a part of NATO. Russia has the most territorial coverage of the Arctic region. Scientific cooperation is put at risk as it is getting more difficult for scientists to continue their research with Russians and have them share the results of their discoveries, which reduces connectivity. While TFICA’s goal was to increase connectivity for scientific cooperation purposes, it may nowadays change for security and defence objectives.

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March 9

Breakout Session

S12

International Governance of the Central Arctic Ocean: Science, Indigenous Knowledge, and the Rule of Law

S22

Indigenous Co-Production of Arctic Knowledge: Toward a More Inclusive Arctic Scientific Research

S12-S22-O01

Shared Arctic Variables and Expert Panels as a forum for co-production and capacity sharing

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Shared Arctic Variables (SAV) are sets of observables that provide a means to align the information needs of end users in order to better coordinate observations of Arctic phenomena. SAVs are a core element of the Sustaining Arctic Observing Networks (SAON) Roadmap for Observing And Data Systems (ROADS) process [1], which formed an advisory panel in 2021 and is ready to accept SAV expert panel proposals. SAVs draw on the Essential Variable concept developed for global observing efforts, comprising variables with an associated set of observing requirements guided by information users. What makes SAVs unique is the process by which they are identified and defined: Expert panels representing a wide range of perspectives and information use cases, centering the perspectives of Indigenous peoples and regional decision makers, collaborate to identify the variables that would yield collective benefit through greater alignment and coordination of observations. These expert panels can serve as a platform for co-producing SAV observing requirements. They can also be a source of empowerment for communities on the local or regional scale. By convening and supporting information users and observers from different perspectives (scientists, government, and Indigenous communities), working together to define Shared Arctic Variables, the process can build relationships and link information and observing resources to where they are needed. SAVs, by recognizing Indigenous knowledge systems as an important means of observing in its own right, may also help in efforts to develop interfaces between Indigenous Knowledge systems and regulatory or management frameworks. This presentation describes what SAVs are, the expert panel process to develop SAVs, and how the process was designed to facilitate co-production and capacity sharing.

References

[1] Bradley, Eicken, Lee, Gebruk, Pirazzini. 2022. Shared Arctic Variable framework links local to global observing system priorities and requirements. *Arctic.*

S12-S22-O02

Remaking the world in who's image? Arctic Geoengineering, consent, and the Co-production of knowledge

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As the gap between ambition and reality on emission reductions grows, research into climate intervention 'geoengineering' has been fuelled by a sense that more drastic action is needed. there are legitimate concerns raised over transparency, indigenous consent and procedural justice where the implementation of geoengineering is concerned, especially as research thus far shows that there has been very limited dialogue and engagement on geoengineering research and development with Arctic Indigenous peoples. This path raises concerns about how inclusive these solutions are and the long-term consequences. As non-state actors engage with geoengineering research and development, against the background of complex Geopolitics and an ill-equipped legal order - The Arctic states, and the Arctic Council, are faced with the challenge of ensuring indigenous participation with this highly complex issue.

Evidence suggests the current legal framework may be ill-equipped to deal with the introduction of geoengineering. Against this background, this paper examines geoengineering governance, examining how its development and potential application in the Arctic may affect Indigenous participation. The FPIC procedure has already been an important tool for the empowerment of Indigenous peoples like the Sámi. Thus, this paper explores the nature of consent and whether co-production of knowledge could offer guidance on how to appropriately address the challenges of the Arctic and future technologies.
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S12-S22-O03

Working together with local communities to understand changes in the coastal environment and their impact on society in Inglefield Bredning, northwestern Greenland

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The Arctic environment has been changing more rapidly than what we expected. In the past decade, researchers of GRENE, ArCS and ArCS II projects have been collaborating with residents in Qaanaaq, a small village on the coast of Inglefield Bredning to understand changes in the environment. The studies have revealed links between changing natural environment and the society, as represented by an important mechanism of high productivities near marine-terminating glaciers [1]. Here, we introduce our on-going scientific research conducted with the local society in Qaanaaq in the summer of 2022 as a part of the ArCS II project. We have conducted multiple at-sea observations and sampling to understand changes in the coastal environment. For example, we counted the number of marine mammals and seabirds and deployed multiple passive acoustic recorders from the vessels of local hunters. In addition to these surveys, we collected samples during local subsistence hunting activities to study diet, contaminants, and stress in marine mammals and seabirds. These data are useful for determining the distribution and its controlling factors of marine top predators and their response to environmental changes. Finally, we shared our ideas and scientific activities with local communities including school children during workshops in Qaanaaq (Figure 1), Qeqertat and Siorapaluk to raise awareness of challenges in the current environment. The residents also kindly shared their ecological knowledges and concerns with us. We have repeatedly organized such workshops with residents since 2016. The active interaction and co-production of knowledge with Inuit and local society are essential for us to tackle challenges that we face in the Arctic.

Figure 1. Workshop in Qaanaaq

References

[1] S. Sugiyama, N. Kanna, D. Sakakibara, T. Ando, I. Asaji, K. Kondo, Y. Wang, Y. Fujishi, S. Fukumoto, E. Podolskiy et al., Rapidly changing glaciers, ocean and coastal environments, and their impact on human society in the Qaanaaq region, northwestern Greenland, *Polar Science* **27**, 100632 (2021)

S12-S22-O04

Nordurslod Arctic Exhibition Ark & Global Indigenous Centre: A Gateway to New International Dialogue, Innovation and Constructive Action

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[1]*Emissary on Nordurslod, Arctic Circle, Iceland*

Up to 80% of the world's biodiversity is managed by Indigenous Peoples [1]. As the world faces multiple crises in climate change and biodiversity loss, a new international centre in Iceland, Nordurslod, offers a 21st century model for innovation, dialogue and constructive action focusing on the Arctic, climate change, oceans and green energy [2]. At this critical time, Nordurslod aims to bring the Indigenous worldview into focus within the activities of the building by establishing a Global Indigenous Centre and Exhibition Ark for the purpose of fostering community, facilitating knowledge sharing, and deepening cultural understanding.

A report on the concept of a Global Indigenous Centre is expected to be published in 2023 highlighting voices from Indigenous leaders and recommendations for the development of this concept. A Global Indigenous Centre in Iceland offers a common ground not only for Indigenous peoples to gather, but also an intersection for the international community, including non-Arctic States, to deepen their understanding of the Indigenous worldview. Such a place could help to facilitate better practices in co-production of research by providing a platform for relationship building and knowledge-exchange.

References

[1] https://www.un.org/development/desa/indigenouspeoples/publications/state-of-the-worlds-indigenous-peoples.html (last accessed 31 October 2022)

[2] https://www.arcticcircle.org/journal/nordurslod---the-north-path (last accessed 31 October 2022)

A Research Agenda for Central Arctic Ocean Fisheries Agreement: Science, Indigenous Knowledge and Rule of Law

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An Effective implementation of the Central Arctic Ocean (CAO) fisheries agreement, now entering its crucial second year since entering into force in June 2021, poses huge challenges for the scientific, Indigenous and legal communities, and this paper examines a potential academic research agenda in meeting those challenges through multidisciplinary research project ArCS II. After sorting out the intricacies involved in those challenges, compounded by the Russian invasion of Ukraine, this paper will showcase the scientific agenda discussed under the Provisional Scientific Coordinating Group (PSCG) to create Joint Program of Scientific Research and Monitoring (JPSRM), one of the key pillars for the effectiveness of the Agreement. It will then turn to the unique requirement under the Agreement for co-production of scientific and Indigenous knowledge to meet the objective of this Agreement. All these scientific and Indigenous agenda should be legally and institutionally framed under the Agreement, such as in the Rules of Procedure (RoP) of the Conference of the Parties (COP) and the Terms of Reference (ToR) of the Joint Scientific Meeting. A legal analysis of those international instruments is called for. This paper will be based on the outcome of the inaugural meeting of COP on 23-25 November 2022 in Republic of Korea.

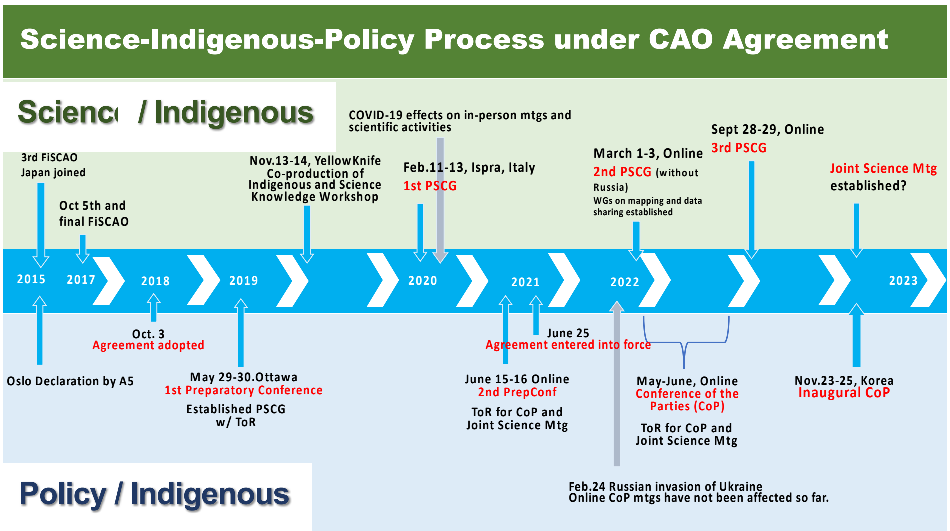

Figure 1. Process under the CAO Fisheries Agreement: 2015-2022

S12-S22-O06

Development of the Joint Program of Scientific Research and Monitoring (JPSRM) under scientific meetings

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In October 2018, ten countries/organization signed an international agreement to prevent unregulated commercial fishing in the high seas of the CAO (Agreement). Then, the signatories tasked the Provisional Scientific Coordinating Group (PSCG) to develop and operationalize JPSRM and relevant data sharing protocols in a manner consistent with Article 4 of the Agreement and to identify processes and mechanisms to incorporate Indigenous and local knowledge (ILK) in the work of the PSCG. This paper introduces the discussions in the PSCG meetings on questions for the guidance of development of JPSRM, mapping and monitoring programs, and incorporation of ILK to the PSCG. This paper will then compare the co-production of ILK and western science to Japan's "*Sato-umi*" concept under which local communities voluntarily conduct resource management and successfully increase production and diversity, then discuss how to enhance the cooperation with ILK toward the development of Agreement.

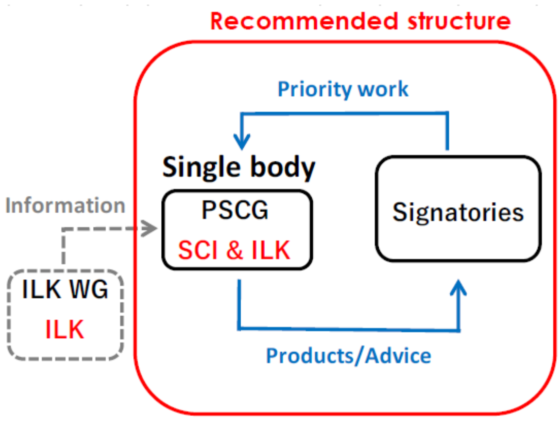

Figure 1. Schematic figure of recommended structure of incorporation of ILK in the 1st PSCG meeting (2020; Single and coherent body for ILK and science), along with potentially additional option: establishment of ILK working group, to foster dialogue.

Reference

[1] Report of the 1st meeting of the Provisional Scientific Coordinating Group (PSCG) of the Agreement to Prevent Unregulated High Seas Fisheries in the Central Arctic Ocean (2020).

S12-S22-O07

Taking into account of Indigenous Knowledge under the CAO Fisheries Agreement: Lessons from 2022 ICC Protocols for Equitable and Ethical Engagement

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The Agreement to Prevent Unregulated High Seas Fisheries in the Central Arctic Ocean (CAO Fisheries Agreement) is a challenging treaty, particularly for Japan as its Contracting Party and for Japanese scientific communities, that explicitly and legally requires its Parties to "ensure" that a collaborative scientific program under the Agreement (Joint Program for Scientific Research and Monitoring (JPSRM)) "takes into account…indigenous … knowledge" (Art.4, para.4). In its preamble, the Agreement explicitly recalls the 2007 United Nations Declaration on Rights of Indigenous Peoples. Thus, the interpretation as well as implementation of the Agreement should be based on the fundamental normative tenet of the right of self-determination and self-governance of the Arctic Indigenous Peoples in all issues affecting their lives, including fisheries in the Arctic seas. For them, the Arctic seas are one and integral, undivided by artificial borders and maritime jurisdictional lines. The requirement under the Agreement should not be read only as searching for technical and procedural means of co-production of knowledge between Indigenous Peoples and Western Science. In this regard, 2022 Circumpolar Inuit Protocols for Equitable and Ethical Engagement (EEE Protocols) adopted by the Inuit Circumpolar Council (ICC) provides a powerful message how fundamentally the Agreement should ensure the incorporation of Arctic Indigenous Knowledge in its implementation process. For example, Protocol 1 Directive stipulates: "Work with us (the Indigenous Peoples) throughout the development, interpretation and implementation of all agreements…within (their) homeland". This paper examines the lessons that should be learned from the 2022 EEE Protocol for the effective and ethical implementation of the CAO Fisheries Agreement.

< https://iccalaska.org/about/icc-international/ >

Reference

[1] ICC 2022: EEE Protocols: < https://www.inuitcircumpolar.com/project/circumpolar-inuit-protocols-for-equitable-and-ethical-engagement/ >

March 6

Breakout Session

S13

Building a region: Arctic identities and identity politics

S13-O01

The Rise and Demise of the Arctic as a Region? – The Arctic Council without Russia

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For Arctic international relations, the Arctic Council (AC) has been the central institution advancing the "cooperation, coordination, and interaction" of the Arctic Eight states since 1996. Focusing on international Polar research, climate change, energy and resource development, indigenous peoples, fisheries and oceans, urbanization, populations in the Arctic, pollution, and plastic in our oceans, transshipment through Arctic waters, research and development in the Arctic, etc., the AC has been pivotal in drawing attention to many of these emerging and ongoing concerns. Such activities and international impact have been called into grave question because Russia, an AC member covering half of the Arctic, declared an illegal war on Ukraine on 24 February 2022. Much of the international community has reacted by issuing sanctions on Russia, its leadership, and many of its oligarchs. Seemingly caught flat-footed, the Arctic Council, with Russia as the Chair from 2021-23, has suspended all formal activities because of Russia's aggression.

In this paper, I explore the question of the future of the Arctic Council without the participation of Russia while it is at war with Ukraine. The Chairship of the Arctic Council is due to change from Russia to Norway in 2023. My focus will be on three key concerns: 1) as Norway takes the Chairship of the Arctic Council from 2023-2025, what will define the Arctic Council with half of its territory excluded? 2) how will the isolation of Russia from the rest of the Arctic Council shape international relations in the Arctic and outside of it; and 3) what impact will the exclusion of Russia mean for international agreements such as the search and rescue agreement and the Central Arctic Ocean fisheries agreement?

I attempt to answer these questions by interviewing Senior Arctic Officials, analysing discourse and media, and examining Russia's activities and pronouncements since 24 February 2022 as Chair of the Arctic Council.

Region-building in the West Nordic Arctic

K. Ingvarsdottir
University of Iceland

Christopher Hemmer and Peter J. Katzenstein are among those scholars who claim that regions are created by politics rather than geography. To them, "even regions that seem most natural and inalterable are products of political construction and subject to reconstruction attempts" [1]. The West Nordic islands—Greenland, Iceland, and the Faroe Islands—are close neighbors in the North Atlantic and can be seen as forming a natural region in geographical terms. Nonetheless, the islands did not become close partners, regionally and internationally, until in the last decades. A major milestone in this regard was the establishment of the inter-parliamentary West Nordic Council in 1985. The Council's goal has been to strengthen cultural, political, and economic relations between the three islands, and since the 2010s, an Arctic agenda has become increasingly apparent in its work. Although the West Nordic islands only have approximately half a million inhabitants between them, they have increasingly made themselves heard in regional and international forums on the Arctic. The paper will explore the geography and competing identities of the West Nordic region, as well as political efforts towards—and obstacles against—region-building. The paper will also devote special attention to the development of an Arctic identity shared across all three islands.

Reference

[1] C. Hemmer, P. J. Katzenstein, Why Is There No NATO in Asia? Collective Identity, Regionalism, and the Origins of Multilateralism, *International Organization*, **56**, no 4, (2002): 575.

Roles of imported whale meat from Iceland and Norway

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This paper aims at explaining (1) changes of whale meat supply chains in Japan after withdrawing from the IWC in 2019, (2) influence of whale meat imported from Iceland and Norway into Japanese markets, and (3) articulating socio-political and socio-economic links between Japanese foodways and the two Nordic countries, which both are members of the regional North Atlantic Marine Mammal Commission (NAMMCO). Since July 1, 2019, Japan resumed commercial harvest of three whale species: 187 Bryde's whales, 25 sei whales and 134 minke whales aligned to quotas within Japanese EEZ. Compared to the research whaling period (1988 - 2018), domestic supplies of whale meat in the market have shrunk to no less than 2,000mt. Japan resumed importing whale meat in 2008 for the first time since the moratorium of commercial whaling took effect in 1988 to fill the gaps of domestic demand [1]. Since then, consumption of imported whale meat began, particularly fin whale meat and blubbers from Iceland. Based on literature review, statistics, and fieldwork among stakeholders, the paper will illustrate marketing strategies by both Japanese whaling companies and importing companies centered on producing *sashimi* quality products, which may affect local whale meat production in Iceland and Norway.

Figure 1. Domestic production and imports of whale meat (mt)

References
[1] Akamine, J., Tastes for blubber: Diversity and locality of whale meat foodways in Japan, *Asian Education and Development Studies* **10** (2021)

S13-O04

Polska jako członek obserwator Rady Arktycznej

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Arctic plays more and more important role in world politics. Its geopolitical, economic and ecological significance causes that not only countries within arctic region but also those in indirect influence tend to show interest in using polar regions.
This tendency can be plainly seen when looking at Polish activity. This country has been a state observer of Arctic Council for over 20 years and has conducted scientific research on arctic related topics for more than 40 years.
The aim of presented research is to answer the question regarding causes of Poland's rising interest in Arctic Council activities and - looking broader - importance of state observer in international organisation. Supplementary, but still an important part of this study is identifying role of Poland as a member of European Union and the form of its activities at Arctic Council meeting and effectiveness of completing its own political goals.
Basis for presented issues will be official Arctic Council documents and assumptions of Polish Arctic Policy. In the former case Arctic Council Observer regular reports play the key role. In the latter, documents regarding Polish Polar Policy released by Ministry of Foreign Affairs.

S13-O05

Cooperating and Observing towards an Ideal: The Arctic in Japan's Foreign Policy Identity

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A decade since its inception into the Arctic Council as an observer, how is Japan adapting its approach to the Arctic in response to recent global developments and what is the influence of Japan's broader foreign policy identity in its approach to the High North? Buttressing the notion that Arctic policies are not standalone policies but the extension of national and foreign policy initiatives and identities, this presentation considers Japan's approach to the Arctic in the context of broader policy initiatives on traditional and non-traditional security issues. How is Japan's idea of an "Ideal Arctic" [1] that takes into account developments concerning environmental changes, sustainable economic activities and the rule of law, adapting given current global developments? Specifically, the presentation addresses how the war in Ukraine has impacted Japanese foreign policy and, resultingly, how this affects Japan's approach to the Arctic, in particular concerning governance and research. As the idea that two Arctics are emerging in the aftermath of the war in Ukraine, how does Japan envision its role in fractured multilateral governance structures and the defining institution in the Arctic, namely, the Arctic Council? In its review of how Japan has asserted its place in the Arctic since becoming an observer, drafting an Arctic policy and in the context of broader foreign policy initiatives and identity, the presentation considers the role of scientific research collaboration, Hokkaido as a "gateway" to the Arctic and implications of the planned 2023 upgrade of central Japanese policy documents (i.e. National Security Strategy) for relations with Arctic states. Through a discourse and practice analysis, it unpacks how security, on traditional and non-traditional and on national and international levels factors in Japan's approach to the Arctic and demonstrates the synergy between Arctic security issues and broader, prioritized foreign policy issues, such as freedom of the seas, peaceful coexistence and environmental sustainability.

References

[1] MOFA Japan "Speech by H. E. Mr. Taro Kono, Minister for Foreign Affairs of Japan at the Arctic Circle 2018" 19 October (2018).

S13-O06

Constructed Proximity: Identity and China's Near-Arctic State Concept

M. Lanteigne[1]

[1]*UiT The Arctic University of Norway - Tromsø, Norway*

Although China is not the only non-Arctic country which has sought a greater say in Arctic affairs, it is the largest and arguably the most influential. For over a decade, Chinese research papers and policy documents have referred to the country as a 'near-Arctic state' (*jin beiji guoja* 近北极国家), a phrase that was later codified in the Chinese government's 2018 White Paper on Arctic policy. The term has been viewed by critics as evidence that China is seeking a revisionist role in the far north, given that China has no Arctic geography. However, in examining Chinese Arctic diplomacy since the country became a formal observer in the Arctic Council in 2013, it is necessary to study the concept of 'near-Arctic state' within the parameters of China attempting to create a distinct Arctic identity. Beijing wishes to be seen as a responsible stakeholder and partner in Arctic discourse and development, a task which has since been complicated by the suspension of the Council in 2022, as well as by concerns from some Arctic governments about China's longer-term goals for the far north. Nevertheless, it is useful for studies of Chinese Arctic policy to better look at the country's 'Arctic-adjacent' status as a key facet of the country's interests in not only developing scientific and economic links in the region, but also in playing a potential enhanced role in future areas of Arctic governance. Thus, the constructivist study of identity and norm-generation is required in developing an improved understanding of Beijing's Arctic engagement, at a time when the region has become a strategic concern to Arctic and non-Arctic actors alike.

March 8

Breakout Session

S15

Redefining the well-being of Arctic communities in the context of global environmental and societal change

S15-O01

Using Traditional Ways of Education to Maintain Indigenous Communities

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From the second half of 20th century, arctic/subarctic indigenous societies in the U.S.A and Canada have experienced several major changes, such as sedentarization of settlements, the introduction of monetary economies, and non-traditional education systems. Indigenous people have been forced to live under the rule of Nation-state governments as minorities and faced discrimination. New social situations brought severe problems, especially to children and adolescents who lost opportunities to learn from their traditional culture. Indigenous societies have since faced identity crises and lost their pride as indigenous people. From the 1960's, behavior of adolescents (often unlawful or inappropriate) became a major problem in indigenous communities. Some of the leaders of these societies recognized the problems and started cultural programs to educate young people by passing on their values. Programs such cultural camps are still conducted widely among Alaskan indigenous societies [1-2].

In the Gwich'in societies in interior Alaska, leaders started the Youth Survivors program to provide opportunities to teach their tradition to younger generations in 1980's. This program was unique because it was not just a camp for groups of children, but, instead, used their traditional methods of mentoring—one expert hunter/trapper/fisher taught only one boy through practice. They then brought their mentee on hunting/trapping/fishing trips and taught not only skills and knowledge, but their value, philosophy, world view and discipline. Most of these mentors learned their traditional culture through their life in the bush before sedentarization, as wells as more academic and western methods of through their college education and/or military services.

In this presentation, I will report on this kind of mentoring and as well as cases of support for children and adolescents who have behavioral problems or committed minor crimes. In one example, a mentor taught traditional values and ways of mutual help to children and adolescents through one-on-one mentoring, leading them to rebuild social relations with other community members. Analyzing these cases, I will show that teaching activities that pass on traditional values and traditional methods of living method can play important roles in maintaining community in the modern indigenous settlement society.

Acknowledgement

This presentation is based on the research supported by JSPS KAKENHI Grant Numbers JP15K12960 (Grant-in-Aid for Challenging Exploratory Research "Practical Anthropological research to promote social working in the indigenous societies in Alaska"). The research plan passed evaluation by the research Ethics Committee, Josai International University, and obtained permission from the President of the University.

I would like to thank the residents of Fort Yukon and the Gwich'in of Fairbanks for their support.

References

[1] S. Kondo, Teaching and Leaming Culture in Interior Alaska: Activities in Nikolai, Alaska, *Annual Journal of Cultural Anthropology* **9 37-48,** (2014)

[2] Tanana Chiefs Conference, Culture Camps. *Tanana Chiefs Conference Home Page.* https://www.tananachiefs.org/services/youth/culture-camps/#more-3285

(Revised: October 25th, 2022)

S15-O02

Ainu People and Well-being
: A Case Study of Salmon Fishing and Ceremony under the Ainu Policy Promotion Act

Hiroya Noguchi

Hokkaido Museum of Northern Peoples / Tohoku University. Japan

In 2019, a new law on the Ainu people, The Ainu Policy Promotion Act (APPC), was enforced in Japan. This law prohibits discrimination against the Ainu people and aims at creating a society where the Ainu people can live with pride as an indigenous people through measures of government and municipalities. Since the main purpose of these measures is the promotion of Ainu culture, the APPC is closely related to "Cultural Well-being (Manning & Fleming 2019) " for the Ainu people. This presentation will examine how and to what extent the APPC will contribute to the well-being of the Ainu people, by using field research data and analyzing changes in salmon fishing under the APPC as a case study.

Salmon had been the staple food for the Ainu people for a long time, but their livelihood, fishery, was banned by the Japanese government in the late 19th century. Now, the Ainu people is permitted to catch salmon only for special purposes such as a salmon ceremony. The Ainu people have long demanded the restoration of their salmon fishery rights, and in recent years their demands have grown stronger. Therefore, the new law includes a little deregulation of salmon fishing. In other words, regarding salmon fishing, the new law has expanded a little scope of the Ainu people’s possibilities to live their own culture.

However, despite the deregulation, there have been only a few changes in salmon fishing under the APPC. Therefore, at least in the case of salmon fishing, the contribution of the new law to well-being is limited. The reason why the APPC cannot fully contribute to the well-being of the Ainu people is due to the institutional design. The process of reflecting their demands in measures is left to each municipality. Therefore, improvements in salmon fishing have only occurred in areas where local Ainu groups and the municipality have worked together for many years. Municipalities which have not built a good relationship with local Ainu groups have difficulty in making a good policy plan which reflects the demands of the local Ainu people. In order to contribute to well-being through the APPC, it is necessary to develop a system to reflect the Ainu people's demands in measures.

References

Matthew, Manning & Christopher Fleming

2019 Understanding Wellbeing. In M. Matthew & C. Fleming (eds.), *Routledge Handbook of Indigenous Wellbeing.* London and New York: Routledge, pp. 3-10.

S15-O03

Food Life History Project in Alaska: Community-based Participatory Research on Underground Caches

Y. Kugo[1*], M. Koskey[1], G. Iwahana[2], T. John[1], K. Saito[3], Y. Hirasawa[4], and S. Tatsuzawa[5]

[1]*Center for Cross-Cultural Studies, University of Alaska Fairbanks, USA*
[2]*International* Arctic Research Center*, University of Alaska Fairbanks, USA*
[3]*Research Institute for Humanity and Nature, Kyoto, Japan*
[4]*Department of Human Sciences, University of East Asia*
[5]*Graduate School of Humanities and Human Sciences, Hokkaido University,*

This paper presents a progress report on the study of "food life history" in northern Alaskan communities. Food Life History (FLH) is a framework for a cycle of harvesting food (fishing, hunting, and plant gathering), processing and preserving food, and transportation, distribution, and consumption of food. Each region has developed its own techniques to hunt animals and prepare the meat in their environment. Alaska Native peoples have used ice cellars, underground caches, and pits to preserve and share locally harvested food for at least three reasons: 1) Storing a mass of meat supports the food needs of community, 2) Quickly storing meat in a cellar helps meat from spoiling, and 3) Some meat processing techniques require skills, such as to achieve meat fermentation. Based on our preliminary fieldtrips in the partnering communities in the summers of 2021 and 2022, we learned that the northern food storage practices have changed due to rapid environmental fluctuations (e.g. permafrost thawing, thaw and moisture conditions) and the arrival of modern education, technologies, and economy. Our research team consists of social and natural scientists 1) to investigate the traditional use of underground cache practices in Arctic communities, and 2) to document local concerns of the current harvesting, sharing, and consumption of local foods in response to thawing frozen ground and socioeconomic changes, especially since the introduction of refrigeration in the 1960s.

We have used a community-based participatory research (CBPR) to gain local perspectives and build research questions from local and researchers' perspectives. Community assistants have helped to prompt Elders' memories to talk about their life experiences traveling, harvesting food, and using an underground cache. Reawakening the memory and oral history of these features through CBPR provides locally relevant, meaningful information for the communities' well-being, and for informing their future cultural revitalization plans.

S15-O004

How are waste management issues recognized in people's lives in small remote villages in Alaska

Kaori Ishii*

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Small and remote villages in the Arctic region have geographical characteristics that could be disadvantageous for managing waste. These characteristics include transportation networks limited to sea and air routes, changes in travel methods in summer and winter, and the lack of resources and facilities. Subsistence activities occupy a crucial place in Alaska villages even today. Simultaneously, the modernization of livelihoods has progressed due to small aircraft operations that started in the 1930s and settlement policies implemented during the Cold War. Such changes have increased the variety of waste materials, including car batteries and home appliances. Locally, waste is self-hauled, end up in open dumps, and is incinerated at low temperatures, raising concerns about its impact on the human body and the environment. This presentation is designed to demonstrate how these issues are recognized in the lives of people in small and remote villages in Alaska. In the US, household waste disposal, including hazardous waste, is generally local governments' responsibility, and municipalities are typically required to oversee waste disposal and recycling. In contrast, it is geographically and socially difficult for villages to manage waste in remote areas of Alaska, and outside actors such as the state, NPO/NGOs, and natural scientists are deeply involved in identifying problems and providing technical assistance. Therefore, it is critical to understand the perceptions of both people who live there and the outside actors. In this presentation, I will examine how people experience waste problems in daily life and discuss the following issues. (1) The change in quality and quantity of waste resulting from not only modernization but also changes in nature and the social environment, including food availability and climate change. (2) Relationships between people and waste that are not always problematic. (3) While people are welcoming support for solving problems and increasing employment, they are also concerned about risks from the increasing complexity of the waste stream.

S15-O05

Community-based wild reindeer monitoring and establishment of adaptive hunting area in the Siberian Arctic: as autonomous adaptation to climate change

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In the Arctic region of the Sakha Republic in East Siberia, rapid changes of distribution and life history of fauna and flora have taken place over the past 30 years. Wild reindeer, on which northern indigenous peoples have depended for their livelihoods, have changed their seasonal migration routes, making traditional hunting difficult and becoming one of the reasons they give up on their traditional lifestyles. In addition, conflicts between wild and domesticated reindeer, such as competition for feeding grounds and abductions, are increasing, so the concept of "pest" which was not previously held is spreading in indigenous people. Therefore, we will work with local people to clarify the latest seasonal migration routes and wintering grounds of wild reindeer using satellite transmitters and provide this information to stakeholders to establish a new wintering reserve. In addition, integrated management of both wintering reserve and hunting area by the local committee has enabled both poaching control and sustainable use of wild reindeer population. This is an example of community-based adaptive wildlife management in the Arctic region, and we would like to evaluate it from both socio-economic and cultural perspectives as a model of autonomous adaptation to climate change.

S15-O06

Livelihood of Indigenous People under A Changing Climate in Yakutia, Russia: Description and Analysis of A Quantitative Household Survey

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[5]*Institute of Finances and Economics, North-Eastern Federal University, Russia*
[6]*Arctic Research Center, Hokkaido University, Japan*

In this study, we examine the livelihood of indigenous people in Yakutia, northern Siberia, Russia, based on our own quantitative household surveys. The traditional ways of living for indigenous people are constantly exposed to the rapid changes of modern technologies and of socioeconomic structure. Furthermore, climate change and resulting environmental changes can affect the local climatic conditions and the biodiversity of local species that form the foundation of their traditional lives, and these influences can be of particular significance in northern Siberia which is one of the world regions where the warming trends are most evident. We conducted two series of household surveys: broad surveys covering 18 settlements over all Yakutia conducted from June 2021 to early 2022 and an in-depth survey conducted April and June, 2022 in which we focused on a single settlement and covering 102 households. The questionnaire design followed that of a standard nationally sampled household socioeconomic survey but was adjusted to reflect the traditional livelihood of indigenous people. Our aims in this study are to examine: (1) the overall well-being levels of indigenous people, along with their basic demographic and socioeconomic characteristics; (2) the patterns of consumption, farming, hunting, and gathering of traditional, non-traditional, and market-based items; (3) the extent to which they are involved in (or dependent on) modern socioeconomic activities outside their settlements, including temporary and permanent migration to other parts of Russia and remittances from these migrants and; (4) their own perceptions on the impacts of climate change. These points describe their dependence on traditional methods of food acquisition and on local climate and species—or lack thereof. They also illustrate the potential impacts of climate change on their livelihood and well-being that may occur if the warming trends further intensify.

This study is a part of an e-Asia Joint Research Program project entitled "Climate change Resilience of Indigenous SocioEcological systems," funded by Japan Science and Technology Agency (JST).

S15-O07

Arctic LNG Business in Russia: Retreat or Resume?

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In this paper, I demonstrate the trends and prospects of Japanese foreign direct investment (FDI) in the Arctic energy business against the background of the recent development of energy resources in Russia's Far North. More specifically, first, to what extent and why Japan, one of the world's biggest importers of liquid natural gas (LNG), has been involved in Russian Arctic oil and gas programs is to be discussed in consideration of Japan's diplomacy toward Russia. Second, I overview the business activities of Japanese investors in the Arctic LNG 2 project in the Gydan Peninsula in the northern part of Siberia and describe how and why they decided to invest this controversial project with generous support from the office of the Prime Minister of Japan. Third, I review the potential financial losses of the Japanese companies involved in the Arctic LNG 2 project due to the harsh economic sanctions against Russia over Moscow's actions in Ukraine. It is concluded that Russian LNG from the High North is not an essential source of the energy for Japan's business entities in the long run; it would rather pose a significant risk to corporate management in the wave of de-carbonization and de-Russification. In this way, Arctic energy FDI represents a significant challenge to sustainable development, even in terms of purely economic efficiency, not to mention environmental and social sustainability in the Russian Far North.

Figure 1. Arctic LNG 2 in Norther Siberia
Source: Novatek's website (https://www.novatek.ru/en/business/arctic-lng/)

References

[1] M. Tokunaga, K. Suganuma, Japan's Foreign Direct Investment in Russia: A Big Return from a Small Opportunity, *Eurasian Geography and Economics* **61** (2020)

[2] M. Tokunaga, Russian Arctic Development and Environmental Discourse, In: Veli-Pekka Tynkkynen et. al (eds.), *Russia's Far North: The Contested Energy Frontier*, Routledge, Chapter 8 (2018)

S15-O08

Economic Development in the Arctic Regions in Russia: before and after February 2022

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Russia's invasion in Ukraine in February 2022 has significantly changed the Russian and world economy, including international economic relations and energy trade. Until February 2022 the economic development in the arctic regions in Russia had been driven by oil and gas development [1-3]. Since the beginning of this war, I have been engaged in the analysis of the impacts of economic sanctions on the Russian and world economy, based on own estimates of declining oil and exports from Russia. It is expected that oil and gas exports from Russia to the West (unfriendly countries in Russian government terminology) will decrease to zero until 2027. In this paper, I consider these impacts on the arctic regions in Russia. Will oil and gas development stop completely in these regions? Then how will be future development in these regions? Will the Russian government abandon the strategy of advanced development of its Arctic regions?

In this paper, statistical analysis is made using socio-economic data of the Russian Arctic regions in the past two decade. Most attentions are paid to two regions: Sakha Republic and Yamalo-Nenets Autonomous Oblast. Changes in Russian government strategies and policies concerning the Arctic development are analyzed as well. In addition, some comparisons are made between Russia and the other Arctic countries/regions where oil and gas development is the driver of the economic growth.

References

[1] S. Tabata, The Contribution of Natural Resource Producing Sectors to the Economic Development of the Sakha Republic, *Sustainability* **13** (18), 10142 (2021)
[2] S. Tabata, Flow of Financial Resources between the Federal Budget and the Arctic Regions in Russia, *Region: Economics & Sociology*, No. 3 (103) (2019) (in Russian)
[3] V. Tynkkynen, S. Tabata, D. Gritsenko, M. Goto eds., *Russia's Far North: The Contested Energy Frontier*. Abingdon, Oxfordshire, UK: Routledge (2018)

Potential Climate Refugees from Permafrost Area: Are People Ready to Leave Their Native land?

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Articles about Permafrost Climate Refugees stand out from the numerous publications on climate change and migration in recent years [1,2,3]. The most common causes of forced migration are the consequences of climate change, such as extreme weather events, sea-level rise and food insecurity [4]. Thawing permafrost could also push for growth of a number of climate refugees. By 2050, nearby 70% of the modern infrastructure of the cryolithozone are located in areas with a high potential for melting of near-surface permafrost. Climate warming will cause significant damage to infrastructure (up to 60-80% of infrastructure elements) [5].

The permafrost zone occupies almost 65% of the territory of Russia. The Government of the Russian Federation is concerned about the problem of permafrost melting. In future, permafrost thawing will bring large expenses for the maintenance of critical infrastructure and probably make these territories uninhabitable. In 2020, Ruslan Edelgeriev, the special representative of the President on Climate Issues, allowed the mass relocation of the population living in the Far North to the southern regions due to the melting of permafrost.

In order to identify the degree of availability for the emigration of residents of the Sakha Republic (North-East of Russia), in our sociological survey "Climate Change in Yakutia" we set the following question: "Are you ready to move to another region of Russia on condition of reimbursement of all relocation costs with providing housing and employment?"

The survey revealed that 39% of respondents are ready to leave their homeland, but 48.1% are not agree to emigrate, 13% found it difficult to answer.

Social groups' analysis of responses showed up that women, young people and urban residents are more willing to change their place of residence. The main reason for their decision to leave Yakutia is catastrophic forest summer fires, which cause heavy smoke and deterioration of air quality.

References

[1] Jakobeit, C., Methmann, C. 'Climate Refugees' as Dawning Catastrophe? A Critique of the Dominant Quest for Numbers. In: Scheffran, J., Brzoska, M., Brauch, H., Link, P., Schilling, J. (eds) Climate Change, Human Security and Violent Conflict. Hexagon Series on Human and Environmental Security and Peace, vol 8. Springer, Berlin, Heidelberg (2012).
[2] Farbotko, Carol. Wishful sinking: Disappearing islands, climate refugees and cosmopolitan experimentation. Asia Pacific Viewpoint. 51. 47 – 60 (2010).
[3] Qin, H. Collectif Argos: Climate Refugees. Hum Ecol 39, 699–700 (2011)
[4] Sen Roy, S. Climate Refugees. Linking Gender to Climate Change Impacts in the Global South, 93–115. (2018)
[5] Hjort, J., Streletskiy, D., Doré, G. et al. Impacts of permafrost degradation on infrastructure. Nat Rev Earth Environ 3, 24–38 (2022)

Arctic river settlements of Yakutia in changing climatic conditions (social challenges of changing the hydrological regime of the Arctic in the 21st century).

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Like all over the world, the river systems of the Arctic region of Yakutia play a huge role in the life of the indigenous population. Being the most important source of resources, the northern rivers play an important role in the social development of aboriginal ethnic groups, being the basis for their economy and culture. Global climate transformations around the world also have a significant impact on the Arctic ecosystem, including its water balance. To disrupt the fragile balance of the Arctic natural environment and the sustainable development of local aboriginal communities that depend on it, often only small changes in climate cycles and temperature regimes are enough. In the 21st century on the territory of Yakutia, including its Arctic part, there is an increase in natural crisis manifestations associated with water resources, such as floods, shallowing of rivers, degradation of permafrost in adjacent territories, etc. As a consequence, this entails the growth and complication of social problems for the local population.

It should be noted that indigenous peoples live in the Arctic regions of Yakutia: Yakuts, Evenki, Evens, Dolgans, Chukchi and Yukaghirs, who preserve traditional types of economic and culture. In recent decades, these communities have faced great internal and external difficulties and are very vulnerable to any critical situations. At the same time, their way of life, which is closely interconnected with the surrounding natural conditions, determines a high degree of dependence on climate change. Confronting the natural disasters of local communities in Yakutia is complicated by financial poverty, unemployment and migration of the able-bodied population typical of local villages. In this report, our attention will be paid to a special type of settlements in Yakutia - Arctic river settlements located on the banks of rivers and completely dependent on river resources.

Our focus was on the village of Siktyakh, located on the banks of the Lena River in northern Yakutia, and the village of Argakhtakh, located on the banks of the Alazeya River in northeastern Yakutia, where the authors of the report conducted field research in 2021–2022. These settlements are of interest due to their remoteness from the main regional economic, political and cultural centers of Yakutia, and, consequently, their strong autonomy and autarchy. This feature is an important factor in their life, leaving a special imprint on the history and prospects for their development. Despite the general similarity of the conditions in which they exist (natural location, remoteness, ethnic composition, economy and demography), societies that are located on the banks of large rivers are forced to face different threats and their consequences. The example of the village of Argakhtakh, located in the north-east of Yakutia, demonstrates the stressful state of the local population and the reduction in the scale of the traditional economy caused by regular floods and the degradation of permafrost that is largely dependent on it. At the same time, residents of the Siktyakh village, unaffected by floods, located on the banks of the Lena, are forced to face a different set of problems caused by changes in temperature and seasonal regimes, as well as local economic and logistical cycles that depend on it. The study of these remote communities, living largely autonomously from the rest of the world, can demonstrate a wide range of both potential threats and the response and adaptation strategies they have developed in the harsh conditions of Arctic Yakutia.

Arctic policy and fiscal problems in Russia: the case of the Sakha Republic

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This paper focuses on the Sakha Republic in the Russian Far East as one of the Arctic regions. Russia's Arctic policy gives priority to improving the living standard and quality of life of Arctic inhabitants. I examine the feasibility of Russia's Arctic policy in the context of economic and social situation in the Sakha Republic and fiscal capacity of local governments, which are responsible for the provision of social public services.

The Arctic region is an important 'donor' for the Russian economy, which can bring abundant tax revenues to the state budget[1]. However, it has not been considered enough if this wealth contributes to the sustainable development of Arctic societies. This paper provides an overview of Russia's Arctic policy, followed by an analysis of the socio-economic situation in the Sakha Republic after the collapse of the USSR. Then, local public service provision and its finance is analyzed based on the fiscal statistics of the Republic.

I conclude that the feasibility of the Russia’s Arctic policy was diluted by Russia's own actions and policies. Goals such as attracting private investments have become extremely difficult to realize after the invasion of Ukraine. In addition, improving public services in the Arctic region such as education and health care, which are considered to be of poor quality, also is difficult as local governments in the Republic have neither the financial resources nor the autonomy for decision-making to meet the goal, as a result of centralization in the past decades.

References

[1] S.Tabata and M.Goto (2020), *Hokkyoku no Ningen to Shakai*, (Human and Society in the Arctic. in Japanese)

March 7

Breakout Session

S16

Making of Arctic exhibition and material study: the potential of collaboration study with local people

S16-O01

Anthropology of exhibitions in Russian Arctic: Sharing the visual images beyond borders

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Complicity and co-creation is a key words for anthropology in the contemporary Arctic research. The indigenous peoples are not mere an object for study but a collaborator for the development of science in society. The trans-disciplinary approach guides to create new conceptual, theoretical, methodological innovations that move beyond discipline-specific approaches involving many types of stakeholders in the context of real-world problem. This paper documents some exhibitions related Siberian ethnography organized by the authors to evaluate the anthropological and social significances. As an influential work among the related previous research, Sara Pink (2007), in her book of the applied visual anthropology, advocates the cultural intervention for changing societies using the visual materials. Following this idea, the authors explore the challenges in Russian Arctic contexts. In this presentation, while we describe how we involve people, local administration, and the related scholars across countries for the exhibition and argue the way the exhibition affects the local peoples and the scholarship. We also examine the exhibition methodology in terms of digital technology in progress, presentation, distribution and promotion of modern science achievements. They guide reconsidering the conventional anthropological view and the way of collaboration with the local people. The exhibition as an applied visual anthropology project recaptures the new meaning of ethnographical snapshot as scientific knowledge. The exhibition is becoming a new form and attribute of research work and scientific exchange, but also a tool and resource for communication and social interaction.

S. Pink ed. (2007).*Visual Interventions: Applied Visual Anthropology*. New York: Berghahn.

S16-O02

The Relational Exhibition: Connecting Landscapes, Communities, and Research Archives

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This study explores the ways in which the archival photography exhibition negotiates the relationships within and between different community groups. My case-study for this project is the black and white photography exhibition entitled “In Search Of Gold In Siberia: The Heritage Of The Finnish Geological Expedition to Uriankhai in 1917” and its opening event which took place on January 13th, 2016, in the Nordic Culture Point in Helsinki, Finland. The exhibition was a result of then three-year-long work on the heritage of the Finnish geological expedition to Uriankhai which is currently known as the Tyva Republic in North Asia, a part of (Soviet) Russia since 1944. I have collaborated on this heritage project with Sjundby Traditionsförening—a community organization based in the Swedish-speaking municipality of Sjundby (its Finnish name is Siuntio) in southern Finland. The head of the organization is retired farmer Carl-Johan Lindén whose father, Erik Lindén, participated in the 1917 expedition to Tyva.

Prior to the exhibition, in summer 2013, we followed the 1917 expedition’s routes in Tyva together with Carl-Johan Lindén and three members of his family. During the trip, we visited the same locations featured in the archival photographs, shared the historical expedition’s story with local communities and tried to identify descendants of people who were photographed back in 1917. I have continued the same work in the following years, while conducting ethnographic fieldwork for my doctoral and postdoctoral research projects.

I approach the exhibition (its preparation, assembling the photographs and artefacts, and the opening programme) as a social process which connected its diverse audiences: the Sjundby community, researchers, people who are interested in Tyva, and numerous descendants of the 1917 expedition’s members from Finland and abroad. In this work, I discuss how each of these groups makes use of the exhibition.

Life of a Big River
: Russia-Japan Traveling Exhibition Project

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"Life of a Big River" is a Russia-Japan traveling exhibition project dedicated to the main river of Western Siberia – the Ob. This project was started in collaboration between Russian aquarium specialists from Aqua Logo Engineering and a Japanese researcher at water environment outreach.

This project was designed for local city residents of Western Siberia, especially children ages 7 to 14. The people living in this region have a fish-eating culture and the main source of fish is the Ob river. Nevertheless, people had little chance to learn about the life of the Ob.

This exhibition tells fish ecology, food chain, fisheries, industries, fish-eating, and parasites in the Ob. All the topics are guided by typical fish characters. Most of the exhibition items can be touched. Visitors can play interactive games, work with microscopes, take pictures with old fishing gear, learn at a masterclass, and sometimes feed the real fish. Each item is modularized and can be arranged flexibly according to the space. About 100 square meters were required for the total exhibit.

After about a year of development, the exhibition tour started in October 2019. The exhibition has visited three Siberian cities: Kogalym, Noyabrsk, and Langepas. The young Siberians in each city played and learned about the life of the Ob and its inhabitants at the exhibition.

Figure 1. The location of the Ob River and traveling venues

Figure 2. The guided tour starts at entrance

Figure 3. Exhibition and visitors at Kogalym

S16-O04

Possibilities and Difficulties involved in the holding Arctic Exhibitions in Museums with Small Arctic Collections

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The purpose of this presentation is to consider the difficulties and possibilities of holding arctic exhibition in museums with small or few collections of arctic culture, and located in non-arctic regions. This presentation will chiefly aim to clarify answer to the following two questions. (1) How do museums in non-arctic regions go about holding arctic exhibitions? and (2) How can researchers conduct studies of materials and extend those studies into the exhibitions?

In regard to (1), the talk will address what kind of exhibition methods and content are effective for visitors from non-arctic regions in order to share and arouse interest in arctic issues by analyzing the British Museum's exhibition. This exhibition of arctic climate and its culture was held from Oct. 2020 to Feb. 2021. The exhibition emphasized arctic issues in terms of global climate change and the resilience of arctic communities by displaying ethnographic materials and records such as fur clothes and hunting tools, artworks, photos, historical records.

In regard to (2), the talk will explore what kind of research and exhibitions are possible in museums with small collections of arctic culture by focusing on the case of animal fur materials. Animal fur is one material that protects the human body from the cold. Residents both in arctic and non-arctic regions have developed their own culture centering on animal furs through understanding local environments and the characteristics of animals. Therefore, animal fur is one of the most common materials in both arctic and non-arctic regions, and this commonality will arouse interest in arctic issues among people in non-arctic regions.

In the case of museums that focus on indigenous history and culture in Japan, animal fur collections of indigenous cultures, for example Ainu culture, are very small despite the number of historical ethnographies on fur. By focusing on the size in number of fur materials of Ainu culture, it can be pointed out that there is a bias in museum collections caused by collector's colonial interests concerning indigenous culture.

Even if there are a few materials in museums, restoration and comparison are effective ways of exhibiting arctic materials. The restoration of traditional materials based on detailed research of ethnographic records gives opportunities for indigenous peoples to learn and deepen their culture. In this case, it can be said that material study combined with historical ethnographies have a possibility to contribute to the cultural revival of the indigenous peoples and to become an opportunity to consider their indigenous rights on natural resources and land through comparing them with other arctic regions.

S16-O05

More than dissemination: two-ways interaction between science and the local community.

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Arctic Centre, University of Lapland, Finland

The research dissemination section is nowadays an obligatory part of any academic project proposal. However, it mainly reflects the top-down dissemination of scientific knowledge to a passive audience. In the last decade, the question of how to facilitate more direct, two-ways engagement with public interests has aroused more attention in the scientific community.

The proposed presentation focuses on the essential role of the exhibition, literal devotion and visualization as powerful tools in breaking the barriers of scientism, knowledge co-production and knowledge repatriation. In doing so, I refer to different public events organised for different audiences in Finland, Norway, Sweden, Russia, Spain and Germany as an outcome of my research projects and perspectives of local communities in the Arctic on environmental changes, human-nature relations, or pastoralism. I will analyse different ways of science popularization that give access to a spectrum of experimentation, reflection and liaison with art, but also require mobilizing ethics, improvisation and often missing technical competence.

March 8

Breakout Session

S17

Arctic Shipping: Economic Feasibility and Challenges

The economic impacts of opening the Northern Sea Route under political uncertainty

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The opening of the Northern Sea Route potentially reduces distances to transport goods between East Asia and Europe compared to the traditional Southern Sea Route. At the same time, political uncertainty in the region could hinder the adoption of a commercial service. This study examines the economic impacts of opening this route, considering the trade-off between the benefit of the shorter traveled time and potentially high political uncertainty. Utilizing several economic and political uncertainty indices (namely the World Uncertainty Index and the Geopolitical Index), the elasticity of trade costs with respect to political uncertainty is estimated and then used for simulation in a trade model.

In the simulation model, consumers have love of variety, which differs from the standard Armington model, where each country's goods are treated as unique. The elasticity of substitution between modes of transportation is estimated from the data, which allows for potential changes in modes of transportation. The world economy is projected to every five years from 2015 to 2030 with different growth scenarios. The economic impacts (namely the change in trade cost, trade volume, GDP, and welfare) of the opening of the Northern Sea Route is evaluated for the different magnitudes of potential political uncertainty.

Economic Prospect of Arctic Container Liner Shipping

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The continuous retreat of summer-autumn Arctic sea ice enables navigation in formerly ice-clogged Arctic waters. Compared with traditional shipping routes, the Arctic passages shortened the distances among main industrialized belts in the world – East Asia, Northwest Europe, and North America significantly, so more and more ships appear on these passages during navigation season. The Northern Sea Route (NSR), the passage through Russian Arctic Exclusive Economic Zone (EEZ) in the Arctic where the summer-autumn sea ice retreats faster, has witnessed rapidly developing navigation activities and the corresponding icebreaking service and regulation system since 2009. Even on the Northwest Passage on the North American sector where thicker ice is cumulated, navigating ships are increasing in these years. Under the background of global warming and polar amplification, it is doubtless that the declining trend Arctic sea ice will keep the Arctic passages open during a longer navigable time window in the future.

Container liner is one of the three main patterns of the global shipping market (the other two are bulker and tanker). The majority of international trading categories of cargo is transported by container liners, especially high-valued or time-sensitive cargoes. The trading among industrialized belts highly depends on container liner shipping, and correspondingly three east-west main-lanes are formed, namely Asia-Europe, Transpacific, and Transatlantic. According to the continuous sea ice retreat in the Arctic, the shifting of container liner shipping from these traditional main-lanes to Arctic passages is not unimaginable. If this happens, a large amount of shipping costs can be saved due to the shortened distance and lowered consumption of fuel, even though only a part of time in a year (generally speaking, from August to October in recent years) is navigable for low- or non-ice-classed ships. This advantage will attract container operator tycoons into this region, and with the further development, the ports located in northern areas will become attractive, and even the global container network will be re-shaped.

In study discusses the economic feasibility of the Arctic passages used for container liner shipping in the future is discussed. In the months before or after the three navigable months, namely “shoulder season”, the sea ice partly exists along the shipping routes, but ice-class ships can pass through. A solution of combined container service, shifting between Arctic passages in navigable and shoulder months and the traditional routes in other months, is conceived. There is a trade-off in this situation: an ice-class ship has higher costs due to lower fuel efficiency in open water and higher built-price, but can sail in a longer Arctic navigable time window compared with a non-ice-class ship. Therefore it is necessary to calculate and compare the economic performance of combined solution with the traditional routes.

In this study, a shipping cost model is constructed to solve this question. Several scenarios are provided to take the uncertainties in the near future into consideration, such as the climate change, and the impacts of Russia-Ukraine War on Arctic shipping. It is reasonable to predict that the NSR will be forbidden to foreign ships, so the economic feasibility of a higher latitude route that bypasses the NSR will be studied. The Northwest Passage, which has been passed through for limited times in late years, will also be studied. The area of sea ice on the central Arctic and North American sector is decreasing drastically, so the above two routes not impossible for commercial navigation in the future. In this study, future sea ice conditions along the Arctic passages, collected from Copernicus Marine Service database, are used as determinants of the Arctic container liner shipping in the future.

S17-O03

Multicommodity Cargo Flow Simulation of Northern Sea Route using Global Logistics Intermodal Network Model

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International freight transportation has become increasingly important in transporting a wide variety of commodities around the world. Although there have been many analyses of transportation behavior using simulation models, most of them have been conducted only for containerized cargo or have been applied only to a limited geographic region. In this study, we extend the multi-commodity global logistics intermodal network simulation (M-GLINS) model developed by Kosuge et al [1] that considers both containerized and dry bulk cargoes to the Northern Sea Route and analyzed its practicality. As a result, it is now possible to consider cargo transport on major global shipping routes, including the Arctic Sea Route, while considering congestion and multi-commodity competition, thus broadening the model's analysis, and enabling scenario setting and consideration of transport behavior from a more diverse perspective.

The remaining challenges exist. In this study, the Northern Sea Route is represented in the same format as other maritime shipping routes. However, the Northern Sea Route has different characteristics from other routes in various respects, suggesting that the Northern Sea Route needs to be considered as a different mode from other routes to further improve the reproducibility and practicality of the model.

References

[1] N. Kosuge, R. Shibasaki, K. Kawachi, H. Arai, T. Nakamura, L. Liu., Development of Multicommodity-type Global Logistics Intermodal Network Simulation Model Including Both Containerised and Dry Bulk Cargo, 9th International Conference on Transportation and Logistics (TLOG2022), 19-20 September 2022, Incheon, South Korea

S17-O04

A Model-Based Social Impact Evaluation of R&D topics related to Northern Sea Routes

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In recent years, interest in Arctic shipping has increased due to the effects of global warming. Although researches on the economic performance of Northern Sea Route (NSR) Shipping have been increasing, no unified conclusion of its economic feasibility has been reached due to the complexity and uncertainty of the global logistic system. [1] Therefore, a comprehensive system for determining technological development for the use of Northern Sea Routes is needed. This study aims to identify technological R&D topics with high priority for the social implementation of Northern Sea Routes by evaluating the relationship between technology development and its impact on society. The complexity and uncertainty of NSR shipping are managed a model-based approach.

The development of technology will change the QCD, i.e., Quality, Cost, Delivery, of the NSR shipping service. First, we categorize technological needs related to the Northern Sea Routes and estimate how each technology development would influence the QCD of NSR shipping. The stage of development is categorized into high, middle, and low, to consider the technological uncertainty.

The social impact of QCD changes is evaluated in two steps. First, the change of cost in NSR transportation costs will affect the import/export cargo transport volume among countries. We use the GTAP model, a general equilibrium model, to measure changes in import/export cargo transport volume. Next, the changes in cargo traffic are used as scenario inputs (e.g., boundary conditions) of the Global Maritime Container Shipping Network Simulation (GMCS-NS) model. The model can resolve container flows through the Northern Sea Routes and other routes, providing deeper insight into the QCD influence on NSR shipping. For example, how longer the NSR shipping period can impact the number of voyages observed. We aim to provide various evaluations to stakeholders, such as increased sales, reduced costs, and improved safety. As a result, we found that these models, which can deal with complexity, provide insight into the impact of technological development on society. To manage uncertainty, our future work is to implement participatory modeling with various experts and stakeholders to provide an accredited model for decision—making.

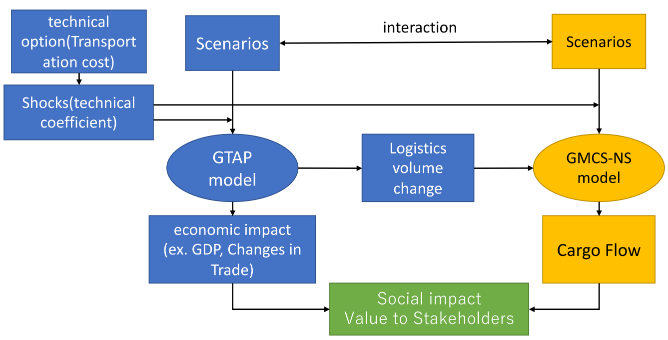

Figure1. Model Flowchart

Reference

[1] Chathumi Ayanthi KAVIRATHNA, Ryuichi SHIBASAKI, Economic feasibility of Arctic shipping from multiple perspectives: a systematic review, *Okhotsk Sea and Polar Oceans Research* **5** (2021)

S17-O05

Analysis of Arctic Shipping Prospects under the Influence of Climate and Political Factors

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The Arctic route has huge potential for shipping between Europe and Northeast Asia with significant savings in transit time and distance compared to traditional routes (such as Suez Canal Route, SCR). However, decarbonization is currently an urgent issue for the international shipping industry and greenhouse gas (GHG) emissions (especially CO2) from shipping would harm the environment of Arctic area.

Potential Market Based Measures of GHG emission reduction are under consideration. The maritime Emission Trading Scheme (METS) is an effective measure, while carriers' profit-driven reactions, such as route reconfiguration and segment speed optimization, may affect its effectiveness. Thus, it is important to investigate the carrier's economic viability under METS and the CO2 emission considering the utilization of the Arctic route. Since various countries, regions and shipping organizations have not yet reached a consensus on METS policy implementation, the METS policy settings based on coverage, carbon allowance price and free carbon quota may also affect the carriers' fleet deployment decisions and thus the emission abatement effectiveness.

For carriers, the main countermeasure to cope with METS is slow steaming in the restricted area to reduce emission volume and allowance cost. But constrained by the cargo delivery time, carriers may choose to speed up outside the METS region to meet the delivery requirement. Therefore, METS would guarantee a short-term emission reduction within the METS area regardless of the policy design, but the volume of overall CO2 emission in some scenarios would be even larger. METS disincentivizes carriers to use the Arctic route when it is implemented in the Arctic area or with high carbon price. When the Arctic is not restricted by the METS policy while other regions, such as the EU and China, have implemented it, the use of the Arctic route is more economically preferrable for carriers and more emission abatement effective globally than SCR. In individual cases, while ensuring the carbon reduction of the whole voyage, METS positively affects the carriers' economic viability since they could sell the extra carbon allowance they have saved through operation and management. It implies that a moderate carbon price setting and a high free quota proportion may be appropriate for balancing carriers' economic performance and CO2 emission reduction, in whole or in part.

Moreover, another uncertainty factor for Arctic shipping comes from the Russia-Ukraine conflict. First, the dispute over the rights of the Arctic route may further deepen, and Russia and Canada will further deepen the restrictions on the right of passage of the Arctic route. Moreover, the sanctions imposed by the Arctic countries on Russia interrupt Russia's resource exports and trade flows, which may reduce the demand for Arctic shipping, and the utilization rate of the Northeast Arctic route may decline. But on the other hand, to promote the development and utilization of the Arctic route, Russia will vigorously implement a series of support measures including the construction of new icebreakers, port construction and climate, navigation satellite launches, etc. These measures will make Arctic shipping more capable of reducing costs and passage times.

There is no doubt that the role of the Arctic shipping lanes will grow as global warming and trade grow. The Arctic has not only strategic value, but also great economic value, and these economic values will not be exclusive to Arctic countries because of their geographical advantages. However, sustainable development of the Arctic is inevitably accompanied by policies (e.g., METS), so the carriers will need to weigh in on these more complex conditions.

S17-O06

A Research on the Turkish Shipyards in the Arctic: Opportunities and Challenges

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The Arctic region has been experiencing an extensive transformation and several economic opportunities have emerged due to the shrinking sea ice. While the Arctic Ocean has become more convenient for navigation, both Arctic and non-Arctic states have updated their Arctic policies according to recent developments. There has been a substantial increase in the number of studies studying three main sea routes: Northwest Passage (NWP), Northeast Passage (NEP) and Trans-Polar Passage (TPP) [1], [2], [3]. Albeit the existence of contradictory results, the interest in Arctic shipping presents a growing trend. The Turkish shipyards increasingly participate in tenders as well. While Çelik Tekne Shipyard stands out as the first Turkish shipyard to win the tender for shipbuilding in accordance with polar conditions, a significant increase has been observed in the number of shipyards within the Arctic shipping tenders since 2018. In addition to Atlas and Akdeniz Shipyards, which produce ice class vehicles in accordance with the requirements of the Pole Code, it is possible to multiply examples from Beşiktaş Shipyard, which built ice class fuel ships, Sanmar Shipyard, which won the icebreaker tugboat tender, and Sefine and Kuzey Star Shipyards, which participated in the icebreaker tenders [4]. Besides, participation of Turkish shipyards as sole contractors in the Russian Arctic as of 2021 indicate their determination to become active actors in the Arctic shipping industry. Accordingly, this paper discusses the opportunities and challenges of Arctic shipping based on the Turkish case.

Keywords: Arctic, Arctic Shipping, Turkish Shipyards.

References

[1] Pastusiak, T., The Northern Sea Route as a shipping lane expectations and reality. Springer, (2016).

[2] PAME, Shipping in the Northwest passage: comparing 2013 with 2019, *Arctic Shipping Status Report*, April (2021).

[3] Moe, A., Stokke, O. S., Asian countries and Arctic shipping: policies, interests and footprints on governance, *Arctic Review on Law and Politics* 10, (2019): 24-52.

[4] Caymaz, E., Enhancing industrial development in the Russian Arctic: the Northern Latitudinal Passage, the Arctic Institute, April (2022).

S17-O07

Full-Scale Prediction of Ship Resistance in Ice Condition

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Predictions of ship resistance in ice have recently attracted the attention of ship designers. Full-scale ice trials provide an opportunity to determine full-scale ship resistance in ice, but such trials do not allow direct determination of ship resistance in ice if the ship is not towed through the ice; thus, full-scale ship resistance must be determined based on Newton's second law and the concept of energy conservation. The purpose of this study was to investigate ship resistance in ice and establish a reliable performance analysis procedure. First, ice trials with IBRV Araon were carried out in the Ross Sea in Antarctica in 2019. During these tests, ship performance data (position, speed, draft, engine output, propeller revolutions, etc.) were collected using a voyage data recorder (VDR) and an alarm monitoring system (AMS). The ice conditions were recorded simultaneously using a network camera system on the ship, and the ice's material properties were obtained from field measurements. The ship resistance in ice was then calculated based on the work-kinetic energy theorem, and the speed–resistance and speed–power relationships were determined under pack ice conditions. Finally, the predicted full-scale ship resistance in ice was compared with the calculation results derived from the empirical formula, and this paper discusses the method's accuracy.

Figure 1. Ice conditions in the Ross Sea during the IBRV Araon ice trials.

References

[1] Suyuthi, A.; Leira, B.J.; Riska, K. Full-Scale Measurement on Level Ice Resistance of Icebreaker. Proceedings of 30th International Conference on Ocean, Offshore and Arctic Engineering, OMAE 2011–50066, Rotterdam, Netherlands, June 19–24 1995, pp. 983-989.
[2] Jeong, S.Y.; Choi, K.; Kim, H.S. Investigation of ship resistance characteristics under pack ice conditions. Ocean Engineering 2020, 219, 1–17.

S17-O08

Risk-Aware Route Planning for Arctic Maritime Navigation.

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The Arctic is a remote and harsh environment with difficult navigation due to inhospitable waters infested by sea ice. However, due to climate change, the sea ice is melting, opening way to new navigation routes having longer operation time windows. Sailing in the Arctic brings new challenges and risks for the ships [1], but also for the environment. The International Maritime Organization (IMO) Polar Code entered in force in 2017 to define standardized rules to help manage these risks and to protect the Polar regions' sensitive environment. Among these rules, the Polar Operational Limit Assessment Risk Indexing System (POLARIS) was defined to assess the operational capabilities for ships operating in ice [2]. This risk assessment system is an IMO guidance used to determine if the vessel is susceptible to get damaged in ice.

The presented research relies on 25 years of daily environmental data covering the Arctic fully. Using this large environmental database, daily statistics have been produced to assess the spatial and temporal variability and uncertainty of this risk index and to derive statistical scenarios. As a result, a spatio-temporal graph covering the Arctic and depicting the daily ice and risk scenarios over time has been developed. Since ships behave differently in ice, they must adapt their sailing speed depending on various meteorological and environmental parameters and available escort assistance. A speed profile has been defined to adapt the speed of the vessel regarding its ice class and the relative POLARIS risk encountered along its route.

The time-dependent graph has been used to optimize a risk-aware shortest path (in time) between any two locations in the Arctic [3]. The planning tool is able to compute different route proposals for various vessel ice classes and risk scenarios. The risk encountered, vessel speed and required icebreaker escort along these routes can be visualized on decision support and planning maps [4].

References

[1] Fedi, L., Faury, O. and Etienne, L. (2020). Mapping and analysis of maritime accidents in the Russian Arctic through the lens of the Polar Code and POLARIS system, *Marine Policy*. 18 103984. https://doi.org/10.1016/j.marpol.2020.103984

[2] IMO, (2016). Resolution MSC. 1/Circ 1519, 6 June 2016, Guidance on Methodologies for Assessing Operational Capabilities and Limitations in Ice.

[3] Wang, Y., Yuan, Y., Ma, Y., Wang, G., (2019). Time-dependent graphs: Definitions, applications, and algorithms. *Data Science and Engineering* 4 (4), 352–366.

[4] Cheaitou, A., Faury, O., Etienne, L., Fedi, L., Rigot-Müller, P., & Stephenson, S. (2022). Impact of CO2 emission taxation and fuel types on Arctic shipping attractiveness. *Transportation Research Part D: Transport and Environment*, 112, 103491.

S17-O09

Logistic configurations as a risk management and sustainable tool.

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Arctic navigation implies to manage the inherent related risks, to consider the impacts of transportation on the environment, and at the same time to make the navigation as profitable as possible such as ice presence and harsh weather conditions [1]. Considering these risks, the current optimal solution is to invest in winterized vessels which improves the capacity to sail in this ocean [2] which leads to questioning its profitability [2]. As stressed by [2-3], fuel consumption represents one of the highest expenditures. To counteract the risk of remoteness and increase the number of cargos shipped, investments in ports have been made to make the navigation safer and more profitable [3].

We propose a model based on a 1A container vessel sailing between Shanghai and Rotterdam through the NSR. The vessel could use one hub, both or no hubs for cargo transshipment. The ship is fueled with MGO, VLSFO or LNG and face three ice conditions . We considered that a TEU cargo value is around 22,000 USD [4].

We compute the ratio of the cost of fuel to the value transported for one USD over a year considering ice conditions and logistic organization.

References

[1] Fedi, L., Faury, O. and Etienne, L. (2020). Mapping and analysis of maritime accidents in the Russian Arctic through the lens of the Polar Code and POLARIS system, *Marine Policy*. 118 103984. https://doi.org/10.1016/j.marpol.2020.103984

[2] Faury, O., Cheaitou, A., & Givry, P. (2020). Best maritime transportation option for the Arctic crude oil: A profit decision model. *Transportation Research Part E: Logistics and Transportation Review*, *136*, 101865.

[3] Cheaitou, A., Faury, O., Etienne, L., Fedi, L., Rigot-Müller, P., & Stephenson, S. (2022). Impact of CO2 emission taxation and fuel types on Arctic shipping attractiveness. *Transportation Research Part D: Transport and Environment*, 112, 103491.

[4] Rodrigue and Slack (2017a) Intermodal Transportation and Containerization. in Jean-Paul Rodrigue (2017), *The Geography of Transport System*. New York: Routledge, 440 pages. ISBN 978-1138669574. https://transportgeography.org/?page_id=1768

Vessel speed optimization in China transportation market with the EU in multiple modes including the Northern Sea Route

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China-EU's transportation market is dominated by maritime shipping through Suez Canal (SCR), besides airline and China-EU railway express. Recently, the Northern Sea Route (NSR) provides a new alternative to connect China and the EU by shipping. However, maritime shipping is continuously losing its competitiveness with the increasing high-price commodities and reducing costs in railway. Figure 1 also proves this point, representing that the trade value of shipping is gradually caught up by the rapidly increasing air and rail.

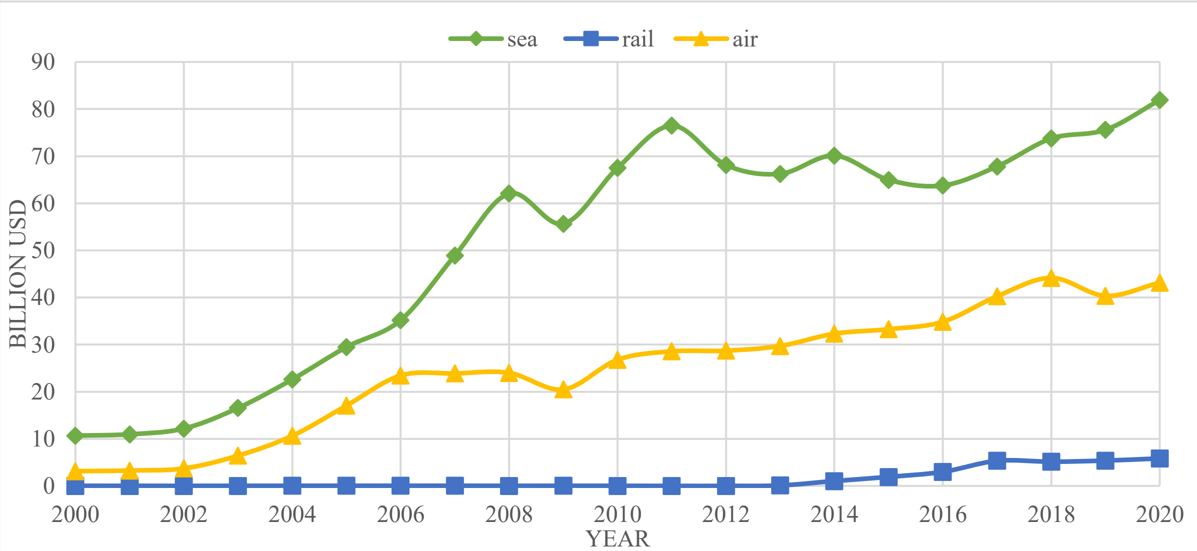

Figure 1. Trade value of three transportation modes (GTA forecasting)

This research mainly aims to maximize the profit of shipping companies with speed optimization, focusing on the competition between the four transportation modes (NSR, SCR, railway, and airline). The shipper's preference is taken into consideration, with two commodity types categorized by the cargo price. The sensitivity analysis is also conducted with increasing ice-classed vessel size and fluctuating fuel prices. Our findings show that vessels can be operated at full speed on NSR due to the saving in shipping distance and fuel cost, while a bit lower than maximum speed is preferable in SCR. Larger ice-classed vessels benefit NSR with economies of scale while increasing fuel prices reduce the competitiveness of shipping. This research also provides suggestions for liner companies in operating vessels to make a profit in the competition with the railway and the airline in the final.

References

[1] GTA forecasting database: https://ihsmarkit.com/products/gtas- forecasting.html

Bulk Vessels Diversions to the Arctic Shipping Routes with the Effect of Emission Trading System

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Maritime transportation accounts for over 80% of the world trade [1], while bulk shipping facilitates the movement of nearly half of the world's seaborne trade. These bulk vessels mainly carry general cargo, iron ore, coal, grain, and other industrial cargo, contributing significantly to the world economy and various industries. Despite the economic contribution of the bulk shipping sector, there is a considerable environmental impact from vessel-based emissions, which highlights the significance of various market-based emission control mechanisms. Besides, the economic and environmental impacts of bulk shipping are greatly affected by the characteristics of individual voyages, their shipping routes, voyage distances, navigation speeds, and vessel characteristics, among others.

The Nothern Sea Route (NSR) is an alternative maritime corridor for international freight distribution that emerges with sea ice deformation in the Arctic sea. Numerous previous studies analyzed the economic feasibility of the NSR compared to conventional shipping routes and came up with diverse conclusions [2]. This study aims to investigate the diversion potential of bulk vessels from conventional shipping routes such as the Suez Canal Route (SCR) and Cape Route (CR) to the NSR, considering the economic and environmental feasibility of using NSR. An emission trading system (ETS) is incorporated in this study to analyze the diversion potential of shipping moves. This study computes the greenhouse gas (GHG) emission abatement potential considering the implied carbon pricing effects under the ETS mechanism [3]. The vessel-based emissions are estimated in terms of CO2-equivalent incorporating GHG pollutants and their Global warming potential.

A sample of shipping moves in 2018 is considered for analysis with their respective origin-destination pairs and associated shipping demands. A mixed-integer optimization model is developed to decide the optimum diversion pattern of bulk vessels. A detailed estimation of vessel speed and navigation conditions is done considering the special-temporal variation of sea ice conditions along the representative navigation path along the NSR. To decide the navigation speed, the Polar Operation Limit Assessment Risk Indexing System (POLARIS) framework is incorporated. The results identify the optimized vessel diversion pattern considering the restrictions associated with NSR navigation and the potential gain with the ETS mechanism from both economic and environmental objectives. Sensitivity analysis is carried out with different carbon prices, cargo volume, and fuel prices to discuss significant policy implications.

References

[1] UNCTAD, Review of maritime transport, available at: https://unctad.org/webflyer/review-maritime-transport-2021 (2021).

[2] C.A. Kavirathna, and R. Shibasaki., Economic feasibility of Arctic shipping from multiple perspectives: a systematic review. *Okhotsk Sea and Polar Oceans Research*, 5: pp: 15–22 (2021).

[3] Z., Wang., J.A. Silberman, and J.J, Corbett., Container vessels diversion pattern to trans-Arctic shipping routes and GHG emission abatement potential, *Maritime Policy and Management*, 48 (4), pp: 543-562 (2020).

March 9

Breakout Session

S18

Arctic Sea Route and Coastal Protection: environmental, engineering, and economic assessment

Development of Arctic data visualization system for ice navigation support

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For ships navigating in the Arctic Ocean, accurate information on sea ice, ocean and weather is essential for their safe and planned navigation. The required information nowadays contain large amount of data, such as radar satellite images and high resolution forecasts from numerical simulation models. To efficiently utilize these data for decision makings on Arctic navigations, it is important to compose a sophisticated IT system managing data communication and visualization. In this study, an integrated ice visualization system was developed to support ice navigation. This system consists of cloud storages and a server installed on board a ship. The server acts as a web server, provides a web application that can be accessed from various kinds of terminals inside the ship LAN. Items visualized by the system includes realtime data such as sea ice forecasts, ice analysis charts, SAR satellite images, weather forecasts and wave forecasts. These data can be overlayed, and displayed with the ship's track. To reduce the amount of data transferred to the ship, some of the data are vectorized. It helps efficient data communication under limited satellite based communication environment in the Arctic. The application applies Mapbox GL JS (Ver. 1) JavaScript library to create interactive web map, which allows users to move and zoom in to any location. It also supports two map projections: Polarstereo and Mercator. Polarstereo projection is suitable for viewing geographical data in high latitudes including the North Pole, and Mercator projection is widely used in navigation system. Users can switch to each of the projections dynamically. It was operated for two Arctic cruise of the research vessel MIRAI in 2020(MR20-05C) and 2022(MR22-06C). This system received high evaluation from users for its high operability and enhanced visual experience, indicating the usefulness of the system. On the other hand, large discrepancies were found between analysis and forecast of ice distributions. The cause of the discrepancies is assumed to be an inaccuracy of initial condition of ice, which is composed from AMSR2 passive microwave satellite observations. It is necessary to improve accuracy of the initial ice conditions to resolve the issue.

Figure 1. Screen shot of the Arctic ice visualization application showing ice concentration forecast, SST forecast and SAR images

Preliminary analysis for ice thickness estimation for the wide area of Arctic Sea using AMSR2

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[2]*School of Engineering, Kogakuin University, Japan*

The microwave radiometer (AMSR2) onboard the JAXA satellite GCOM-W can observe the entire Arctic Sea with high frequency. The purpose of this study is to estimate ice thickness in the Arctic Sea widely and accurately using the observation capability of AMSR2. In order to develop an algorithm for estimating ice thickness, as a preliminary analysis, the correlation between brightness temperature obtained by AMSR2 and ice freeboard obtained by the radar altimeter (SIRAL) onboard the ESA satellite CryoSat-2 was investigated. In the analysis, a total of 91 pairs of polarization ratio (PR), frequency ratio (GR), and cross polarization ratio (XPR) were calculated from the horizontal and vertical polarization of the 6 GHz to 89 GHz band (7 frequencies) of the AMSR2 data, these were compared with the SIRAL data. For comparison, since AMSR2 and SIRAL have different data point resolutions, the SIRAL data with finer resolution were averaged according to AMSR2 resolution. Furthermore, the number of data required for averaging the SIRAL data was divided into cases, and the correlation was calculated. From the analysis so far, a correlation was obtained for each specific analysis period. However, through the overall analysis, no consistent trend was obtained as to which brightness temperature and brightness temperature ratio are correlated with ice freeboard.

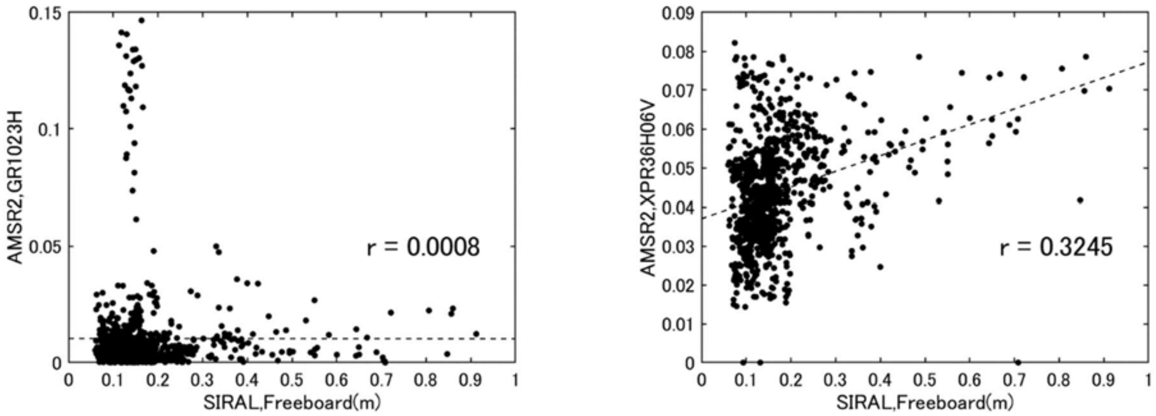

Figure 1. Scatterplot of temperature ratios from AMSR2 and ice freeboard from SIRAL in the Kara Sea from December 1, 2019 to March 31, 2020. (a)Weakest correlation: Comparison of frequency ratio of 10 GHz and 23 GHz horizontal polarization (GR1023H) and ice freeboard. (b)Strongest correlation: Comparison of cross polarization ratio of 36 GHz horizontal polarization and 6 GHz vertical polarization (XPR36H06V) and ice freeboard. Note that both (a) and (b) were calculated when the average number of the SIRAL data was 20 or more.

S18-O03

Seasonal and regional predictability of Arctic sea ice: Lagrangian ice tracking applications

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The motion of sea ice contributes to the predictability of ice coverage, a critical environmental parameter in the Arctic Ocean, for which both observational and modeling efforts contribute to improving forecasts. The Sea Ice Tracking Utility (SITU) is a tool, accessible online, that can be used to calculate Lagrangian sea ice trajectories using observations-based sea ice drift [1]. Over recent years, we have developed several applications that contribute to understanding the role of dynamic mechanisms on the predictability of sea ice at a seasonal timescale in different peripheral seas of the Arctic Ocean. In this contribution, we synthesize some key results: in the Laptev Sea, winter coastal divergence explains up to 40% of the interannual variability of the minimum sea ice extent by preconditioning the pack ice regionally for the summer melt [2]; the same mechanism displays predictive skill in the Beaufort and Barents Seas, where it also surpasses the reflected solar radiation as a seasonal predictor [3]; in the Chukchi Sea, predictability from dynamic processes is lost more rapidly, while the Bering Strait ocean heat transport has a strong influence on the spring and early summer sea ice conditions [4]; year-round ice tracking shows increasingly important loss of multi-year ice in the Western Arctic, while first-year promotion ice is progressing northward in the Eurasian Arctic [5]. Sea-ice motion itself is also important to material transport, and SITU has been used in fore- and hind-casting, e.g., to estimate future risks of oil spills and the provenance of sea-ice melt anomalies [6]. Ongoing work aims at correcting biases and improving the accuracy of observations-based drift datasets, supporting additional applications based on Lagrangian sea ice tracking.

References

[1] G. Campbell, S. Pfirman, B. Tremblay, R. Newton, W. Meier, and C. Fowler, Sea ice tracking utility. *NSIDC Labs*, http://icemotion.labs.nsidc.org/SITU/ (2020)
[2] C. Brunette, B. Tremblay, and R. Newton, Winter coastal divergence as a predictor for the minimum sea ice extent in the Laptev Sea. *Journal of Climate*, **32** (2019)
[3] J. E. Lenetsky, B. Tremblay, C. Brunette, and G. Meneghello, Subseasonal predictability of Arctic Ocean sea ice conditions: Bering Strait and Ekman-driven ocean heat transport. *Journal of Climate*, **34** (2021)
[4] R. Kim, B. Tremblay, C. Brunette, and R. Newton, A regional seasonal forecast model of Arctic minimum sea ice extent: Reflected solar radiation versus late winter coastal divergence. *Journal of Climate*, **34** (2021)
[5] J. Hart, B. Tremblay, C. Brunette, C. Dufour, and R. Newton, Examining the transition from a perennial to a seasonal sea ice cover in the Arctic Ocean: a Lagrangian approach. *McGill Science Undergraduate Research Journal,* **14** (2019)
[6] P. DeRepentigny, A. Jahn, B. Tremblay, R. Newton, and S. Pfirman, Increased transnational sea ice transport between neighboring Arctic states in the 21st century, *Earth's Future*, **8** (2020)

S18-O04

Numerical Simulation of Ships Navigating Through Broken Ice Fields

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A method called Physically Based Modeling was used to numerically evaluate the channel resistance of ships navigating through the broken ice fields. The results were compared to the Finnish-Swedish Ice Class Rules (FSICR). In this paper, channel resistance is examined from two perspectives: fluid forces around ice pieces and the shape of the bow. First, the effect of added mass was examined. Numerical experiments were conducted by incorporating a mass model into the existing fluid force model. The results of this calculation were compared with a drag-based fluid force model. Several bow shapes with arbitrarily changed waterline entrance angle (α), the stem angle at the centerline (φ1), and the stem angle at the waterline at breadth B/4 (φ2) were generated. The generated ship models were designated as "α-φ1-φ2" manner such as 35-75-75. Simulated ship and ice behavior in a brash ice channel to determine trends in channel resistance. The results show that the effect of added mass on the ice pieces is relatively small. Next, the largest increase in channel resistance occurred when α changed (Figure 1). As α increases, channel resistance also increases. On the other hand, in the range where α is small, the change in channel resistance may be small and channel resistance may decrease. The effect on channel resistance is greater for φ2 than φ1.

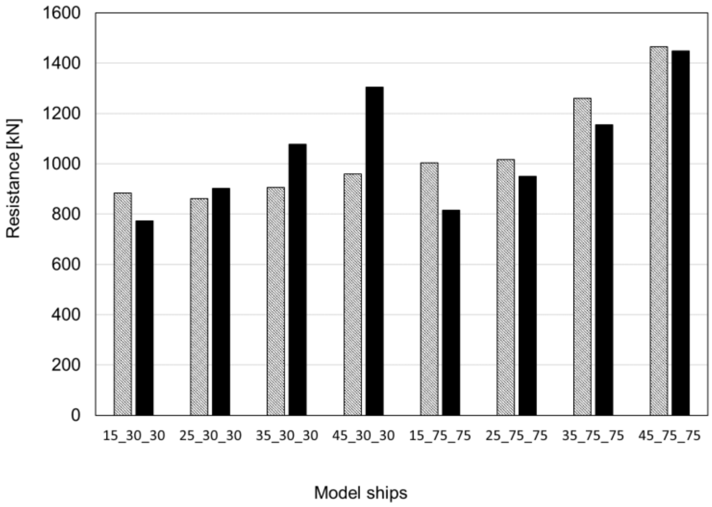

Figure 1. Channel resistance for each different α: (stripe) resistance by FSICR formula, (black) resistance by numerical calculation. Results of numerical calculation are quadrupled to compare trends with results by FSICR formula.

References

[1] Konno, A., 2009. Resistance evaluation of ship navigation in brash ice channels with physically based modeling. Proceedings of the 20th International Conference on Port and Ocean Engineering under Arctic Conditions (No. POAC09-105). Luleå, Sweden.
[2] Tokudome, T., Yoshida, Y., Konno, A., 2021. Fluid force modelling affecting on ice piece for ship navigation in broken ice fields. Proceedings of the 26th International Conference on Port and Ocean Engineering under Arctic Conditions (POAC '21). Moscow, Russia.

S18-O05

Development of a method for evaluating brash ice channel condition for ship navigation

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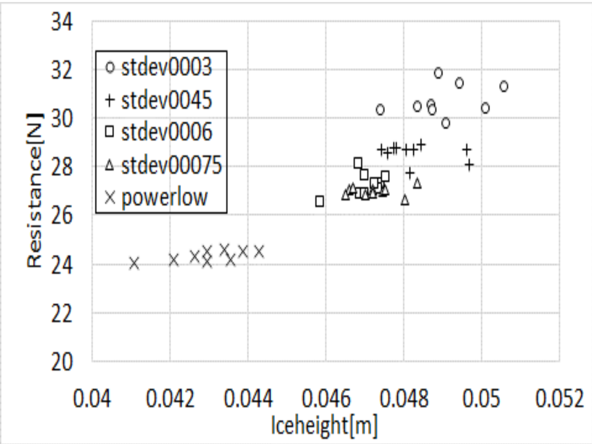
For ships navigating through brash ice channels, resistance is assumed to be affected by ice thickness and porosity, but the relationship between ship resistance and brash ice thickness or porosity is not clarified yet. In addition, there is no established method for calculating the thickness and porosity of the brash ice channel to be prepared for numerical analysis, and a reasonable method for calculating them needs to be studied. In this study, two methods were developed to evaluate the analytical conditions of brash ice thickness, and preliminary analyses were conducted to investigate the correlation between ice thickness, porosity and hull resistance. Simulations of ship navigation is conducted using KISIS[1], a ship navigation simulator in ice-infested waters developed in the authors' group. This simulator can calculate the resistance of an arbitrary ship shape navigating in an arbitrary brash-ice-channels. The results showed that the variation of the acquired channel thicknesses differed significantly between the two measurement methods. The analysis also showed that there was a tendency for hull resistance to increase as the ice floe thickness increased. This correlation was found to be a linear relationship. The same trend is observed for ice volume. These trends are also observed for several hull shapes. In contrast, no correlation between porosity and hull resistance was observed in both power and normal distribution cases.



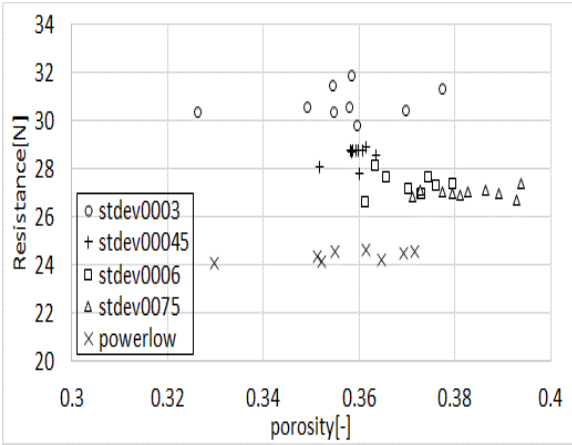


Figure 1. The relationship between (left) average cross-sectional area or (right) porosity and resistance

References

[1] Taiki Tokudome, Yuya Yoshida, Akihisa Konno, 2021. FLUID FORCE MODELLING AFFECTING ON ICE PIECEFOR SHIP NAVIGATION IN BROKEN ICE FIELDS, Proceedings of the 26th International Conference on Port and Ocean Engineering under Arctic Conditions

S18-O06

Investigation of Hydrodynamic Forces Acting on an Ice Piece Downstream of Floating Ice Pieces

Ryota Hayashi[1*], Akihisa Konno[2], Zhou Jinxin[3], Daisuke Kitazawa[3]

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To estimate an appropriate fluid force affecting on ice pieces for numerical simulation of ship navigation in ice-infested ocean, we investigate fluid force acting on an ice piece downstream of floating ice pieces by comparing simulation and experiment. In this study, ice arrangement types were single, two, and group of ices. Simulation was performed using Simcenter STAR-CCM+ ver2021.2. RANS and k-ε turbulence models were used for computational stability and short computation time. Experiments were conducted following the method by Yoshida et al. (2018), but a tricomponent force transducer is replaced to measure accurate fluid force. Results showed that fluid force acting on single ice correspond to the experimental result that fluid force was proportional to the square of the flow velocity (Hayashi and Konno, 2022). In the case of an ice piece downstream of two ices, fluid force decreased as the distance closed between the two ices. This trend was consistent between the simulation and the experiment, but the slope of the Fluid Force - Ice Distance graph was larger in the simulation than in the experiment (Hayashi and Konno, 2022). In the case of an ice piece downstream of group of ices, simulation showed an increase in fluid force as the number of front ice rows increased, while experiments showed a decreasing trend (Hayashi et al., 2022).We have not been able to find out this cause at this stage. Therefore, trial-and-error process is underway to have hints, such as changing the arrangement of ices, and turbulence model. We will continue to investigate this cause as a future issue.

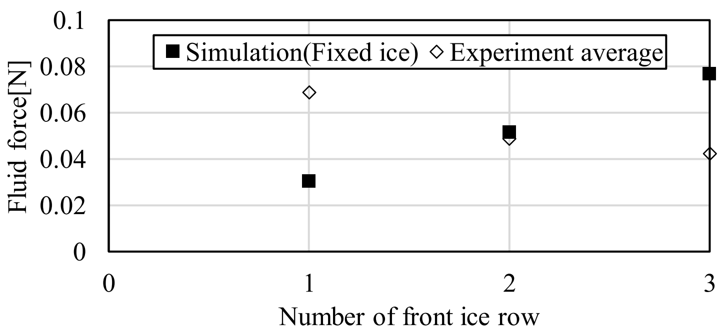

Figure 1. Average of fluid force in case of group of ices compared to experiment

References
[1] Takero Yoshida, Sota Kanno, Daisuke Kitazawa, Akihisa Konno: Modeling Fluid Force Acting on Single Floating Body in Group of Floating Bodies, The Japan Society of Naval Architects and Ocean Engineers, Vol. 27, pp. 9-14, 2018.
[2] Ryota Hayashi, Akihisa Konno: Investigation of Hydrodynamic Forces Acting on an Ice Piece Downstream of Floating Ice Pieces, Proceedings of Annual Spring Meeting of The Japan Society of Naval Architects and Ocean Engineers, Vol.34, pp.305-308, 2022.
[3] Ryota Hayashi, Akihisa Konno, Zhou Jinxin, Daisuke Kitazawa: Investigation of Hydrodynamic Forces Acting on an Ice Piece Downstream of Floating Ice Pieces, Proceedings of Annual Autumn Meeting of The Japan Society of Naval Architects and Ocean Engineers, 2022, accepted.

S18-O07

Laboratory Experiments of Urea-doped Water Spray Icing on Cylindrical Specimens

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[3]Kogakuin University, Japan

In recent years, the strength of summer ice is weakening in the Arctic Ocean, and the use of the Northern Sea Route is expected to increase. It is expected that the use of large vessels with low ice resistance will increase near future, so evaluation of ship icing is one of the most important factors for the operational safety of the Arctic routes. In this study, laboratory experiments of spray icing were conducted using simple-shaped test pieces that resembles a member of a ship's superstructure with the goal of predicting the amount of icing on individual vessels.

The experimental apparatus (Fig. 1) was set up in an ice tank (20 m in length × 6 m in width) at the Technical Research Laboratory of Japan Marine United Inc. Since the use of salt water was forbidden in this ship model basin, wet ice was grown by spraying urea-doped water with a concentration of about 20 ‰ to conduct experiments on the icing characteristics of brine-containing ice. The spray nozzles were fan-shaped one-fluid nozzles installed on both sides of the fan. The spray particle size distribution was measured by the splay particle counter SPC. The test specimens were cylindrical PVC models with diameters of 520 mm, 165 mm or 60 mm and heights of 1.2 m. The distance of the specimen from the spray nozzle was 3 m. The icing experiments were conducted 12 times with different combinations of specimen diameter, wind speed and spray particle size. Two wind speed patterns, about 10 m/s and about 7.5 m/s, were used near the center of the specimen. Fig. 2 shows the growth rate of spray icing on φ60, φ165 and φ520 mm cylinders. In all tests, it can be seen that the growth rate per unit area was faster for the φ60 mm cylinder and slower for the φ520 mm cylinder. In order to see the effect of the cylinder diameter on the amount of impinging droplet particles, the ratio representing the freezing rate relative to the impinging urea-doped water was calculated in each test. In each experiment of φ165 and φ520 mm cylinders, about half of the impinging spray was frozen under these conditions, and there was no significant difference in the amount of ice formed on the entire specimen per unit area. On the other hand, the Φ60 cylinder had a high freezing rate, more than 70%.

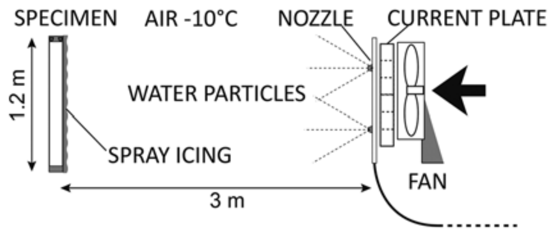

Figure 1. Experimental Apparatus.

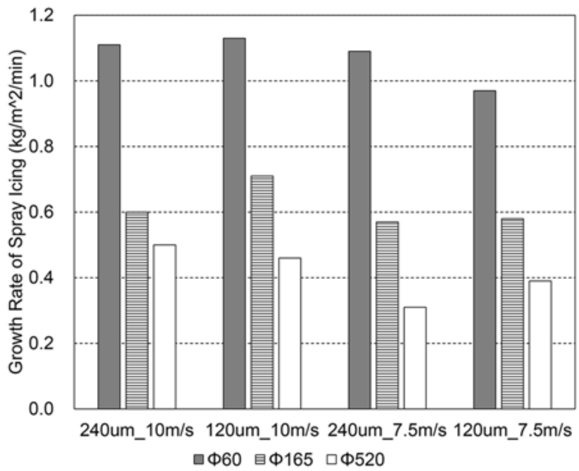

Figure 2. Growth rate of spray icing on φ60, φ165 and φ520 mm cylinders using urea-doped water. Wind speed were about 7.5 or about 10 m/s, and principal spray sizes were about 120 μm or about 240μm.

March 9

Breakout Session

S20

Toward sustainable Arctic -developing a network of Arctic researchers and other Arctic stakeholders-

S20-O01

HAI-FES: Problem-solving project for the sustainable Arctic

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It is undeniable that the "global environmental problem" is a consequence of the progress of modern science in subdivided disciplines. The Anthropocene, a period in which human activities are changing the "Earth system" itself as the basis of our existence, has strengthened the need for interdisciplinary integration of global environmental science and an international joint research system since the 1980s, by promoting the establishment of the Global Environmental Change Research Programs. However, governments, UN agencies, and others have criticized saying, "We have made progress in understanding, but not in research toward solutions to global environmental problems."

In response to these criticisms, “Future Earth” was established as a framework to unite these international collaborations while promoting research toward a sustainable global society in conjunction and collaboration (transdisciplinary) with academia and society.

“Future Earth” is, through collaboration and integration of natural sciences, humanities and social sciences, engineering, agriculture and medicine and Trans-disciplinary collaboration and cooperation with various stakeholders in society, to provide wisdom to avoid and mitigate risks of global environmental change and to promoting the transition to a sustainable global society for Designing a sustainable global society based on new values.

“HAI-FES” is a Hokkaido University funded project for promoting interdisciplinary and transdisciplinary sciences in the University and for launching “Future Earth Global Arctic Network” (FEGA-Net), which is a framework for Arctic and non-Arctic stakeholders to work together on Arctic-related issues in order to respond to the rapid environmental and social changes in the Arctic region that are affecting the entire planet and to achieve sustainable use of the Arctic region. Past activities of HAI-FES include the seminar series intended to create the network of people by inviting researchers who are engaged in Future Earth and problem-solving project.

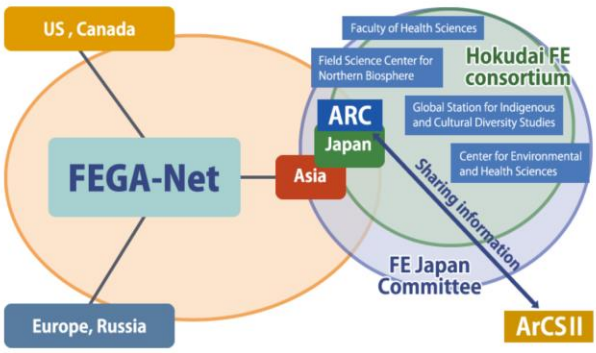

Figure 1. Schematic diagram of FEGA-Net

S20-O02

Developing guidelines, standards and best practices for sustainable development in the Arctic

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CAPARDUS is a Coordination and Support Action under H2020, running from 2020-2023 with focus on developing guidelines, standards and "best practices" in research, resource exploitation and management, shipping, tourism and community planning. The project involves scientists, economic actors, local communities, managers and regulators. Workshops and dialogue meetings are used to discuss how the social-environmental systems are changing Arctic communities and what are the drivers for these changes. The climate change and its consequences in the Arctic leads to new requirements for planning and decision-making based on scientific and economic data, assessments and predictions. A prerequisite for good planning is access to data and information of relevance to the local communities, public resource managers, and operators in the Arctic.

One goal in CAPARDUS is to design an Arctic Practices System (APS). The system is envisioned to be a sustained repository for practices related to environmental observations, resource exploitation and other activities in the Arctic. A ´practice´means a documentation in digital form of how things are done for example in observation of a specific ocean phenomenon. People living and working in the Arctic are operating according to ethics, norms, guidelines or common practices, which often evolve as a bottom-up process. In other cases jurisdiction or regulations provide a top-down framework for guidelines and practices.

What an APS should do will is explored in dialogue with people living or working in the Arctic with knowledge about practices in their daily work. The APS will cover the whole "value chain" from societal requirements, to data acquisition, products, services and societal benefits. The APS will be designed from practices and methods of the local communities and other actors who are involved in the project though the workshops and research schools organized by CAPARDUS.

CAPARDUS contributes to the Arctic Practices Community by documents on standards, guidelines and practices of relevance for scientists, commercial operators, Indigenous and local communities, NGOs and governance bodies. The Arctic Practices Community is an initial repository for supporting CAPARDUS Arctic Practices System Design. The APS will build on the UNESCO/IOC Ocean Best Practices System (OBPS; www.oceanbestpractices.org) , which was implemented to address similar challenges in the marine domain, hosting forward-facing best practice management system in tune with standards in global ocean observing. The OBPS operates a permanent repository for documents, where CAPARDUS has established a "Polar Collaboration" community with more than 150 documents https://repository.oceanbestpractices.org/handle/11329/1291. The final CAPARDUS report will synthesise how practices, guidelines and standards are evolving in support of sustainable development in the Arctic.

Acknowledgement: This work is supported by the CAPARDUS project (grant agreement no. 869673) under the European Commission Horizon 2020 program.

S20-O03

Food Life History in Greater Beringia: Types, History, and Current Issues of Cold Storage

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This paper introduces and reports the results of the preliminary results on the "Food Life History of the North" project, conducted partly as a feasibility study at the Research Institute for Humanity and Nature, and as a project of the National Science Foundation (NSF 2133706, USA), focusing on varieties and commonness of the issues of cold storage that use the natural cold environment extending from Siberia and Alaska, the "divided twins" in Beringia, to the middle latitudes, namely Mongolia and Japan. Along the latitudinal and climatic gradient, the underground thermal states change from continuous and discontinuous permafrost in the higher latitudes to seasonally frozen ground. The ecosystem and major harvests also change accordingly. Consequently, the types and purposes of storage vary as well, from permanent cellars for all-season usage for food and ice for drinking to temporal pits for occasional storage on hunting, and to ice or snow houses that hold winter-time ice or snow for cool storage or use of ice to the next warm seasons. The usages and practices of their cold storage are consonant, directly or indirectly, with their lifeway and culture, but have been pressured under multiple environmental changes both in human societies and nature; modernization (e.g., use of electricity, global supply chains, monetary and market economy, changes in dietary) on one hand, and climate changes (warming and wetting) on the other. The related issues include security and sovereignty of food and energy, health, traditional and scientific knowledge, rituals and tourism, sustainability and resilience, autonomy, and worldviews. We conducted preliminary research in the above-mentioned areas for current issues in use such as dysfunctions or abandonment of cold storage facilities through questionnaires, recordings (oral interviews), literature, and aerial surveys. We will present the results from our preliminary surveys, and the overall outlook of the continued work in the areas extending from Beringia to the mid-latitudes.

Figure 1. Cold storage in Siberia, ice stored for drinking, and an ice-cellar schematic.

S20-O004

Sustainability of the Northern Sea Route, commercial, environmental, and social perspectives

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Due to the long-term sea ice retreat in the Arctic Ocean[1], ice free summer along the Northern Sea Route (hereinafter NSR) will expand and navigation condition will become calmer. In parallel with this, commercial use of the NSR has been developed toward 2021. The main driver of this achievement is natural gas and crude oil exploitation of the Kara Sea coast, and the NSR is gradually becoming a new energy resource corridor. Furthermore, Russia intends to develop year-round container shipping service by SMTC Project, which plans to start pilot shipment in 2025[2]. Against the background above, environmental, societal, and other concerns are highlighted together with expectable benefits and commercial interests. The typical characteristics of the NSR shipping is its shortened distance between Europe and Asia, remoteness of the route, and ice navigation. Due to the shortened shipping distance, reduction of shipping cost and emission, and various advantage of shortening of lead time would be expected[3]. The chance to connect the NSR will increase for remote cities along the Arctic coast and inland cities along the large river. And Arctic cruise tour will also get attention from non-Arctic people. On the other hand, under water noise occurrence will increase by large ship navigation and may cause negative effect to marine mammal's living environment. And if cargo ship and/or cruise ship navigation route and season overlaps marine mammal's nursery ground, they will be pressed to find another area or lose it. Risk of maritime accident and release of hazardous materials to the Arctic Ocean will also increase. There are not enough facilities of accommodation, medical service, and emergency service in remote coastal cities and settlements if an emergency incident happens along the NSR. And all these issues might have some effect to local societies mainly along the Arctic coast.

Under the above merits and demerits, it would be important to utilize the NSR by sustainable manner that to work on effort for consensus building with local stake holders such as communities along the coast of NSR and people who rely on the coastal marine environment. In the academic activity, it could be possible to tackle on an assessment that covers conceivable issues as much as possible and examine interrelation of those issues by multiple standpoints. The key to achieve this assessment would be transdisciplinary discussion and examination. In the session presentation, overview and idea of the assessment will be discussed.

This work was supported by JSPS KAKENHI Grant Number JP19K12304 and Arctic Challenge for Sustainability ArCS II(JPMXD1420318865).

References

[1] IPCC, *Sixth Assessment Report Summary for Policymakers*, pp.5 and pp.16, (2021)

[2] Naida Hakirevic Prevljak, Rosatom to deploy 1st Arctic boxship on Northern Sea Route in 2025, *Offshore Energy*, https://www.offshore-energy.biz/rosatom-to-deploy-1st-arctic-boxship-on-northern-sea-route-in-2025/, viewed Mar. 2022, (2021)

[3] N. Otsuka, H. Sasaki, T. Kakizaki, E. Nakamura and A. Moriki, Summary of the Northern Sea Route trial shipping of containers, *The 35th International Symposium on the Okhotsk Sea & Polar Oceans*, pp.43-45, (2020)

SMART/Dual-purpose Trans-Arctic Cables: Industry-Academia Cooperation initiative too good to be missed?

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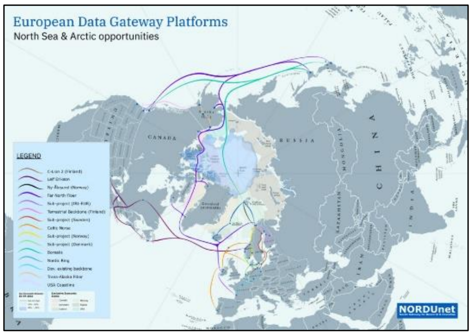
As Howe et.al. [2019] have pointed out, SMART (Sensor Enabled Scientific Monitoring and Reliable Telecommunications) or dual-purpose cable initiatives incorporate the demand for greater connectivity and the need for improved climate change mitigation and ocean management tools. The SMART cables integrate different types of environmental sensors measuring temperature, ocean circulation, tides, seismic activity, for example, into commercial submarine telecommunications cables. Usually repeaters, which are devices strengthening the fiber-optic signal and located 50-100 kilometers from each other, are envisioned as the parts of the submarine cable system where sensors could be attached to. Alternatively, the fiber itself can be used as the sensing element without adding any sensors in the submarine part of the cable [Marra et al. 2018]. If implemented, this type of cooperation could be highly beneficial both to the cable industry (part of the installation costs covered by the scientific community purchasing also part of the data transmission capacity) and the academia (establishing a unique research infrastructure with a reduced price). Although the implementation of SMART initiatives has witnessed difficulties ranging from sensors' possible impact on the functioning of the cable to problems in regulation, discussion concerning the dual-purpose use of cables have recently intensified. At the same time, SMART initiatives are also increasingly discussed in the context of trans-Arctic submarine fiber optic cables. This study shortly introduces the different trans-Arctic cable initiatives, elaborates the possibilities that the new kind of industry-academy cooperation could bring forth, and describes the steps that should be taken in order to move forward toward the implementation.



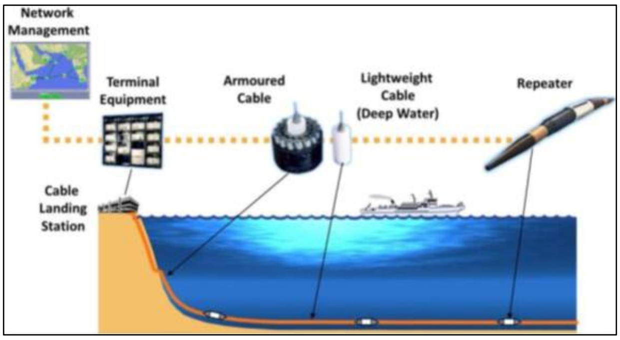


Figure 1. Trans-Arctic cable projects (https://nordu.net/polar-connect/)
Figure 2. Construction of submarine fiber optic cable system (Alazri 2018).

References

[1] Howe et al. (2019). Scientific Monitoring and Reliable Telecommunications (SMART) Cable Systems: Integration of Sensors into Telecommunications Repeaters for Climate and Disaster Mitigation. Suboptic 2019, April 9.
[2] Marra et al. (2018). Ultrastable Laser Interferometry for Earthquake Detection with Terrestrial and Submarine Cables. *Science* 361 (6401): 486–490.
[3] Alazri, A.S. (2018). The Threat and Vulnerabilities of Submarine Cables in Information Security and Telecommunication. *International Journal of Multimedia and Image Processing*.

S20-O07

Yakutia as a platform for science diplomacy in Russia's Arctic

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In this study, we examine advantages, risks, and opportunities of implementing international scientific research in Yakutia. For a long time, Yakutia has been an extremely appealing object of scientific research, thanks to its unique features. Most researchers believe that Yakutia, as a region, is interesting for the scientific community due to a combination of harsh climate, a variety of natural landscapes, and low population density, all of which allow it to act as a large testing ground for scientific research. Furthermore, Yakutia is notable for the openness of its scientific community and its local population. However, several factors inhibit Yakutia's competitive edge in the scientific environment. These include the predominance of projects in natural sciences domain; the lack of local trained professionals in some branches of scientific knowledge; a decreasing number of researchers, as well as their aging; and the fact that the scientific infrastructure of Yakutia is competitive only compared to other Russian regions, but not globally. Among the constraining factors are acquisition conditions and terms of use of equipment, complicated transportation, and lack of infrastructure in the Arctic regions, and organizational issues, including the issuance of visas, etc. In addition, international scientific cooperation is also prone to foreign policy risks. The avenues for scientific cooperation in the Arctic largely depend on the intensity and sustainability of contacts via international organizations.

In this work we also present few insights from implementation of the COPERA (2015-2017) and RISE (2021-2024) international projects. Both of them were implemented North-Eastern Federal University (Yakutsk, Russia) in cooperation with Hokkaido University (Sapporo, Japan). The last one is an example of a successful international project being implemented under conditions of pandemic and political fluctuations.

Funding: The reported study was performed under the e-Asia Climate Call and funded by RFBR, project number 21-55-70104

S20-O06

The review of the KoARC's activities and visions

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The Korea Arctic Research Consortium (KoARC) is a multidisciplinary network of domestic institutions, Universities and industries involved in the Arctic Research which was kicked-off on November 2, 2015 under the 1st Masterplan for the Arctic Policy (2013-2017) as a follow-up action of getting the observer status of the Arctic Council in 2013. KoARC's secretariat has been operated and supported by Korea Polar Research Institute since 2015 which is belonging to the policy division of KOPRI as a function.

KoARC's vision is to serve as the national hub for Arctic research cooperation by creating links and opportunities for academia, industries, and research institute, etc. In order to fulfill this visions, KoARC has been doing the various activities and projects: to develop multidisciplinary research projects, (ii) to set the mid-to-long term research direction, (iii) to provide a platform for collaboration and networking among the Arctic experts, (iv) to participate in domestic & international events and activities relevant to Arctic researches for information sharing (v) to suggest policy proposals to the Korean government based on the research output.

Member institution of the KoARC has increased from 23 institutions in 2015 to 40 in 2022 including DSME, Hyundai Heavy Industries, Academia and Research institutions (KOPRI, KMI, KRISO…) and based on the KoARC members' expertise, a lot of projects and events have been launched and carried out. KoARC embarked on 'Polar Issue Report publication project' in 2019 which covers various issues from scientific issues (climate change, permafrost) to Arctic shipping, ship-building, governance, etc, which is supported by Ministry of Oceans and Fisheries. According to this project, 8 themes are selected through editorial meeting of the Expert-board every year, and as the next step, expert writing and relevant visual materials (short-video, and infographics regarding 8 themes) for public understanding is made, and lastly report-publishing and exhibition for visual-materials are executed at the Korean Arctic Partnership Week (Busan) every December.

Regarding multi-disciplinary project, in 2022 KoARC launched the eco-friendly icebreaking container vessel development research project (under the preliminary study stage) suggested by DSME and universities, industries, research institutes do the collaborative researches, finally we plan to develop this project as national R&D project in 2023. Also, Korean Arctic-information interface (GIS) development project is now underway by university and industry members, which targets to supply the detailed and practical information in developing new projects, and help experts to do the researches. KoARC holds the breakout session at the Arctic Circle Assembly (Reykjavik) based on the themes of multidisciplinary projects and polar issue report project. In addition, every two months we host online expert-seminar using the Zoom for information sharing and discussion on the recent the Arctic issues.

In the stage of stabilization of the KoARC's various projects, KoARC will try to improve the system for facilitating the cooperation with academia, research institutions and government, , as a substantial herb among the domestic Arctic players, and will expand the collaborations with JCAR, ARCUS and AEC, etc.

References

[1] HK Seo, KoARC's vision & Knowledge-based Activities. 2020 Arctic Frontiers Poster session presentation (2020)

March 8

Breakout Session

S21

Funding International Arctic Science

S21-O01

Challenges in International Arctic Research Cooperation

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It is well known that Arctic is not an isolated region, but climate change affecting locally Arctic land, ocean and its people, is also affecting globally. Finding solutions to both local and global challenges need cross-regional inter- and transdisciplinary research, which calls for international cooperation with adequate funding schemes. One example of such successful large-scale initiative is MOSAiC expedition, however will it stay as a one single case of such investment in collaboration with multinational research institutions? At the organizational level, long lasting cooperation has been going on with International Arctic Science Committee (IASC), International Arctic Social Sciences Association (IASSA) and University of the Arctic (UArctic), which all also work in partnership with other organizations creating even more opportunities for international cooperation. This presentation focuses to the University of the Arctic, which is a cooperation network of 169 members representing both Arctic and non-countries and to its 61 thematic networks and UArctic Institutes with partners from over 30 countries, majority being from outside Arctic. Thematic Networks are platforms for thematically focused joint research, education and knowledge sharing guided by UArctic's values: circumpolar, inclusive, respectful, collaborative, open and influential. UArctic develops knowledge to address local and global challenges of relevance to Arctic peoples and societies by providing unique educational, research, and innovation opportunities through collaboration within a powerful network of member institutions. For doing that all different knowledge systems are needed in a respectful relationship, with co-designing and working together across the disciplines and borders with mutual partnerships with local and Indigenous Peoples. However, a challenge is the lack of truly international, cross-regional funding instruments allowing time for co-developing and planning of the transdisciplinary research. Arctic research is often funded through national funding agencies and polar programs, and by regional funding schemes such National Science Foundation in USA, or by European Union through its H2020 and Horizon Europe funding. How could international science partnerships influence to existing regional and national funders to collaborate and create joint Arctic cross-regional funding schemes or is it time to create completely new funding instruments?

Overview of European Polar Research Funding

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The European Polar research funding landscape is diverse and complex. At a national level, Polar research funding structures vary widely across Europe. Some countries have specific Polar research funding programmes managed by national agencies or ministries, others have established national Polar research institutes, that define priorities and provide resources to carry out their national polar research programme and/or provide logistics support to its polar scientists. Some countries provide funding for Polar research only through national open competitive calls for basic research.

The EU-funded EU-PolarNet 2 project aims to provide an overview and better understanding of the landscape of Polar research funding in Europe and of the diversity and coordination potential of European Polar research programmes. The project has already published a Directory of European Polar Research funding programmes and a White Paper on the European polar research funding landscape. These documents contribute to understanding the polar activities, national resources, investments, and funding structures in European countries. A strong European polar research environment requires efficient and effective national and European polar research programmes that are complementary and coordinated. By generating a better overview of the landscape and diversity of the funding strategies, structure and priorities, stronger cooperation and partnerships shall be facilitated in support of large international initiatives and the establishment of a European Polar Research Area.

Cooperation in European Polar Research: current status, and upcoming developments

P. Elshout[1*] and R. Badhe[1]

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Polar science is crucial to understand climate change and the effects of climate change all around the globe. Out of the 9 climate tipping points that the IPCC has identified, 6 are located in the polar regions. Polar regions are difficult to work in, and polar science is expensive to run. The operating of polar research infrastructure (consisting of research stations, research vessels and supply logistics) requires a long-term vision, both for research and funding.

Due to these difficult operating conditions, cooperation between scientists, projects and small and large polar programs is common. The EPB is a great example of this kind of cooperation at an organisational level, where its Members, small and large, communicate and share best practices. Another example is the Horizon2020 funding program of the EU, which encourages multilateral scientific cooperation. Amongst the EU Horizon2020 are polar projects such as INTERACT, EU-PolarNet2 and SO—CHIC; and also the EU Polar Cluster, through which several projects and organisations work together. On a longer term, EU-PolarNet 2 and EPB are working towards setting up the European Polar Coordination Office (EPCO) that will focus on continued research prioritisation, optimisation and funding of European polar research. With this presentation, the European Polar Board will share further information about these developments in coordinating European polar research.

S21-O04

Evolution of Arctic Research System in Japan -From individual research to national project, and international collaboration-

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Arctic science in Japan has been carried out continuously for the last 30 years, and has changed especially in the last decade. In the past, it was mainly carried out by individual activities and small, short-term projects.

In response to the establishment of IASC in 1990, a liaison meeting was formed as the momentum to organize activities in Japan increased, and Ny-Alesund was established as a regular observation point. In addition to Svalbard environmental observation, Greenland ice sheet drilling, and land observation in Siberia, collaboration with IARC began at the end of 1990 as an activity base in Alaska. Sailing has begun.

Since 2011, a national project has been implemented to integrate these activities. Implementing GRENE Arctic project, ArCS, then ArCS II, the aim has moved from research in a single field to interdisciplinary collaboration, then connecting transdisciplinary. Domestically in Japan, such cooperation and activities have been promoted. Furthermore, activities within an international framework are also required. We have been participating in the development of multipoint observation networks and the international sharing of observation data through projects.

ArCS II, which started in 2020, is also preparing opportunities for research cooperation. This is not the dispatch of individuals, but the initiation and strengthening of collaboration between research institutes, making it possible to adapt to the collection of two-way and multinational institutions. Also, by always including young people, it is an attempt to connect to future sustainability.

Research activities, infrastructure and budgets have also progressed from individuals and small groups to being assembled into national projects. At ASM, research reports from various countries were collected, but most of them were conducted within a single country. ASM recommended international collaboration, which should be carried out multilaterally. There is a need for a forum for such discussions and a mechanism for its implementation.

In addition to those that can be maintained by domestic projects and those that can be implemented through individual cooperation with overseas, the idea of ASM is to consider what international management organizations need, such as human exchanges, international forums, observation networks, and observation campaigns. IASC, SIOS and many European collaboration, data centers exist, we can seek for further actions, and their sustainability and/or non vulnerable system.

S21-O05

Organizing funding for observing in the Arctic

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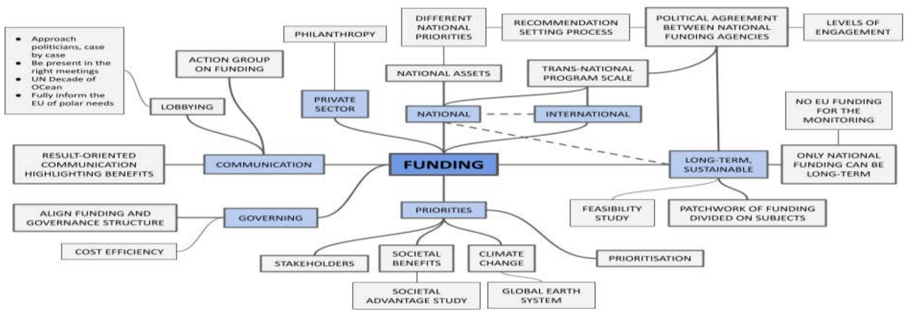
The Arctic is undergoing profound transformations. Observations, and data derived from them, can support important decisions on mitigating actions and adaptive responses in the Arctic and beyond. The challenging environmental conditions of the Arctic, limit the use of standard technology and increase the costs of observations. The high costs of the observations in turn makes it more challenging to raise the necessary funding to expand and integrate the Arctic observing systems.

A recent workshop with coordinators of polar observing systems, arranged by the EU-funded *EU-PolarNet 2*, addressed this challenge by discussing future recommendations for e.g. the coordination of funding. The current lack of a systematic planning and funding mechanisms to develop and link observing and data system requirements and implementation strategies in the Arctic region is addressed by The Roadmap for Arctic Observing and Data Systems (ROADS) through generating a systems-level view of observing requirements and implementation strategies. The ROADS process is one of the drivers of the EU-funded project *Arctic PASSION*. This presentation provides an update of the outcomes from the *EU-PolarNet 2* workshop, and *Arctic PASSION*.



Mindmap on organizing funding for observing. Outcome of the EU-PolarNet2 workshop in June 2022.

References
[1] EU-PolarNet 2 - Co-ordinating and Co-designing the European Polar Research Area. Deliverable No. 6.4: Minutes of a Workshop with Coordinators of European Polar Observing Systems
[2] Starkweather *et al*: Sustaining Arctic Observing Networks' (SAON) Roadmap for Arctic Observing and Data Systems (ROADS)
https://journalhosting.ucalgary.ca/index.php/arctic/article/view/74330

S21-O06

New initiative toward the International Platform for Arctic Science : Call for ECSs proposal using R/V Mirai 2023 Arctic Cruise

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Japan has been conducting continuous observation research in the area where sea ice has disappeared in the Pacific sector of the Arctic Ocean using the research vessel "Mirai" (R/V Mirai) since 1998. However, since R/V Mirai is not an icebreaker, it was not possible to conduct observations in the sea ice area. There were many discussions about how to conduct observation in the sea ice area and obtain high-quality Pan-Arctic observation data as R/V Mirai is doing. Then, finally, the Japanese government decided in December 2020 to build a new research vessel with icebreaking capabilities to expand observation and research in the Arctic Ocean. The steel-cutting ceremony for the new research icebreaker for Arctic Science was held in March 2022 and is scheduled to be delivered in JFY 2026. We will have the trial cruise for the Arctic Ocean in 2027.

On the other hand, the 3rd Arctic Science Ministerial meeting (ASM-3) was held in Tokyo in May 2021. With the participation of 35 countries and organizations, discussions and presentations were held on promoting research and observation in the Arctic region, addressing social issues, and further promoting international scientific cooperation. In this meeting, it was announced that Japan will 1) promote the construction of an icebreaking research vessel for Arctic science, which will be operated as an international research platform to enhance international collaboration in Arctic research, and 2) promote efforts to foster young researchers involved in Arctic research.

Japan’s Arctic research project, ArCS II (Arctic Challenge for Sustainability II), is implementing various activities related to the promotion of international research collaboration and the capacity building of young researchers. In accordance with the objectives of the ArCS II project and in collaboration with the Association of Polar Early Career Scientists (APECS), we conduct a new initiative (the call for Early Career Scientists (ECS)) that ECS from not only Japan but also other countries are invited to apply for a research and observation proposal using the research vessel MIRAI 2023 Arctic cruise to be conducted from August to October 2023. This is the first initiative of Japan’s Arctic research activities.

This call opened in early September 2022 and the deadline for submissions was on October 20. After reviewing many applications, 11 proposals from Japan and 5 other countries are accepted. We now contact the accepted ECSs to make a cruise plan and prepare the observation. We will have the R/V Mirai observation cruise in Aug.-Oct. 2023 as an international collaboration cruise for ECSs. After the cruise, we can also organize workshops and propose sessions at international conferences and meetings.

This new initiative is toward the international research platform of Japan’s new icebreaker for Arctic science and we believe that it encourages the capacity building of ECSs and international research collaboration for Arctic Science.

S21-O07

Science Process and its outcomes of the third Arctic Science Ministerial (ASM3) – international cooperation in Arctic research

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[3]*Ministry of Education and Children, Iceland*
[4]*Arctic Research Center, Hokkaido University, Japan*

The Arctic Science Ministerial is an intergovernmental gathering of science Ministers. It aims to strengthen scientific cooperation and collaboration among both Arctic and non-Arctic States in order to develop our understanding of the rapid changes impacting the Arctic. The Third Arctic Science Ministerial (ASM3) followed the First Arctic Science Ministerial (ASM1), hosted by the United States in 2016, and the Second Arctic Science Ministerial (ASM2), co-hosted by Germany, Finland, and the European Commission. ASM3 was co-hosted by Iceland and Japan, and took place on 7-8 May 2021 in Tokyo, Japan.

The ASM3 Science process followed the structure of the previous Ministerials by soliciting theme-based project updates and new projects from participating countries, Indigenous Peoples' organizations, and international organizations engaged in Arctic science and education, while also attempting to create a more formal consultation process with the wider research community through other international forums and through the ASM3 Webinar Series.

The intention of this wide-reaching science process was to have robust and inclusive science outcomes to provide a strong foundation for all the final outcomes of the ASM3. These outcomes create useful tools for cooperation, deepen our understanding of both the achievements and challenges that lie ahead, and provide a strong framework for taking urgent action. This presentation introduces a concise summary of the ASM3 science process and outcomes, including the report [1], database, and other resources available online [2].

Figure 1. ASM3 Report

References

[1] Jenny Baeseman, ASM3 Science Advisory Board, MEXT (Japan), and MRN (Iceland) (ed), *"Knowledge for A Sustainable Arctic", The third Arctic Science Ministerial Report* (2021)

[2] https://asm3.org/conclusions/asm3/ (last accessed 31 October, 2022)

Funding the future of polar research

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The future of polar research depends on the next generation of polar scientists. The Association of Polar Early Career Scientists (APECS) is a non-profit organization with approximately 4500 members from over 70 countries that provides a global network for collaboration, career development, education and outreach among polar enthusiasts. The internationality of APECS members is one of the organization's greatest assets, as early career researchers (ECRs) are able to build international networks through active engagement in our activities. These networks help our members secure jobs, develop new projects and research directions, and provide peer-to-peer support as our members navigate through their careers. Just as we have seen within APECS, Arctic science majorly benefits from international coordination, allowing countries and institutions to share and build ideas and achieve far greater goals than any entity could achieve alone.

International coordination of Arctic science funding is critical for the sustainability of our organization. As our activities grow, we naturally require more funding. Since members across the globe benefit from our activities, it follows that our organization is funded from a number of international sources. APECS and large, international projects (e.g. ARICE, Arctic PASSION) have mutually benefited from employing APECS Project Officers that help projects carry out their goals with regards to ECR engagement and development, and tie APECS, and thus its members, to cutting edge science activities. This is just one small but meaningful example of the many benefits of internationally-funded and -coordinated projects.

European countries naturally co-fund projects through the programs of the European Commission, but there is a need for more large-scale initiatives that combine government funds from additional regions including North America and Asia. Collaboration on Arctic science already exists across these regions on the individual scientist scale, but needs to be developed at the highest levels of government and reflected in government budgets. The MOSAiC Expedition and the associated MOSAiC School are clear examples of what can be achieved when funds from multiple governments are combined. Current geopolitical tensions make it even more crucial that Arctic science is consistently conducted across borders in order to achieve the best holistic understanding of the north.

Leadership positions within APECS have most often been filled by individuals with European or North American backgrounds. Better international coordination of Arctic science funding will not only benefit scientific outcomes, but will help diversify the APECS network and will encourage ECR participation and retention from regions where APECS has previously had less members. APECS would like to acknowledge the increased emphasis on ECR support by the Institute of Arctic Climate and Environment Research at JAMSTEC and is excited about the opportunities for future collaboration with Japan and other Asian countries. International collaboration and mobility is critical for career progression in research, so enhanced international coordination of science funding benefits Arctic-focused ECRs and Arctic science overall.

S21-O09

Tools for Enhancing International Research Funding Opportunities: Arctic Science Ministerial Resources

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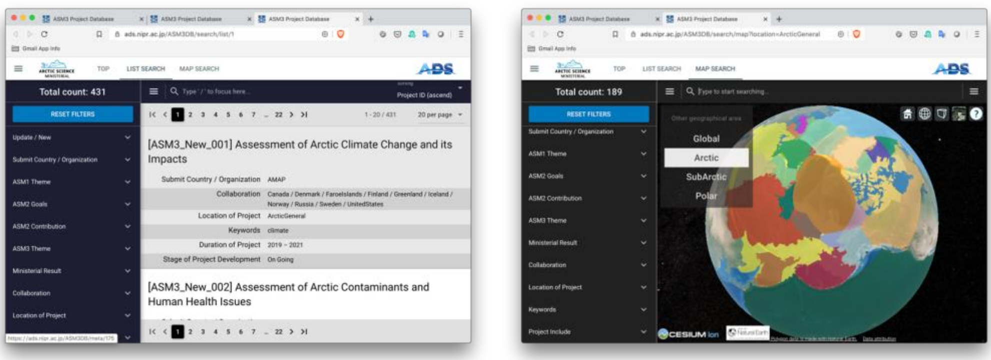
With the Arctic warming up to 3 times the global average, rapid changes are having global implications at unprecedented rates. For society to adapt and prepare for such changes, more research needs to be done and with haste – research that not one scientist or country can do alone, but research that requires international and interdisciplinary collaboration.

To aid in identifying areas where collaborations can more easily be formed and where funding organizations and institutions can pool resources for greater benefit, Japan and Iceland, as the organizers for the Third Arctic Science Ministerial (ASM3), building on the efforts of the US-hosted ASM1 and the German-Finnish-EC hosted ASM2, designed surveys and questionnaires for the 27 participating national governments, 9 Arctic Indigenous People's Organizations and several international organizations with interests in Arctic science and education. This produced a plethora of important information which was distilled into a number of tools helpful for funding organizations and researchers alike. An international interdisciplinary searchable and user-friendly database with over 400 Arctic research projects [1] is complemented by collections of International Collaboration and Cooperation Opportunities, Opportunities for Indigenous Peoples, a compilation of National Arctic Policies, and a thorough report outlining research in the Arctic.

Here, we present how these resources not only provide a detailed overview of what research is happening in the Arctic and where, but how they can help to identify gaps and areas where enhanced international collaboration and funding can dramatically increase the impact of Arctic research urgently needed to address global climate change implications.



List View   Map View

Figure 1. ASM3 Project Database

References

[1] ASM3 Project Database (https://ads.nipr.ac.jp/ASM3DB/, last accessed 31 October, 2022)

S21-O10

Strengthening international collaboration to fund Arctic science: the perspective of the French National Research Agency

A-H. Prieur-Richard[1]*

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This paper aims at presenting avenues for funding agencies to set up joint collaboration to advance research on the Arctic related issues.

Global environmental changes (climate change, biodiversity changes, pollution, etc.) are strongly impacting the Arctic ecosystems and the local communities and populations leaving in this geographic area. Scientific-based knowledge of these issues has been developed over the last decades. However, many questions are still open and request investment in research to provide management and policy solutions based on scientific evidence. This research needs to be highly relevant for local stakeholders. To achieve this, engagement with local populations and communities is key. All types of knowledge need to be mobilized. Another aspect of research in the Arctic is that it is transnational in nature: global changes impacting the Arctic may be initiated outside of the region, conditions to conduct research in the Arctic often request heavy investments. This paper will address those challenges and ways to address them through transnational cooperation from the point of view of funding agencies, including the development of actions of the Arctic Science Funders Forum.

Funding of Arctic science – A Norwegian perspective

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International cooperation in polar research is vital and will become increasingly more important in the years to come. This because the rapid changes in Arctic climate and biodiversity calls for international cooperation. The challenges are more than can be handled by single countries, both with respect to research themes and funding.

The vision of Norwegian polar research is to be one of the world's leading nations in polar research and an important contributor to knowledge of global interest.

The objective of polar research is to enable Norway to fulfil its special responsibility for acquiring the knowledge needed to implement policy, management and economic activity in the polar regions. At the same time polar research is intended to generate fundamental knowledge about the Arctic and the Antarctic.

In Norway there are close to 2000 polar scientists producing nearly 1000 man-years. Norway's annual funding of polar research is ca. 150 million euros, the majority of this funding being spent on high Arctic research.

The Research Council of Norway (RCN) is a major player in funding Norwegian and international Arctic research. RCN has a polar research program dedicated to fund high Arctic research only. RCN organizes annual calls, and we encourage Norwegian scientists to include international partners in their grant proposals to us. The international partners in the projects can be funded by RCN. One way forward to increase international cooperation and collaboration in Arctic science is that more countries opens for international partners in national calls.

RCN also contributes with funding to international calls e.g. through Horizon Europe, Belmont Forum or NordForsk. Future initiatives on Arctic research requires international cooperation and coordination following priorities set by e.g. the international polar research community under IASC (ICARP IV), EU-PolarNet2, WMO and global programs. It is equally important that national funding agencies cooperate as well as the scientists themselves. The national research priorities are a foundation for international cooperation being developed further through the existing international fora.

International cooperation among Arctic science funders requires long-term planning. National priorities and investment plans need to be aligned with priorities from international fora.

March 9

Breakout Session

S23

Multidisciplinary observing systems in Arctic, potential and challenges

Towards a High Arctic Ocean Observation System

Hanne Sagen*, Stein Sandven
Nansen Environmental and Remote Sensing Center, Norway

Sustained in situ observations of the interior of the ocean lacks in the ice-covered Arctic Ocean. This limits the possibility to advance research within climate, weather, ice-ocean processes, and geophysical hazard. A roadmap for sustained ocean observations was established in the EU project Integrated Arctic Observing System - INTAROS. The roadmap includes recommendations for new observing technologies including network of multipurpose mooring providing ocean observations and facilitating for under water geo-positioning systems as well as support for the vision of SMART cables in the Arctic.

As part of the joint U.S.-Norwegian Pan-Arctic experiment Coordinated Arctic Acoustic Thermometry Experiment (CAATEX) a basin wide multipurpose mooring system for ocean observations was operated for one year. Six moorings were installed in 2019 extending from north of Svalbard in the east to the Beaufort Sea north of Alaska in the west. Each mooring was equipped with 50–75 acoustic and oceanographic instruments providing oceanographic point measurements and acoustic thermometry measurements. Two of the moorings were transceivers that included a low-frequency acoustic source (35 Hz), one in the Eastern Arctic and one in the Western Arctic. The acoustic signals were successfully received at ranges from 100 to 2700 km. The CAATEX observations increases our knowledge about the interior of the Arctic Ocean. In particular, the experiment shows that the signals from the low frequency acoustic sources are received at all depths at all the considered ranges which is an important result for establishing an underwater geo-positioning (UW-GPS) system in the central Arctic.

The recently funded Eu Project – High Arctic Ocean Observation System (HiAOOS) will follow up the results from CAATEX. HiAOOS consortium will develop and implement a network of multipurpose moorings for two years operation in the deep Nansen and Amundsen Basins. The network will serve several applications, including oceanographic measurements, acoustic thermometry, geo-positioning of underwater floats, detection of marine mammals, geohazards and human generate noise. A particular focus will be on improving the access to regular ocean data from platforms under the drifting sea ice. This is significant bottleneck we will address using new array technology, underwater communication and ROV technology.

Furthermore, Smart Cables with built-in sensors are in progress in the Arctic e.g., Far North Fiber, Borealis. To facilitate for sustained observations from the full water column the cables will need to support branching points connecting advanced underwater installations observing extending upward into the ocean. Cabled super-sites would become be cornerstones in a future Arctic Ocean Observing System in the High Arctic. Cabled and un-cabled supersites quipped with sources and receivers will form UW-GPS network for floats, gliders, and AUVs.

Acknowledgement: The INTAROS project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 727890 (2016-2022). The CAATEX project (2018-2022) received funding from the Research Council of Norway project number 280531 and from the US Office of Naval Research. Thanks to the more than 300 researchers contributed to the successful completion of the INTAROS and CAATEX projects. A special thanks to the Norwegian Coast Guard for allocating ship time on the icebreaker KV Svalbard, and to the crew onboard KV Svalbard for their support to the complex operations in CAATEX and INTAROS. The HiAOOS (2023-2027) project starts 1 January 2023 receiving funding under grant agreement with European Union's Horizon Europe research and innovation programme.

S23-O02

A New Environmental Monitoring in the Arctic: Cryosphere Integrated Observatory Network on Svalbard (CRIOS)

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[7]*Adam Mickiewicz University, Poland*
[8]*University of Wrocław, Poland*
[9]*Warsaw University of Technology, Poland*
[10]*Nicolaus Copernicus University in Toruń, Poland*
[11]*Maria Curie-Skłodowska University, Poland*

One of the most significant challenges for monitoring systems in remote areas is establishing and accessing automated measurement stations that continuously record high-quality data. This is especially important in regions with limited access – like glacierized, mountainous and polar areas, where harsh terrain and weather conditions decrease the possibility for safe and continuous direct observations. While remote sensing products are often satisfactory in providing information about the state of the environment or closing observation gaps, datasets should be validated against in-situ observations. For this reason, we created the CRIOS – a predefined project in Polish-Norwegian cooperation, which is an answer to the needs of the scientific community, described in the annual *State of Environmental Science in Svalbard* Reports [1], published by the Svalbard Integrated Arctic Earth Observing System (SIOS).

This project aims to modernize and expand an automated monitoring network focused on the cryosphere of Svalbard as a calibration/validation system for indirect research. As a first step, we plan to harmonize and expand the monitoring systems in Hornsund, Longyearbyen and Ny-Ålesund (level I stations). The second stage will equate Polish Research Infrastructures (level II stations) – in Kaffiøyra, Petuniabukta, Calypsobyen and Elveflya, with the newest cryosphere monitoring technologies. All measurement stations will operate following the standardized measurement protocols developed as part of joint workshops and training sessions. The key element of the observatory network will be real-time data transfer to the open repositories, following the FAIR principles (Findability, Accessibility, Interoperability, Reusability). The entire network has been divided into four types of cryosphere monitoring: glacier and snow, meteorological, permafrost and remote sensing. The installations are planned on the selected glaciers and in the tundra area at each of the presented sites.

The CRIOS open science data policy will allow the publication of scientific papers, MSc and PhD theses and reports to the authorities responsible for environmental policy and climate protection. It also gives a valuable opportunity to support significantly seasonal, level II stations without permanent funds for long-term monitoring to deliver harmonized, high-quality products and strengthen national, international and interdisciplinary cooperation.

References

[1] Ilkka S.O. et al., State of Environmental Science in Svalbard: Synthesizing the recommendations of the first 4 years, Online Report (2022).

GEOCRI: A Big Data Approach for Cold Region Information Service

Y. Qiu[1], H. Enomoto[2], M. Menenti[3], X. Cheng[4], J. Key[5], H.K. Lappalainen[6]. X. Li[7], S. Sandven[8] and V. Vitale[9]

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** The author's group are the co-lead group to Cold Regions Initiative under Group on Earth Observations (GEOCRI)*

The Cold Regions Initiative (GEOCRI) is a pilot initiative under Group on Earth observations (GEO), which mainly about the cryosphere data stream services in Cold Regions through the Derived and Integrated Earth Observation Products to facilitate the provision and standardization of satellite information products in the cryosphere-dominated cold regions to meet the needs of societies, including high elevation and high latitude cold regions.

GEOCRI brings together the efforts of different science and industry communities' activities currently and stakeholders in the world's cold regions. The core interest of the GEOCRI is to bring fruitful information, gathered continuously by the national and multi-national, growing infrastructures of diverse and complementary Earth observations, to users on a global scale. The contributors to the objectives of GEOCRI are currently operating observational and data infrastructures with high-performance data streaming processing capabilities with open data principles on an international platform. Likewise, data systems have been developed and are hosting rich data assets. We expect the initiative to generate continuous data streams on Essential Cold Regions Variables (ECRVs), and provide pilot services on the water availabilities in the cold mountain area, safety transportation for the land and northern sea routes, emerging cryosphere disaster mitigation, and assessment supporting the UN Sustainable Development Goals (UN SDGs), etc.

The GEO Cold Regions will bring a set of tasks on the fundamental task on variables, services, and pilot services in the next few years.

Bridging the Fram Strait - facilitating collaboration across the largest high Arctic climatic gradient

H.H. Christiansen [1*], S. Rysgaard [2], H.Skov [3], P. S. Mikkelsen[2], S. Shridhar Jawak[4], C. Stedmon[5] and H. Lihavainen[4]

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The Bridging the Fram Strait project aims to facilitate Svalbard-Greenland collaboration by optimizing the existing research infrastructures and data across the largest climatic gradient in the high Arctic, as schematized in the long-term SIOS (Svalbard Integrated Arctic Earth Observing System) and GIOS (Greenland Integrated Observing System) projects. The project conducted a dedicated workshop in October 2022 with thean aim to establish a scientific Bridging the Fram Strait network consisting of researchers involved in using the entire the Fram Strait gradient (between warm Svalbard and cold North Greenland) by developing coordinated participation in research campaigns in the he Fram Strait region. Existing large investments have been made nationally in Svalbard and Greenland respectively in the SIOS and GIOS projects, and the access to both research infrastructures, observations and data are improved through both projects. However, a coordinated regional initiative extending across the entire gradient from the terrestrial parts of Eastern and Northern Greenland across the Fram Strait to Svalbard has been missing.

There is a great potential in linking existing informal collaboration with oceanography [1,2], permafrost active layer thickness dynamics [3]. Comparative work on carbon fluxes using similar techniques in Zackenberg (North East Greenland) and Adventdalen (Svalbard) has been conducted with success [e.g.4] and much more may be developed of the same kind. Studies across this gradient are of global importance for increasing the understanding of Earth System Science in all its spheres. Therefore, establishing a joint regional large-scale research and higher education initiative will facilitate process understanding on pan-Arctic scale and thus place Svalbard-Greenland research in a global perspective. In ISAR-7, we aim to present salient outcomes and present the status of the Bridging the Fram Strait project to reach out to more scientists and facilitate already established collaboration.

References

[1] R. Gonçalves-Araujo, C.A. Stedmon, L. de Steur, C.L Osburn, M. A. Granskog, Decade of Annual Arctic DOC Export With Polar Surface Water in the East Greenland Current. *Geophysical Research Letters*, **47** (2020)
[2] N. Pirk, M. Mastepanov, F. J. W. Parmentier, M. Lund, P. Crill, and T. R. Christensen, Calculations of automatic chamber flux measurements of methane and carbon dioxide using short time series of concentrations, *Biogeosciences* **13** (2016).
[3] C. A.Stedmon, M. A. Granskog, P. A. Dodd, An Approach to Estimate the Freshwater Contribution from Glacial Melt and Precipitation in East Greenland Shelf Waters Using Colored Dissolved Organic Matter (CDOM). *Journal of Geophysical Research: Oceans* **120** (2015),
[4] S. M. Strand, H. H. Christiansen, M. Johansson, J. Åkerman and O. Humlum, Active layer thickening and controls on interannual variability in the Nordic Arctic compared to the circum-Arctic. Permafrost and Periglacial Processes **32** (2020)

S23-O05

Towards 'good practice' in the use of Indigenous, local and scientific knowledge for informing natural resource management

F. Danielsen[1*], M. Enghoff[1], M.K. Poulsen[1], L. Iversen[2], S. Sandven[2], N. Johnson[3], O. Lee[4]

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A prerequisite for good planning is access to data and information of relevance to people living and working in the Arctic. Community-Based Monitoring (CBM) and Citizen Science (CS) initiatives are evolving across the Arctic, providing complementary data to the scientific observing systems [1]. CBM/CS systems are initiated by people who need specific environmental and climate information to support management of resources, local decision-making and safety of human activities. An example is the PISUNA program (*Piniakkanik Sumiiffinni Nalunaarsuineq*; https://www.pisuna.org/, https://eloka-arctic.org/pisuna-net/en) in Greenland [2-3]. Challenges for CBM and CS projects in the Arctic are mainly to (1) bring CBM/CS systems from *ad hoc* initiatives to sustainable observing systems, (2) connect CBM/CS and scientific observations, (3) make use of CBM/CS data in decision-making, and (4) establish sustained funding [1, 4-5]. In this presentation, we use case examples from the Arctic to review these challenges and to discuss potential solutions. Our work is supported by the CAPARDUS project through the European Union's Horizon 2020 research and innovation program under grant agreement No. 869673, and by the Danish Agency for Science and Higher Education through the UArctic Thematic Network on Collaborative Resource Management.

References

[1] F. Danielsen et al. *Community-Based Monitoring in the Arctic*, Univ. Alaska Press (2020)
[2] M. Tengö et al. Creating synergies between Citizen Science and Indigenous and Local Knowledge, *BioScience* **71**, 503-518 (2021)
[3] N. Johnson et al. The use of digital platforms for Community-Based Monitoring, *BioScience* **71**, 452-466 (2021)
[4] H. Eicken et al. Connecting top-down and bottom-up approaches in environmental observing, *BioScience* **71**, 467-483 (2021)
[5] F. Danielsen et al. Community monitoring of natural resource systems and the environment, *Annual Review of Environment and Resources* **47**, 637-670 (2022)

S23-O06

The Climate Change Tower Integrated Project (CCT-IP) and the muldisciplinary observing activities of Italy at Ny Alesund (Svalbard) since 2009

V. Vitale[1*], M. Mazzola[1], A. Viola[1], S. Gilardoni[1], E. Barbaro[1], R. Salvatori[1], R. Salzano[2], A. Spolaor[1], A. Lupi[1], F. Becherini[1], M.Vardè[1], B. Petkov[1,5], F. Tampieri[1], R. Traversi[3], S. Becagli[3], M. Severi[3], D. Cappelletti[4], B. Moroni[5], M. Rinaldi[6], M. Paglione[6], L. Langone[1], S. Miserocchi[1], P. Giordano[1], F.Giglio[1], T. Tesi[1], M. Doveri[7], S. Giamberini[7], A. Augusti[8], O. Gavrichkova[8], M. Azzaro[1], M. Guglielmin[9], N. Cannone[9], and G.Verazzo[1]

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The relaunch in 2008-2009 of the Italian activities at the Arctic station of the CNR Dirigibile Italia (DI) in a broadly multidisciplinary key will be widely presented in terms of conceptual approaches and overall strategy. In the last 15 years, observing activities have been widely expanded and diversified, extending and integrating the three multidisciplinary observation platforms implemented between 2008 and 2010 as part of the "Climate Change Tower Integrated Project" (CCT-IP). The development of the observing program has always followed the dual objective of contributing to the growth of Ny Alesund as an observing super-site, highlighting its uniqueness in the panorama of research stations in the Arctic, and on the other hand allowing us to observe and study the Kongsfjorden area in an Earth System Science perspective. The main research topics developed in recent years will be presented through some of the most important results achieved by the different research groups that contributed and are contributing to this integrated effort. The importance of international collaboration will be also highlighted. Finally, the possible prospects in the short and medium term for the Italian research activities in Ny Alesund and Svalbard area, also as contribution to SIOS, will be presented/proposed.

S23-O07

Estimation of high tundra vegetation productivity using OCO-2, Sentinel 5 and FLoX data

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Accurate quantification of gross primary production (GPP) is essential to provide insight into the vegetation productivity and carbon cycle estimation. Solar-induced chlorophyll fluorescence (SIF) is a result of plant photosynthesis, considered to be an indicator of photosynthetic activities. The previous studies confirmed a strong linear statistical relation between GPP and SIF for different vegetation types. However, understanding how such relations hold in tundra vegetation over high arctic is still elusive. Thus, we studied and evaluated the capability of using SIF from the two satellite missions, OCO-2 and Sentinel 5, together with ground observing systems to explore the growth status of vegetation at the Spitsbergen Island, Svalbard (Arctic Norway). Likewise, we tried to estimate high tundra vegetation productivity based on the relationship between vegetation GPP and SIF.

First, we assessed the potential of using SIF from satellite data to monitor vegetation growth. We begin with evaluation of the spatial and temporal regional coverage of OCO-2 and Sentinel 5 SIF data between years 2019 and 2022. Then, we used SIF-measured from the hyperspectral field sensor (FloX), a part of the Svalbard Integrated Arctic Earth Observing System (SIOS instrument no. 49), to establish a relation between EC-based GPP and FloX-SIF then we used it as a FloX-GPP to estimate the relation between SIFs from OCO-2 and Sentinel 5 and vegetation GPP.

Our results showed that (1) SIF data from both satellite missions, OCO-2 and Sentinel 5, allowing for detail spatial characteristic of vegetation productivity and (2) assessment of temporal variation of vegetation growth in the arctic regions. Further, our results indicated that the values of OCO-2 and Sentinel 5 SIFs varied seasonally and were dependable on changes in vegetation growth. We also confirmed the strong linear relation between SIF and GPP for high tundra vegetation.

Acknowledgement

This research is funded by the EU CHARTER project (no. 869471) and Research Council of Norway (RCN) under project number 269927 (SIOS-InfraNor).

Using Unattended Approaches to Enable Multidisciplinary Study of Seasonal Events in the Coastal Arctic Ocean

S. Laney[1*], S. Okkonen[2], K. Longnecker[1], and L. Catipovic[1]

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Unattended approaches are essential for observing and understanding both ephemeral and seasonal ocean phenomena in polar regions. To obtain greater insight into environmental phenomena that occur annually in the coastal Arctic Ocean, we developed and implemented a strategy to enable unattended multidisciplinary observations over annual scales in seasonally ice-covered nearshore Arctic waters. A combination of year-round ice-resistant bottom moorings [1] and ice buoys [2] deployed manually in late spring were used to study Stefansson Sound, Alaska, from September 2017 to August 2019. Both systems were used in a fully unattended mode, with the moorings retaining their sensor data until retrieval after one year whereas the ice buoys telemetered their sensor data in near-real-time on 6-hour intervals. Together, these complementary observing platforms provided unique insight into several key phenomena that occur seasonally in these waters including the late fall ice-in, the onset of photosynthesis when polar night ends in late winter, the spring freshet arriving from nearby rivers, and sea ice breakup in early summer. Such a multidisciplinary approach was essential for identifying seven different environmental stages that occur annually in this nearshore region and determining their influence on biogeochemical and biological phenomena in Stefansson Sound that relate to climate, the ocean carbon cycle, and terrestrial-ocean interactions.

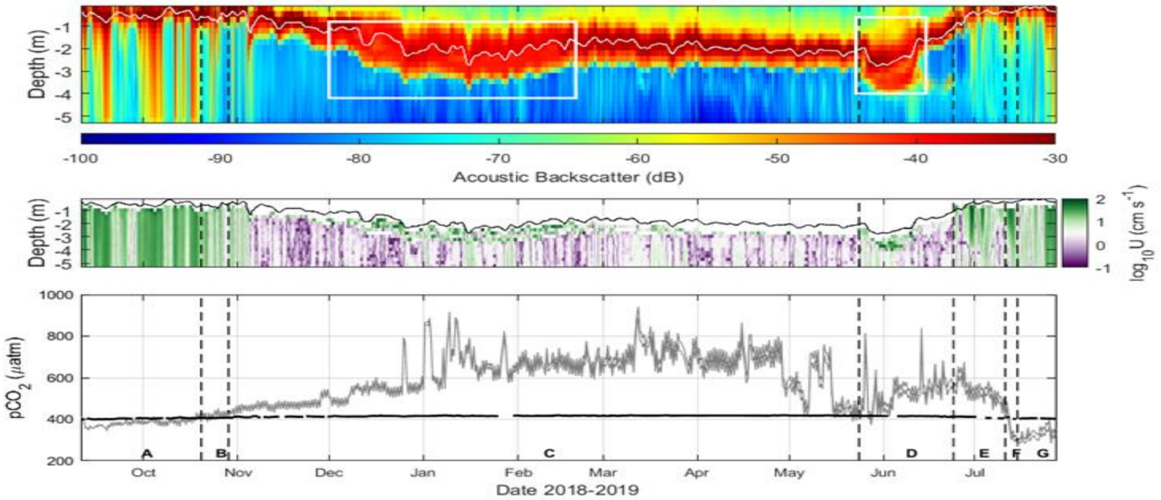

Figure 1. Seven stages were identified in Stefansson Sound during 2018-19 (vertical dashed lines) in acoustic backscatter (top panel), currents (middle), and pCO2 (bottom, grey trace).

References
[1] S.R. Okkonen, S.R. Laney, Optical, structural and kinematic characteristics of freshwater plumes under landfast sea ice during the spring freshet in the Alaskan coastal Arctic. *Journal of Geophysical Research, Oceans* **126** (2021)
[2] S.R. Laney, S.R. Okkonen, An autonomous buoy system for observing spring freshet plumes under landfast sea ice, *Limnology and Oceanography: Methods* **251** (2022)

March 8

Poster Session (online)

Core Time 1 8:20~9:20 (JST)

Core Time 2 17:00~18:00 (JST)

R1-P01

Temporal Variations of the Mole Fraction, Carbon, and Hydrogen Isotope Ratios of Atmospheric Methane observed at Churchill, Canada

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Systematic observations of the atmospheric CH_4 concentration, carbon, and hydrogen isotope ratios of CH_4 ($\delta^{13}C$-CH_4 and δD-CH_4) were conducted at Churchill, Canada, to investigate their temporal variations and the causes of the variations. Churchill is in the Hudson Bay Lowlands, the second largest wetland area in the world, and regarded as one of the important CH_4 source region. The observed time-series of CH_4, $\delta^{13}C$-CH_4 and δD-CH_4 were decomposed into long-term, seasonal, and synoptic time-scale components using a digital filtering technique and each component was analyzed. The long-term component of CH_4 shows an increasing trend after 2007, with an increase rate of 3.4 ppb/yr from 2007-2008 and 16 ppb/yr in 2020. On the other hand, $\delta^{13}C$-CH_4 and δD-CH_4 show decreasing trends after 2014. The rates of decrease for $\delta^{13}C$-CH_4 and δD-CH_4 in 2020 were -0.04‰/yr and -0.8‰/yr, respectively. As for the seasonal components, clear seasonal cycles were observed for all components, with the CH_4 concentration being lowest and $\delta^{13}C$-CH_4 and δD-CH_4 being highest in summer, indicating that CH_4 extinction by a reaction with OH radicals exceed the CH_4 release in summer. Furthermore, high CH_4 concentration events (synoptic time-scale variations) were observed throughout a year. By analyzing the high concentration events using the Miller/Tans plot (Miller and Tans., 2003) and a Lagrangian particle diffusion model (Zeng et al., 2012), we estimate the isotopic ratios and spatial distributions of the CH_4 sources that contributed to the events. As a result, the $\delta^{13}C$-CH_4 and δD-CH_4 values of the CH_4 sources were -61.0 ± 9.0‰ and -355 ± 169‰, respectively, strongly suggesting the influence of wetland-origin CH_4.

References

[1] Miller, J. B., and P. Tans, Calculating isotopic fractionation from atmospheric measurements at various scale, Tellus, 55B, 207-214 (2003)
[2] Zeng et al., Linking carbon dioxide variability at Hateruma station to East Asia emissions by Bayesian inversion. Lagrangian Modeling of the Atmosphere, 163-172(2012)
[3] Fujita et al., Temporal Variations of the Mole Fraction, Carbon, and Hydrogen Isotope Ratios of Atmospheric Methane in the Hudson Bay Lowlands, Canada, Journal of Geophysical Research:Atmospheres/Volime 123, Issue9/p.4695-4711(2018)

Mesoscale Atmospheric Structure near the Sea Ice Edges over the Arctic Region as represented by ERA5

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Over the mid-latitude, recent studies have revealed that steep sea-surface temperature (SST) gradient along the warm western boundary currents (WBCs) exerts significant impacts on the atmosphere [1]. Surface wind convergence, deep ascent and cloudiness are locally enhanced over the WBCs. Furthermore, the WBCs can induce large-scale and remote atmospheric circulation anomalies. In the Arctic regions, similar mesoscale atmospheric features have been identified as the response to steep temperature gradient across the sea ice edges [2,3]. In the present study, the mesoscale atmospheric features near the sea ice edge regions are examined based on the state-of-the-art atmospheric reanalysis, with a particular focus on the comparison among seasons and regions including the midlatitude WBC domains.

In autumn and winter, climatological-mean surface wind convergence, ascent and cloud formation is enhanced near the sea ice edges and SST fronts in the Greenland, Barents (Fig. 1) and Bering Seas (not shown). The wind convergence is significantly correlated with the Laplacian of surface temperature on the interannual time-scale as consistent with the midlatitude regions. The atmospheric responses are found to be dependent on the background wind direction; wind convergence (divergence) response is dominant under background wind blowing from the ocean to sea ice (sea ice to ocean) regions. The ascent response along the sea ice edges is confined within the atmospheric boundary layer. Yet, there is a hint of the deep ascent response along SST fronts in the Barents Sea. Unlike in the midlatitude, the summertime atmospheric response is indistinct.

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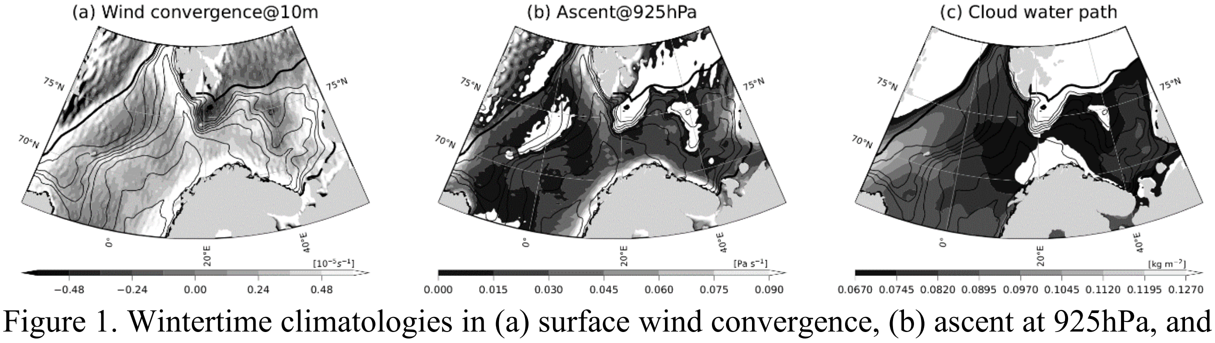

Figure 1. Wintertime climatologies in (a) surface wind convergence, (b) ascent at 925hPa, and (c) cloud water path based on the ERA5 for 2012-21. The thick contours indicate 15% lines of the sea ice concentration and thin contours indicate surface temperature with 1degree intervals.

References

[1] R. J. Small and coauthors: Air-sea interaction over ocean fronts and eddies, *Dynamics of Atmospheres and Oceans,* **45** (2008)
[2] Y. Kawai: Low-Level Atmospheric Responses to the Sea Surface Temperature Fronts in the Chukuchi and Bering Seas, *Frontiers in Marine Science,* **8** (2021)
[3] H. Seo and J. Yang: Dynamical response of the Arctic atmospheric boundary layer process to uncertainties in sea-ice concentration, *Journal of Geophysical Research,* **118** (2013)

R1-P03

Future changes of Arctic cloud and its radiation effect in large ensemble projections by MIROC6

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There is a great uncertainty about the cloud changes and their role in the Arctic climate change. Thus, it is important to clarify how cloud changes and their effects are related to the Arctic warming and sea ice reduction for understanding mechanisms in the Arctic climate change. In this study, we analyzed cloud changes over the Arctic Ocean and their effects on surface radiation balance under two different future scenarios.

This study used data from 50-member experiments conducted by MIROC6 (Tatebe et al. 2019) for the future scenarios SSP126 and SSP585 (Shiogama et al. 2019). Significant decrease in Arctic sea ice was not found after 2050 in SSP126. On the other hand, in SSP585, Arctic sea ices decreased rapidly after 2040, the sea ice in September disappeared by 2070s, and the sea ice from winter to spring decreased significantly after 2070. Cloud cover over the Arctic Ocean in SSP126 tended to increase during October and November by 2050, but the small increase in cloud cover is found after 2050 even without the significant reduction in sea ice. On the other hand, SSP585 showed an increase in cloud cover related to sea ice loss in late autumn and early winter until 2070, but after that, there was not significant cloud cover change related to sea ice reduction because almost all Arctic sea ice was lost.

In this presentation, we summarize the cloud changes and their radiative effects in SSP126/SSP585, particularly with focusing on the effect of sea ice reduction on the cloud change in the Arctic Ocean.

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References

[1] Tatebe, H., Ogura, T., Nitta, T., Komuro, Y., Ogochi, K., Takemura, T., Sudo, K., Sekiguchi, M., Abe, M., Saito, F., Chikira, M., Watanabe, S., Mori, M., Hirota, N., Kawatani, Y., Mochizuki, T., Yoshimura, K., Takata, K., O'ishi, R., Yamazaki, D., Suzuki, T., Kurogi, M., Kataoka, T., Watanabe, M., and Kimoto, M.: Description and basic evaluation of simulated mean state, internal variability, and climate sensitivity in MIROC6, Geosci. Model Dev., 12, 2727–2765, https://doi.org/10.5194/gmd-12-2727-2019, 2019.

[2] Shiogama, H. Abe, M. and Tatebe, H., MIROC6 model output prepared for CMIP6 ScenarioMIP, Earth System Grid Federation. https://doi.org/10.22033/ESGF/CMIP6.898, 2019.

R2-P01

Comparisons of sea-ice reproducibility and their impacts on climate variability in an initialized climate model

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Arctic sea-ice decline has substantially affected the climate system not only in the Arctic but also in the mid-latitudes, and economic activities through the Northern Sea Route, needing more accurate sea-ice forecasts. Initialized climate models have shown, for instance, that the Arctic sea-ice area can be predicted up to several months ahead (e.g., [1]). Meanwhile, how sea-ice reproducibility influences climate variability has not yet been thoroughly investigated. Our goal of this study is to assess which initialization represents better sea-ice fields, and to examine whether the differences in sea-ice reproducibility emerge as a critical signal in climate variability. To this end, five climate simulations with a single climate model MIROC6 were analyzed along with observational data. Comparisons of sea-ice area anomaly in September suggest that constraining sea-ice motion by diagnostic wind stresses is likely better method (Fig. 1). From a regional perspective, initialization with ocean temperature and salinity anomalies is also crucial for the Barents Sea, where oceanic processes are the source of sea-ice variability. The processes that lead to improved sea-ice reproducibility and their impacts on the atmospheric and oceanic fields will be discussed in the presentation. The work was supported by the Arctic Challenge for Sustainability II (ArCS II) Project (Program Grant Number JPMXD1420318865) and MEXT program for the advanced studies of climate change projection (SENTAN) Grant Numbers JPMXD0722680395.

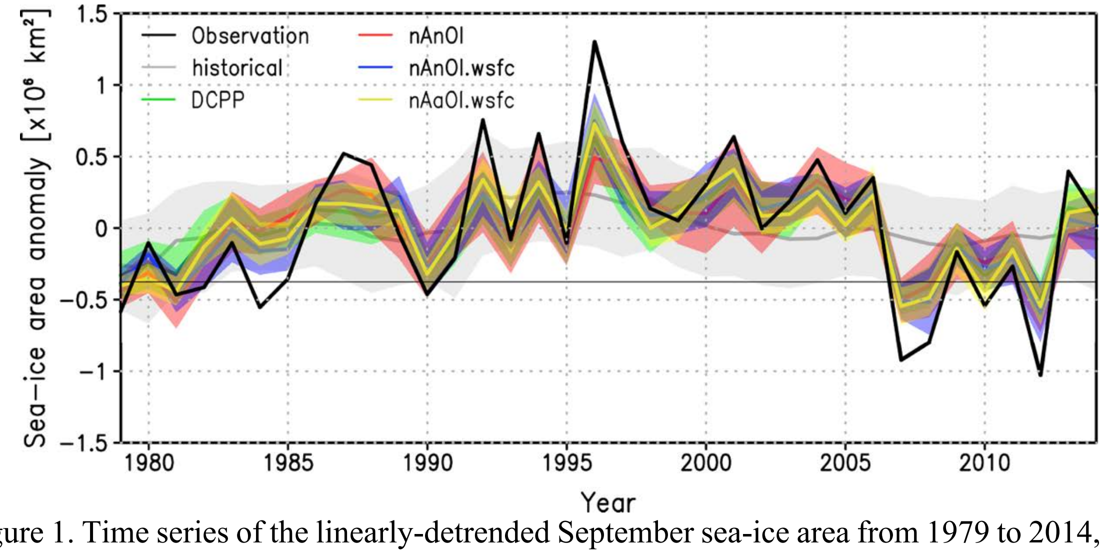

Figure 1. Time series of the linearly-detrended September sea-ice area from 1979 to 2014, from observation (black), historical (gray), DCPP (green; initialization with ocean temperature and salinity anomalies and sea-ice concentration), nAnOI (red; initialization with only sea-ice concentration), nAnOI.wsfc (blue; as in nAnOI but for sea-ice motion constrained by diagnostic wind stresses, and nAaOI.wsfc (yellow; as in nAnOI.wsfc but for initialization with ocean temperature and salinity anomalies). Shadings denote the ensemble spread for each experiment.

References

[1] J. Ono, H. Tatebe, Y. Komuro, M.I. Nodzu, M. Ishii, Mechanisms influencing seasonal to inter-annual prediction skill of sea ice extent in the Arctic Ocean in MIROC, *The Cryosphere* **12** (2018)

R2-P02

First look of ocean and sea-ice conditions from Ice Exercise 2022 (ICEX 2022)

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We deploy an ice-tethered buoy with 6 CTDs within 20 m of sea ice ~300 km offshore of Prudhoe Bay, Alaska as a part of ICEX 2022 hosted by the U.S. Navy in March 2022. The ocean measurements were complemented by tracking the surrounding sea-ice motions with 10 GPS and two cameras overlooking the top of the ice-tethered buoy. The buoy tracks were completely different from the ICEX 2020. While the set of buoys from ICEX 2020 kept drifting westward, the trajectory in 2022 shifts northward near 74 north, 160 west. The timing of sea-ice break-up is qualitatively assessed by detecting the strength of inertial oscillations in the velocity data using the Hilbert-Huang transformation (HHT). The relative amplitude of energy in the inertial frequency band increases at the beginning of July. This suggests that the drifting by the ocean current starts to dominate the sea-ice motions starting in July, whereas the internal deformation was dominant before July. The transition of the sea-ice motions coincides with a formation of melt ponds around the ice-tethered buoy, which are detected by the daily images from the cameras. When the melt pond disappears from the daily images, we detect freshening of the water below the sea ice. The significant freshening is confined within 5 m of the water column. Our measurements suggest that the melt pond formation makes the sea ice fragile, and the melting of sea ice occurs as a burst of fresh water injected into the surface of the ocean.

Satellite-based mapping of sediment-laden sea ice

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Sediment-laden sea ice is a ubiquitous phenomenon in the Arctic Ocean and its marginal seas [1]. This study presents a satellite-based approach at quantifying the distribution of sediment-laden ice that allows for more extensive observations in both time and space to monitor spatiotemporal variations in sediment-laden ice. A structural-optical model coupled with a four-stream multilayer discrete ordinates method radiative transfer model was used to examine surface spectral albedo for four surface types [2]: clean ice, sediment-laden ice with 15 different sediment loadings from 25 to 1000 g m^{-3}, ponded ice, and ice-free open water. Based on the fact that the spectral characteristics of sediment-laden ice differ from those other surface types, fractions of sediment-laden ice were estimated from the remotely-sensed surface reflectance by a spectral unmixing algorithm [3]. The estimated fractions of each surface type and corresponding remotely-sensed surface reflectances were used to train an artificial neural network to speed up processing relative to the least squares method [4]. Comparing the fractions of sediment-laden ice derived from these two approaches yielded good agreements for areal fractions of sediment-laden ice, highlighting the superior performance of the neural network for processing large datasets. Although our approach contains potential uncertainties associated with methodological limitations, spatiotemporal variations in sediment-laden ice exhibited reasonable agreement with spatial and seasonal patterns reported in the literature on in situ observations of sediment-laden ice. Systematic satellite-based monitoring of sediment-laden ice distribution can provide extensive, sustained, and cost-effective observations to foster our understanding of the role of sediment-laden ice in a wide variety of research fields including sediment transport and biogeochemical cycling. This study was published recently in Remote Sensing of Environment [5].

References

[1] Tschudi, M.A., Maslanik, J.A., Perovich, D.K., 2008. Derivation of melt pond coverage on Arctic sea ice using MODIS observations. Remote Sensing of Environment 112, 2605–2614. https://doi.org/10.1016/j.rse.2007.12.009

[2] Light, B., Eicken, H., Maykut, G.A., Grenfell, T.C., 1998. The effect of included participates on the spectral albedo of sea ice. J Geophys Res Oceans 103, 27739–27752. https://doi.org/10.1029/98jc02587

[3] Tschudi, M.A., Maslanik, J.A., Perovich, D.K., 2008. Derivation of melt pond coverage on Arctic sea ice using MODIS observations. Remote Sensing of Environment 112, 2605–2614. https://doi.org/10.1016/j.rse.2007.12.009

[4] Rösel, A., Kaleschke, L., Birnbaum, G., 2012. Melt ponds on Arctic sea ice determined from MODIS satellite data using an artificial neural network. The Cryosphere 6, 431–446. https://doi.org/10.5194/tc-6-431-2012

[5] Waga, H., Eicken, H., Light, B., Fukamachi, Y., 2022. A neural network-based method for satellite-based mapping of sediment-laden sea ice in the Arctic. Remote Sens Environ 270, 112861. https://doi.org/10.1016/j.rse.2021.112861

Laboratory experiment of ice group formation under waves

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Rapid expansion of open-water area in the Arctic region implies an increasing interaction between sea ice and waves. Among wave-ice interaction processes, the wave-to-ice effects including pancake ice formation are less understood and its modeling is immature. Here we present the results of ice floe formation experiments using an 8m-long wave-ice tank. When we freeze fresh water under continuous agitation of waves, ice forms as numerous small pieces. This grease ice forms band-shaped groups, each of which moves like one solid body (Fig 1). Considering the ice group formation as an early stage of pancake ice formation, we investigated the dependence of group width on wave parameters. In the tank filled with grease-like ice, we repeatedly produced monochromatic waves of various amplitudes and frequencies. Group width D was manually measured together with local wave amplitude a using wave gauge.

Let us formulate ice as a thin continuum floating on water surface, nearly following wave orbital motion. If ice group try to move a solid body as large as possible, so that the body can be supported with internal (dynamical) stress τ, we can deduce that $D/\lambda_0 = (2\pi)^{-1}(\tau/8ga)^{1/2}$, where λ_0 and g are wavelength and gravitational acceleration, respectively (cf. [1]). From the experimental results shown in Fig 2, D/λ_0 generally shows $a^{-1/2}$ dependence, which is consistent with many of the cases observed for consolidated ice floes.[2] However, the result seems to show some frequency dependence such that the floes become smaller with lower frequencies, suggesting the influence of factors other than the tensile stress limiting mechanism stated above.

Figure 1. Example of grease ice groups.

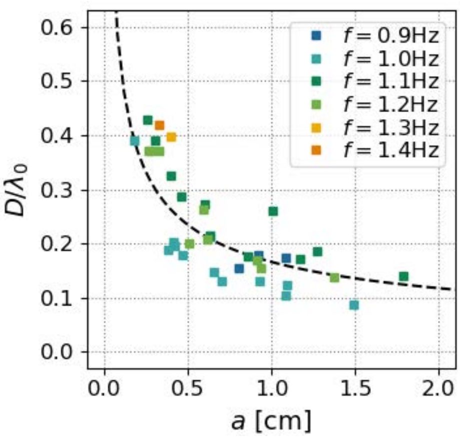

Figure 2. Amplitude and frequency dependence of group width D. Dashed line follows the power law $a^{-1/2}$ fitted to data.

References
[1] Shen, Hayley H., Stephen F. Ackley, and Mark A. Hopkins. "A conceptual model for pancake-ice formation in a wave field." Annals of Glaciology 33 (2001): 361-367.
[2] Fujiwara, Y., Katsuno, T., Waseda, T., Kodaira, T., and Nose, T. “Laboratory experiments of ice floe formation under wave motions”. Japan Geoscience Union Meeting 2021. (2021)

R2-P05

Impacts of freshwater types on sea surface partial pressures of CO_2 in the Pacific sector of the Arctic Ocean

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To assess the impacts of freshwater types on partial pressures of CO_2 (pCO_2), we measured sea surface pCO_2 and the related biogeochemical properties in the Pacific sector of the Arctic Ocean from September to October 2021. Sea surface pCO_2 near the ice edge (most northern part) was not as low as that found around 72°N, where the pCO_2 decreased to ~200 µatm (Fig. 1), although salinity was comparably low in both areas. We calculated the fractions of sea ice meltwater and meteoric water contained in seawater samples from salinity and stable oxygen isotope. As a result, it was found that meteoric water was dominant near the ice edge, while sea ice meltwater was dominant around 72°N. We further classified the meteoric water into river water and snow meltwater based on relationships with colored dissolved organic matter. It indicated that the contributions of snow meltwater were high near the ice edge. Impacts of sea ice meltwater on sea surface pCO_2 could be accounted for by the relative proportions of dissolved inorganic carbon (DIC) concentration and total alkalinity (TA), which are different depending on whether pre-melting sea ice is new or old/rich in snow. Near the ice edge, sea surface pCO_2 was higher, because the impact of reduced TA on raising pCO_2 by the effect of sea ice meltwater rich in snow was enormous. In contrast, around 72°N, sea surface pCO_2 was lower by the effect of melting of relatively new ice.

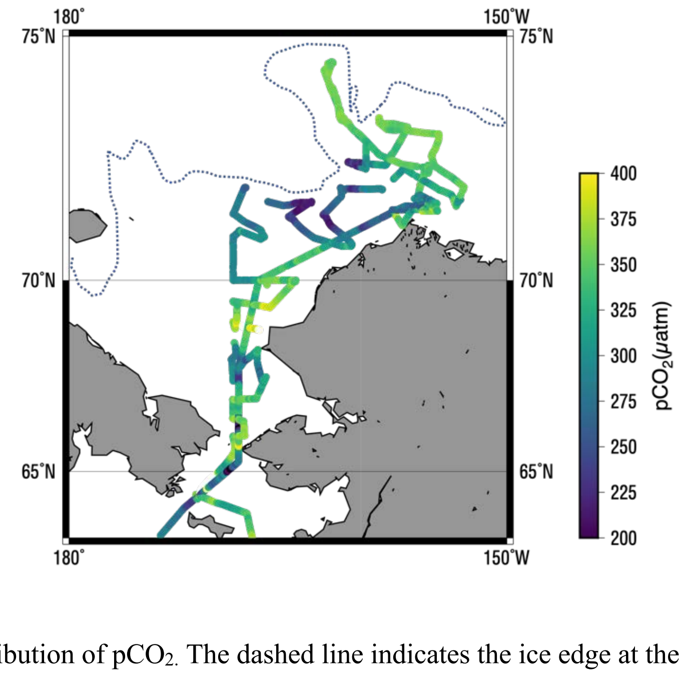

Figure 1. Spatial distribution of pCO_2. The dashed line indicates the ice edge at the observation.

R2-P06

Experimental research on spectral downshift of propagating waves under sea ice

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Wind-waves grow under the action of wind and concurrently the wavelength increases. The continuous reduction of the spectral peak frequency of the growing windsea is called the "Spectral downshift". It is also known that wind-waves propagating into the ice-covered sea undergo spectral downshift. Recent experimental work showed that this spectral downshift under the ice can be attributed to an increased attenuation rate of wave energy at high frequencies (Passerotti et al., 2020) [2]; the attenuation coefficient α ($a/a_0 = \exp(-\alpha x)$) increases with frequency (e.g. $\alpha \propto f^{3.5}$, Weber (1987) [1]). However, observation by Waseda et al. (2022) [3] in the Okhotsk Sea cannot be explained by attenuation alone because low-frequency wave energy grew at the expense of high-frequency components. We present here an experimental case that shows a possible dissipation-driven nonlinear spectral downshift.

It is known that a monochromatic wave at frequency f with sufficiently large wave steepness is unstable to sideband waves with slightly different frequencies $f \pm \Delta f$ (Benjamin & Feir, 1967) [4], a.k.a. "modulational instability". To investigate wave-ice interactions under ice, we produced "sea ice" in a fresh-water ice-wave tank (Fig. 1a) and generated a modulated wave train; a carrier wave, and two sidebands. We confirmed spectral downshift, but its rate is much faster than the evolution of the same unstable wave train without ice. We found that the $f - 2\Delta f$ component grew, which is not created by the wave maker. The results indicate that the nonlinear energy transfer is enhanced due to a strong energy attenuation by sea ice. To confirm this result, we are planning to carry out experiments on a bichromatic wave system (expecting stronger nonlinear interaction) and a monochromatic wave under the ice as a reference.

a) b)

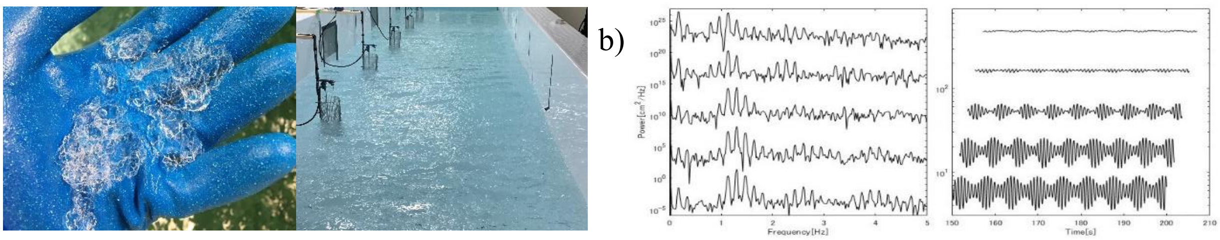

Figure 1. a) The appearance of sea ice created in a fresh-water wave-ice tank; b) The peak spectral frequency drops as waves propagate under sea ice (from bottom to top).

References

[1] J. Weber, Wave Attenuation and Wave Drift in the Marginal Ice Zone, J. Physical Oceanography, **17** (1987)
[2] G. Passerotti et al., Wave Propagation in Continuous Sea Ice: An Experimental Perspective, Proceedings of the ASME 2020 39th OMAE Conference, **7** (2020)
[3] T. Waseda et al., Observation of anomalous spectral downshifting of waves in the Okhotsk Sea Marginal Ice Zone, Phil. Trans. R. Soc. A, **380** (2022)
[4] T.B. Benjamin, J.E. Feir, The disintegration of wave trains on deep water. Part 1. Theory, J. Fluid Mech. **27** (1967)

Melt pond CO_2 dynamics and flux with the atmosphere in the central Arctic Ocean during summer to autumn transition

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Melt ponds are a common and natural feature of the Arctic sea-ice environment during summer, and they play an important role for the exchange of heat and vapour between the ocean and the atmosphere. However, carbon dioxide (CO_2) dynamics and exchange processes with the atmosphere are still largely unknown. Here, we undertook a melt pond time-series study in the central Arctic Ocean during Leg 5 of the MOSAiC international drift campaign (22 August−20 September 2020). The goals were twofold: 1) understand the relationship between the physical environment (e.g., water temperature, salinity) and the CO_2 dynamics in the melt pond, and 2) clarify the CO_2 exchange processes with the atmosphere. The partial pressure of CO_2 (pCO_2) was determined from two carbonate chemical components, dissolved inorganic carbon (DIC) and total alkalinity (TA), obtained by discrete water sampling of the melt pond. In late summer (August 22), sea ice meltwater of low salinity (0.2 to 1.0 psu) was distributed from the surface to the bottom (60 cm depth) of the melt pond. The pCO_2 in the surface layer of the melt pond (10 cm depth) was lower (approximately 315 μatm) than that in the atmosphere (approximately 400 μatm), suggesting the absorption of atmospheric CO_2 by the melt pond. The direct measurement of CO_2 flux between the atmosphere and the melt pond via a floating metal chamber independently confirmed the melt pond as a sink of atmospheric CO_2 (−3.9 mmol C m^{-2} day^{-1}). However, during the course of the observation period, the layer of sea ice meltwater thinned and occupied only the top 30−40 cm due to seawater (30 psu) ingress, forming a strong gradient and stratified interface between meltwater and seawater. The lowest pCO_2 value (approximately 244 μatm) was observed at the interface between these two layers. Such low pCO_2 at the interface can be explained by the mixing process of the carbonate system parameters between sea ice meltwater at the surface and seawater at the bottom of the melt pond. On September 12, the strong stratification disappeared, and the water within the melt pond became relatively uniform from the surface to the bottom (21 to 30 psu). Now the freezing season had started, where cooling and wind-induced ice floe drift caused mixing and an entrance of under-ice water through the bottom of the melt pond. Therefore, the pCO_2 in the melt pond was well interchanged with the seawater below, reaching approximately 300 μatm. Although the pond surface pCO_2 was lower than the atmospheric pCO_2, the melt pond did not act anymore as a CO_2 sink for the atmosphere due to gas exchange limitations of ice thickening at the surface of the melt pond. This observation was supported by the direct chamber measurements which indicated a near zero flux over the frozen pond surface.

R2-P08

Sea ice variability on the Chukchi Sea and the Beaufort Sea since the Late Pleistocene

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Records of the spatial and temporal variability of Arctic Ocean sea ice are of significance for understanding the causes of the dramatic decrease in Arctic sea-ice cover in recent years. However, the late Pleistocene sea ice history of the Arctic is still poorly understood. In this context, the newly developed sea-ice proxy IP_{25}, a monounsaturated highly branched isoprenoid alkene with 25 carbon atoms biosynthesized specifically by sea-ice associated diatoms and only found in the Arctic, and sub-Arctic marine sediments have been used to reconstruct the recent spatial sea-ice distribution. In our study, the piston core and multiple core samples were collected in the Chukchi Sea and the Beaufort Sea. The age models were reconstructed by foraminiferal $\delta^{18}O$ and radiocarbon of carbonate fossils[1]. We obtained comprehensive data of sea ice proxy IP_{25} from the cores ranging from modern to 155 kyr which was probably characterized by a permanent ice cover until the early last century. The results of IP_{25} data showed variable sea ice conditions over all periods, even in the Eemian warm period of 125 kyr which is similar to future warming Arctic conditions. At this conference, we discuss sea ice conditions based on the IP_{25} data in terms of local and global climate changes. The knowledge of past sea ice conditions may help our understanding of the mechanism of contemporary sea ice variability and future warming Arctic conditions.

References

[1] R. Stephan, M. Uchida, Sedimentary organic matter and carbonate variations in the Chukchi Borderland in association with ice sheet and ocean-atmosphere dynamics over the last 155 kyr, Biogeosciences **8** (2011)

R2-P09

Interannual variability of phytoplankton community structure in the Pacific Arctic Region

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Phytoplankton support the basis of the pelagic marine ecosystem of the Arctic Ocean. Their community structure, biomass, and productivity can quickly respond to environmental changes because of their short life cycle. The Chukchi Sea is the Arctic gateway from the sub-arctic Pacific (i.e. Bering Sea) and facing rapid environmental changes such as sea ice loss, warming, freshening, etc. Such environmental changes have consequently triggered the modification of marine ecosystems and biogeochemical cycles. It is crucial to comprehend the primary producers for a detailed understanding of the process of the changes in the ecosystem and biogeochemical cycles. Hence, we aim to comprehend how the phytoplankton community responds to the recent environmental changes using the in-situ collected dataset.

We conducted in situ oceanographic surveys during the late summers of 2008–2017 in the Chukchi Sea and obtained the physical and biogeochemical dataset. Phytoplankton community structure was inferred from the algal pigment composition (carotenoids and chlorophylls) using the CHEMTAX program [1,2] and clustered into typical groups. Then we assessed their adaptation to the oceanographic conditions and the interannual variability of their distribution.

Phytoplankton were divided into 3 clusters; high-chlorophyll-a biomass and diatoms dominated group-1, moderate biomass and taxonomic-mixed group-2, and low-biomass and green-algae dominated group-3. The group-1 was mainly found in the Pacific-origin high-salinity water, which reflects the features of Anadyr water and/or Bering shelf water. The group-2 was found mainly in the Alaskan coaster water, which is relatively warm and less saline. The group-3 was well adapted to cold and fresh sea ice meltwater. The Pacific inflow, especially warm ACW, is one of the factors that cause the warming and sea-ice loss in the area, and group-2 spread widely in the region in the warm years. Such yearly changes in primary producers might be one of the reasons for recent changes in the marine ecosystem in the Pacific Arctic region.

References

[1] Mackey, M., Mackey, D., & Higgins, H. (1996). CHEMTAX-A program for estimating class abundances from chemical markers: Application to HPLC measurements of phytoplankton. *Marine Ecology Progress Series*, *144*, 265–283.

[2] Zhuang, Y., Jin, H., Li, H., Chen, J., Lin, L., Bai, Y., et al. (2016). Pacific inflow control on phytoplankton community in the Eastern Chukchi Shelf during summer. *Continental Shelf Research*, *129*, 23–32. doi:10.1016/j.csr.2016.09.010

Spatial distribution of manganese in surface waters in the East Siberian Arctic Seas

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Based on satellite observation, the East Siberian Arctic Seas (ESAS), including Laptev Sea and East Siberian Sea, have experienced increases in primary production due to ongoing changes in the Arctic climate [1]. ESAS receives large amount of freshwater from Arctic rivers (Lena, Yana, Indigirka, and Kolyma) [2], as well as meltwater from sea ice. The increased freshwater input may supply additional micronutrients to sustain the higher phytoplankton biomass in surface water of ESAS. Because ESAS remains one of the less studied areas of the Arctic Ocean, micronutrients input from the freshwater sources is largely unknown. Here, we present spatial distribution of dissolved manganese (dMn) with a focus on micronutrients in surface waters of ESAS. This study was carried out onboard the Russian Research Vessel *Akademik Tryoshnikov* in cooperation with the Nansen and Amundsen Basins Observational System (NABOS) expedition in September−October 2021.

Surface water in the eastern section of ESAS was relatively fresh (Salinity = 21.4~32.3) and cold (Temperature = −2.0~+0.3°C), which is likely due to the mixing of the summer Pacific Water with freshwater supplied by river and sea ice. The concentration of dMn in the surface water ranged from 5.5 to 24.3 nmol kg^{-1}. The concentration of dissolved organic carbon (DOC), which is known as riverine source in ESAS [2], was as high as 146 μMC in the surface water. To detect the origin of freshwater in the surface water, we calculated volumetric water mass fractions by assuming a mixture of three different water masses: the summer Pacific Water, a river water and meltwater from sea ice [3]. Fractions of mass, salinity and stable oxygen isotopes of water balance equations were solved using these three end-members. The dMn and DOC concentrations in the surface water were positively correlated with a river water fraction ($p < 0.05$), while uncorrelated with a meltwater fraction of sea ice. This result suggest that river water discharge is main source for supplying dMn into ESAS relative to sea ice meltwater.

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[1] K. M. Lewis et al., Changes in phytoplankton concentration now drive increased Arctic Ocean primary production, *Science* **369** (2020)

[2] I. Semiletov et al., Acidification of East Siberian Arctic Shelf waters through addition of freshwater and terrestrial carbon. *Nature Geosci* **9**, 361–365 (2016)

[3] P.-O. Rosén et al., Ice export from the Laptev and East Siberian Sea derived from $\delta^{18}O$ values, *J. Geophys. Res. Oceans*, **120** (2015)

Temporal changes in physical and biogeochemical properties of halocline waters in the Canada Basin

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Warming and freshening of Pacific-origin water flowing through the Bering Strait to the Arctic Ocean have been observed in the last decade. Warming has also been reported for Atlantic-origin water. These changes may alter water mass structure in the Arctic Ocean. Here, we investigate temporal changes in properties of the halocline layer of the Canada Basin, where both Pacific- and Atlantic-origin waters exist, based on observations from 2003 to 2019.

Data analyzed are temperature, salinity, nutrients, and dissolved oxygen. From these, we calculated AOU (Apparent Oxygen Utilization), mixing ratio of Pacific water to Atlantic water (R_{pw}), and the fraction of sea ice melt water (f_{SIM}). R_{pw} was calculated from the relationship between dissolved inorganic nitrogen and phosphorous, and f_{SIM} was calculated from the relationship between δ18O and salinity.

In the upper part of the halocline at salinity layers of S=31.8 and 32.3, corresponding to the layer of Pacific Summer Water (PSW), temperature, AOU, and nutrients increased during 2012-2019. Increases in AOU and nutrients were prominent for the last few years. These can be explained by warming of PSW and increased input of nutrient-rich Pacific Winter Water (PWW) into this layer due to freshening of the PWW, as observed in the Bering Strait. In the middle halocline layer from the core of Pacific Winter Water (PWW, S=33.1) to S=33.6, the warming was significant after 2012. In this layer, significant decrease in R_{pw} also occurred during the same period. These suggest that the freshening of PWW resulted in the reduction of traditional PWW in the Canada Basin, and replacement of lower part of PWW layer by the Lower Halocline Water (LHW), with higher temperature and lower R_{pw}. In fact, the increase in temperature at two salinity layers of S=33.1 and 33.6 can be explained by the change in mixing ratio of PWW and LHW estimated from R_{pw}. Nutrient concentrations also decreased in these two salinity layers, possibly due to a decrease in the ratio of nutrient-rich PWW, but the rate of decrease was smaller than that expected from the decrease in R_{pw}. In the lower part of halocline, in the S range of 33.7-34.5, warming was observed during 2003-2019, and the degree of warming was greatest at the LHW layer (S=34.2). Increase in nutrients and AOU were also found around LHW (S=34.1 and 34.4). These may reflect changes in properties of LHW in its formation region of the Barents Sea or on its transport pathway. As for f_{SIM}, no significant changes were observed for each salinity layers from upper to lower part of halocline.

Observed changes in biogeochemical properties in the halocline may have positive impact on biological productivity in the Canada Basin, but may have negative impact in the downstream region where middle halocline water upwell.

Impacts of non-breaking wave induced mixing on the modelling of Arctic Cyclone through the two-way coupled numerical model

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A dramatic decline in the amount and area of the Arctic sea ice has been seen in recent decades as a striking indicator of current climate change. The increase of open water in the polar regions, specifically in the Arctic, provides opportunities for sensible and latent heat transfer between the atmosphere and ocean. The substantial air-sea energy transport contributes to the birth of extreme weather events, such as Arctic Cyclones (ACs). After the passing of ACs, the local sea ice fields are substantially disturbed, which significantly mediates the surface of sea ice and local wave fields. The ocean surface waves play a critical role in the upper ocean mixing. This is because additional turbulent energy induced by the waves positively contributes to the upper ocean dynamical process (i.e., upwelling). ACs development and intensification are expected to be closely related to the variation of local waves. As the unique vertical temperature and salinity distribution of interior sea water in the Arctic, wave-induced mixing could potentially carry sublayer warm water to the ocean surface, adding extra energy to the development of ACs. It is here where ACs are different from cyclones that happen in tropical and extratropical regions when considering the physical process of wave-induced turbulent mixing. Once the ACs are intensified due to the addition of energy from the sublayer ocean caused by the wave-induced mixing, severe weather conditions (i.e., stronger winds and higher sea state) are afterwards expected. This subsequently leads to the breaking up of local sea ice, which institutionally accelerates the melting of broken ice floes. As such, enhanced removal of ice cover and increments of open water areas are introduced once wave-induced mixing is considered. To study such potential positive feedback among sea ice, local waves, and ACs, we simulated one AC during the summer in the Northern Hemisphere through an atmosphere-ocean-wave coupled model. Based on our modeling results, we expect the positive-feedback system can be verified.

References

[1] Waseda, T., Webb, A., Sato, K., Inoue, J., Kohout, A., Penrose, B. and Penrose, S., 2018. Correlated increase of high ocean waves and winds in the ice-free waters of the Arctic Ocean. Scientific reports, 8(1), pp.1-9.
[2] Waseda, T., Nose, T., Kodaira, T., Sasmal, K. and Webb, A., 2021. Climatic trends of extreme wave events caused by Arctic Cyclones in the western Arctic Ocean. Polar Science, 27, p.100625.

Radiation characteristics of thin sea ice in the ice tank experiments during freezing and melting periods using multifrequency passive microwave radiometers

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Microwave radiation characteristics of sea ice with a thickness ranged from 0 cm to around 40 cm was measured using the passive microwave radiometers having the observation frequencies of 6, 18, 36 GHz in 2021 and 2022 winters. Sea ice growth/melt experiments were carried out using the ice tank which has a diameter of 2.3m and a depth of 1.3m and filled by 5 tons of saline water (32psu) transported from the Saroma-ko lagoon. The ice tank was set up outdoors next to the baseball ground in the campus of Kitami Institute of technology. In order to avoid the effects of melting by sunlight and disturbance by snow, a movable roof was used. A cooler was installed inside the roof to prevent from melting during daytime (Fig.1). Portable microwave radiometers MMRS2 were used and installed at same incident angle (55 degree) to GCOM-W/AMSR2.

Figure 2 shows the brightness temperatures change with ice growth from open water to 0.24m thick ice. The brightness temperature rises rapidly and showed the maximum value at 0.05m. After that, the brightness temperatures showed the tendency to decrease gradually with sea ice thickens. Figure 3 shows the bulk ice salinity decreases with ice growth in freezing season, decreases with ice thinning in melting season.

Figure 1. Photograph of the ice tank experiment

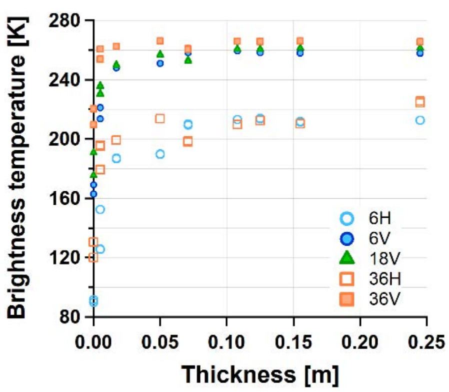

Figure 2. Relationship between ice thickness and brightness temperature.

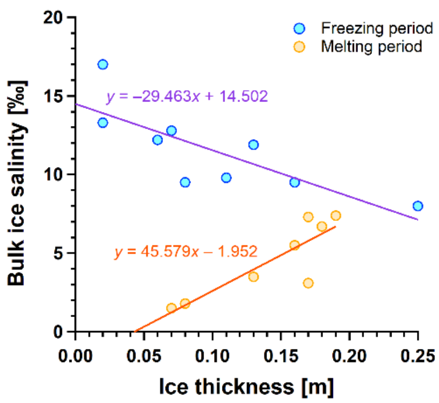

Figure 3. Relationship between ice thickness and bulk salinity of ice sample.

Representation of Microscale Spatial Variability in Thaw Depth in Eastern Siberian Larch Forests

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Spatial variability in thaw depth at a microscale (50m × 50m) was measured in two larch forests in eastern Siberia, Spasskaya Pad and Elgeeii, and modeled using a gamma distribution. The gamma distribution adequately represented the thaw depth spatial variability. Furthermore, the shape parameter k and rate parameter λ of the gamma distribution at both sites depended on the mean thaw depth. Thus, we developed a hierarchy of models that sequentially considered the constant state (Model 1), linearity (Model 2), and non-linearity (Model 3) in the dependence of the rate parameter λ on the mean thaw depth. Although the requirements of the model levels differed between Spasskaya Pad and Elgeeii, the proposed model successfully represented the spatial variability in thaw depth at both sites during different thaw seasons (Fig. 1).

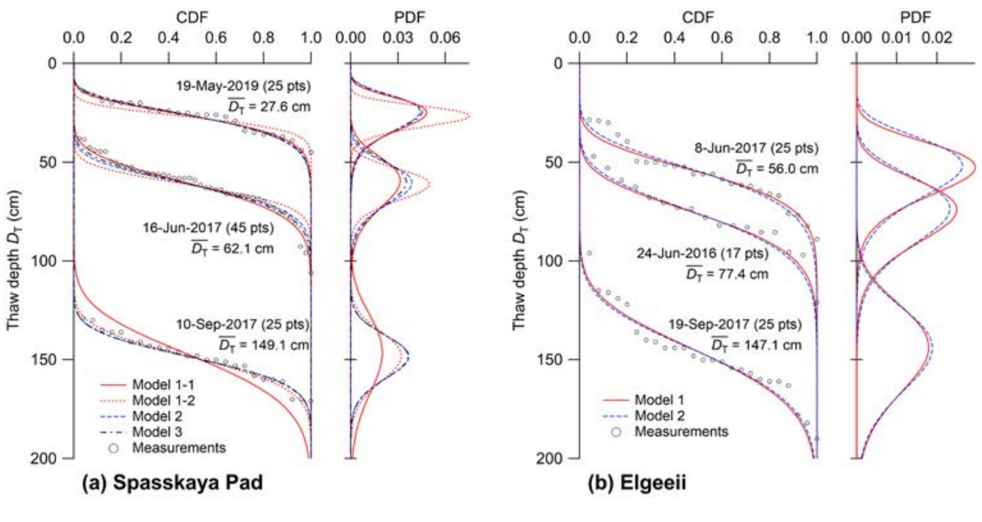

Figure 1. Measured and modeled spatial variability in thaw depth D_T at different times during the thawing season in Spasskaya Pad and Elgeeii. The model results are represented as the cumulative density function (CDF) and probability density function (PDF).

Intraseasonal permafrost thaw processes around Batagay NE Siberia detected by ALOS-2/PALSAR-2 InSAR time series analysis

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Yedoma is a permafrost layer with a high volumetric ice content (up to 90%) and organic sediments. The melting of massive ice in the yedoma layer and run-off meltwater causes irreversible topographic changes (e.g., thermokarst, thaw slump) and damage to the infrastructure of the local residents. Therefore, Interferometric Synthetic Aperture Radar (InSAR), which can detect ground displacement signals with an accuracy of cm, is used for broad monitoring of permafrost degradation. However, detailed degradation processes are unclear due to the coherence loss of C-band data and the low temporal resolution of L-band data. Here, we report detailed intraseasonal processes of thaw subsidence using InSAR time series analysis with high spatial (5 m) and temporal (14 days ~) resolution images taken by Jaxa's L-band SAR satellite ALOS-2/PALSAR-2. Our study site is near Batagay, Sakha republic, Northeast Siberia, where the Batagaika Mega Slump (BMS), the world's largest retrogressive thaw slump, has been formed since the 1970s due to melting yedoma and erosion. In 2022, thaw subsidence occurred in the early-season (~7 cm from May to June), then disappeared in the mid-season, and restarted again in the late-season (more than 7 cm from July to September) near the BMS. Zwieback and Mayer (2021) found the late-season thaw subsidence, caused by "top-of permafrost ground ice melting," in the exceptionally warm and wet summer near Kivalinam, northwestern Alaska. Our results indicate that a similar late-season thaw process would occur near Batagay without extreme climate conditions. In addition, the late-season thaw subsidence within the fire scar, which is on the same slope as the BMS, was spatially matched with the frost heave area. It would suggest that the ice lens formed at the lower table of the active layer within a part of the fire scar. Furthermore, the early-season subsidence processes differed between the fire scars and the surrounding unburned area. We will discuss the difference in thawing processes with on-site data taken in September 2021. The high temporal and spatial resolution of L-band data effectively elucidates the intraseasonal permafrost degradation processes, and the next generation's L-band SAR satellites will be expected to further contribute to mapping ground ice melting.

Reference

[1] S. Zwieback, F.J. Meyer, Top-of-permafrost ground ice indicated by remotely sensed late-season subsidence. *The Cryosphere* **15**, 2041–2055 (2021)

R3-P03

Deep learning-based identification of thermokarst in Eastern Siberia and its relationship with local environment and land use

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In the continuous permafrost areas of Eastern Siberia, Arctic climate change is causing subsidence of the ground surface due to permafrost thawing, known as thermokarst. In particular, the rapid spread of thermokarst in high-latitude regions is raising alarm bells. The following research results have been cited from the viewpoint of geography regarding such environmental changes and their regional characteristics. For example, Kirimura et al. [1], using population data and satellite images, pointed out that thermokarst and land development due to the thawing of frozen soil are closely related as residential areas have expanded along with population growth. In a study by Fujioka et al. [2], interviews and questionnaires were conducted with local residents in Eastern Siberia, and it was found that there were significant differences in perceptions of environmental change among different local resident groups. In particular, they reported that even residents of the same region have different opinions on the perception of precipitation change. Thus, global environmental changes such as global warming, regional anthropogenic influences such as population growth and land development, and local topography and climate are thought to have a combined effect on the emergence of thermokarst. Therefore, this study examines what conditions influence the emergence of thermokarst by overlaying environmental conditions such as climate, topography, and land use data on the location of thermokarst detected by an artificial intelligence model. Detection of thermokarst was conducted by applying a deep learning method called the "chopped picture method" to satellite images. Data such as slope aspect (whether sunny or shaded), sunshine duration, soil, precipitation, wind volume and wind speed are used as environmental conditions. The novelty of this study is that it estimates the occurrence of thermokarst through automatic detection using deep learning. The combination of satellite imagery and deep learning makes it possible to scan a wide area using a fixed method and is expected to reduce fluctuations in accuracy due to individual differences that are a concern in visual identification. In the future, it is desirable to consider the degree of recognition of environmental changes by local residents in this research from the perspective of comprehensive environmental countermeasures.

This study was supported by the Arctic Challenge for Sustainability Research Projects II (JPMXD1420318865) funded by the Ministry of Education, Culture, Sports, Science, and Technology of Japan,

References

[1] Takashi KITIMURA, Yoshihiro IIJIMA, Hitoshi SAITO, Population Growth after 2010 in the Sakha Republic, Russian Federation, Annual Meeting of the Association of Japanese Geographers (2022)

[2] Yuichiro FUJIOKA, Hiroki TAKAKURA, Vanda IGNATYEVA, SaSardana BOYAKOVA, Stepan GRIGOREV Differences in local perceptions about environmental changes among residents of small communities in eastern Siberia, Annual Meeting of the Association of Japanese Geographers (2022)

R3-P04

Thermal Denudation Features on the Yamal Peninsula

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Retrogressive thaw slumps (RTS), or thermocirques, are permafrost features occurring due to thermal denudation affecting ice-rich sediments. On the Yamal peninsula RTSs are caused due to the thawing of tabular ground ice.

Starting from 2012, a large activation of RTS has been noticed on Central Yamal, within the «Vaskiny Dachi» key site [1]. The series of yearly unmanned aerial vehicle survey data for 2017-2021 were processed to reveal RTS dynamics. Multitemporal digital surface models and orthomosaics of 3 RTSs were created (fig. 1).

The growth of RTS is non-linear and mainly affected by the sum of active air temperatures and summer precipitation. The most intensive area increase took place in 2012, 2016 and 2020 years with extremely warm summers. The average annual growth rates of RTSs for the period 2017-2021 varied between 864.8 and 749.2 m^2 in the case of RTS-5 and RTS-4a, respectively, to 2806.1 m^2 in the case of RTS-5n. On top of that, RTS-5n with the highest ice content in exposure has extremely expanded in size by 417% of its initial area. Thus, many local factors such as landform morphology and ice content in exposure determine the individual growth rate of each RTS.

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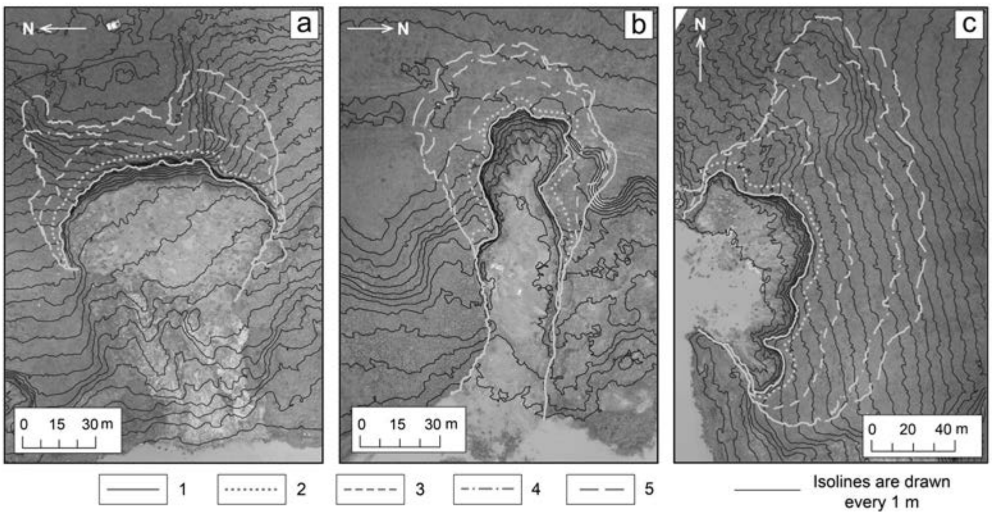

Figure 1. Growth of RTS-5 (a), RTS-4a (b) and RTS-5n (c) in 2017-2021. RTS edge positions for a specific date: (1) 08/28/2017, (2) 07/14/2018, (3) 07/17/2019, (4) 08/23/2020, (5) 08/1/2021.

References

[1] A. Khomutov, M. Leibman, Y. Dvornikov, A. Gubarkov, D. Mullanurov and R. Khairullin, Activation of cryogenic earth flows and formation of thermocirques on central Yamal as a result of climate fluctuations, *Workshop on World Landslide Forum* (2017)

R3-P05

Black carbon and their isotopic signatures in soil and permafrost in Ny-Ålesund, Svalbard: Implication of sources and fate under changing Arctic climate

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Black carbon (BC) is the collective carbon-rich aromatic residues and condensates from the incomplete combustion of fossil fuels and biomass. Anthropogenic BC produced by industrial activity is also enough time to undergo long-distance transport and reach even Arctic region. Because BC can absorb solar radiation, thereby warming the atmosphere, altering the albedo, accelerating glacier melting when deposited on snow, and changing the properties. Additionally, a high-latitude region including the Arctic has the largest reservoir of soil organic carbon (SOC) on Earth. For the past centennial and more, the thawing permafrost and glacier should have been subject to enhanced microbial decomposition to emit GHGs as well as mass mobilization and other erosion processes. However, knowledge of terrestrial archives of BC in the Arctic such as sediments, permafrost soil, ice, and glacier, as well as of the historical contribution of transport of atmospheric BC from remote sites where anthropogenic emission is high, is very sparse. We know these archives serve as ideal archives for exploring future climate and environmental changes. Especially this knowledge is very crucial for assessing the impact of human disturbance on atmospheric composition and thereafter climate. We need to know the historical trend and variability of BC with the source and fates of BC. For this purpose, for the first time, we investigated CTO-375-based BC content and its isotopic signatures (^{14}C and ^{13}C) in soil and permafrost in Stuphallet, Blomstrand, the catchment of the Bayelva River near Ny-Ålesund, Svalbard to assess the source and fates of BC.

References

[1] M. Uchida, Kumata H., Koike Y., Tsuzuki M., Uchida T., Fujiwara K., Shibata Y. Radiocarbon-based source apportionment of black carbon (BC) in PM_{10} aerosols from residential area of suburban Tokyo. *Nucl.Instrum.Methods Phys.Res.,B,* **268 (2010)**.

Detecting spatio-temporal variations in water and vegetation change areas in the East Siberian permafrost zone using backscatter coefficient and DSM

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From 2005 to 2008, precipitation increased in summer in the middle reaches of the Lena River basin in Eastern Siberia (Central Yakutia). The overwetting conditions thickened the active layer with the thawing of the surface layer of permafrost. As a result, the boreal (mainly larch) forest under the inundation has been degraded. Iijima et al. (2013) used the backscattering coefficient of ALOS-PALSAR images of different years (2007-2009) to detect the permafrost/forest degradation areas [1]. However, the subsequent changes after the disturbance have never been explored in conjunction with the detailed topographical relationship. The present study, thus, aims to reproduce a time series of water-logged and vegetation change area maps from 2007 to 2017 in Central Yakutia using the same method as Iijima et al. (2013).

In this study, we used SAR data from the ALOS-PALSAR series during the summer (July to September) of 2007 to 2017. A backscatter intensity image (dB value) was calculated from the obtained data. After the calculating process, the water and vegetation change area is extracted based on the looking table of thresholds determined by Iijima et al. (2013) [1].

We reproduced the time series of the map showing water and vegetation change area from 2007 to 2009 and from 2009 to 2015/2017. From 2007 to 2009, when permafrost thawed with overwetting soil, the proportion of areas verified as weak flooding and forest decline was the highest. Thereafter, from 2009 to 2017, the area with no flooding and forest recovery was the highest. These temporal changes imply that the moistening of the soil was mitigated due to less summer precipitation and the cessation of the deepening active layer after 2009. In addition, the flooding conditions came to be minor likely due to consecutive increases in evaporation as the solar radiation directly on the ground surface at the forest declined area.

On the other hand, areas classified with intense flooding and forest degradation continued to be identified on the right bank of the Lena River from 2009 to 2017. Therefore, the topographic analysis was conducted using a high-resolution AW3D DSM. As a result, the area classified with continuous and intense flooding with forest degradation appeared in topographically low spots, such as the lower part of the river terrace and the surroundings near thermokarst lakes. This local topography may be essential for the forests' continued decline and degradation in recent years, even though no wet years have occurred.

References

[1] Iijima et al. (2013), Spatial characteristics in permafrost and forest degradation in Yakutsk, eastern Siberia, Annual Meeting of the Association of Japanese Geographers, Spring 2013.

R3-P07

Monitoring surface temperature and channel width of the six Arctic rivers from space using GCOM-C/SGLI

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The six Arctic rivers (Ob, Yenisei, Lena, Kolyma, Yukon, and Mackenzie shown in Figure 1) play important roles in the hydrological cycle as well as the ocean-atmosphere energy exchange in the Arctic [1]. Recently, snow cover extent (SCE) in the Northern Hemisphere exhibits negative trends in all seasons during the past four decades [2]. Therefore, recent freshwater cycle and heat flow through the Arctic rivers' watersheds into the Arctic Ocean can be considered to change significantly in response to the recent global warming. This study aims to derive river surface temperature (RST) and channel width (RCW) of the six Arctic rivers along the main streams using a multi-spectral satellite-borne optical imager, SGLI onboard Japanese Earth observing satellite named GCOM-C. Preliminary study revealed that SGLI can retrieve RST and RCW of the six Arctic rivers successfully on a near daily basis during the years of 2018 and 2019 [3]. In this study, the period of data analysis is extended to five years from 2018 to 2022 and the seasonal and yearly changes in RST and RCW will be presented.

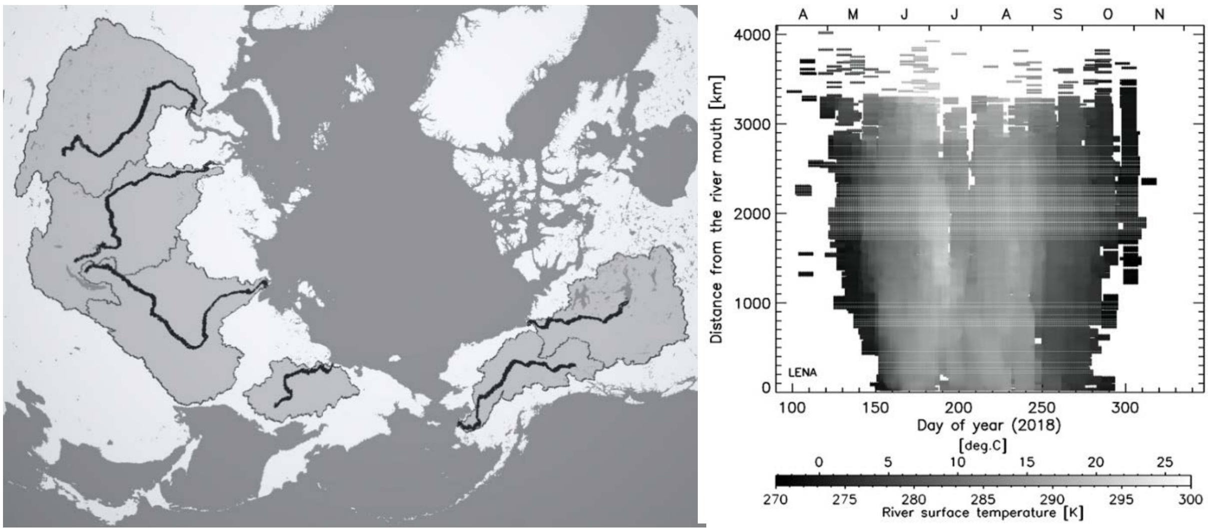

Figure 1. (left) Map of the six Arctic rivers (thick solid lines) and watershed (grey area) examined in this study. (right) SGLI-derived near-daily river surface temperature along the Lena River in 2018

References

[1] H. Park, E. Watanabe, Y. Kim, I. Polyakov, K. Oshima, X. Zhang, J.S. Kimball, D. Yang, Increasing riverine heat influx triggers Arctic sea ice decline and oceanic and atmospheric warming. *Sci. Adv*. **6** (2020)

[2] M. Hori, K. Sugiura, K. Kobayashi, T. Aoki, T. Tanikawa, K. Kuchiki, M. Niwano, H. Enomoto, A 38-year (1978–2015) Northern Hemisphere daily snow cover extent product derived using consistent objective criteria from satellite-borne optical sensors, R*emote Sens. Environ.*, **191** (2017)

[3] Hori, M., Near-daily monitoring of surface temperature and channel width of the six largest Arctic rivers from space using GCOM-C/SGLI. *Remote Sens. Environ*., **263** (2021)

R3-P08

Single-spore PCR revealed the novel parasitic fungi infecting snow algae in alpine ecosystems

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Snow and glacier algae, commonly found on Arctic glaciers and snowpacks, are often infected by parasitic fungi[1]. Recent metabarcoding analyses revealed the novel phylogenetic group of fungi, called as Snow Clade 1, only composed of environmental DNA sequences detected in high mountains around the world[2]. However, their ecology and distribution are still understudied due to the difficulty of culturing and subsequent DNA sequences. These fungi could be parasites infecting ice and snow algae in glaciers and high mountains, as observed by microscopes. In this study, we applied single-spore-PCR[3] during snow algae bloom on Mt. Gassan in Japan to clarify the phylogenetic position of parasitic fungi on snow algae, *Chloromonas* spp. Based on the DNA sequencing of picked single fungal spores and phylogenetic analysis, we identified three novel distinct linages (Sp1, Sp2, and Sp3; Fig. 1), all of which belonged to the Snow Clade 1. The results suggested that the Snow Clade 1 is composed of the parasitic fungi infecting algae in high mountains. We also conducted metabarcoding analyses of various alpine and glacial regions in the world to investigate the distribution of fungi. By comparing the obtained sequences with the metabarcoding analyses, we found that certain ASVs matched with parasitic fungi were only detected from Mt. Gassan, indicating local endemism of parasitic fungi. These results suggest hidden diversity of parasitic fungi infecting snow algae and their local adaptations to respective environments and hosts.

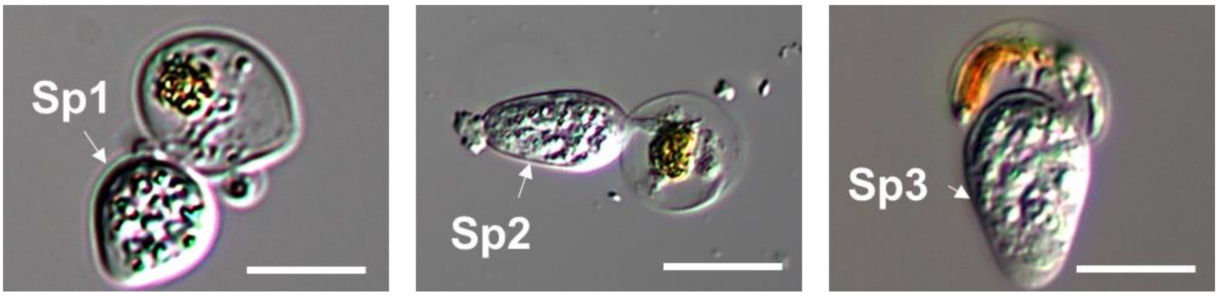

Figure 1. Micrographs of three novel linages of parasitic fungi infecting *Chloromonas* spp. All scale bars are 10 µm.

References
[1] E. Kol, The snow and ice algae of Alaska. *Smithsonian Misc. Collect.* **101** (1942).
[2] C. S. Naff, J. L. Darcy, & S. K. Schmidt, Phylogeny and biogeography of an uncultured clade of Snow Chytrids, *Environ. Microbiol.* **15,** 2672-2680 (2013).
[3] M. Kagami, K. Seto, D. Nozaki, T. Nakamura, H. Wakana, & C. Wurzbacher, (2021). Single dominant diatom can host diverse parasitic fungi with different degree of host specificity. *Limnology and Oceanography*, **66** 667-677 (2021).

R3-P09

In-situ field observations of snow cover characteristics in Alaskan boreal forest during the snow melt season

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To determine the impact of snow cover on land surface processes, we measured the in-situ snow cover characteristics of the sub-Arctic northern forest. We produced time series datasets of various snow cover parameters (forest floor albedo, canopy albedo, snow depth, air temperature, snow cover surface and base temperatures, layer structure, grain size distribution, and snow water equivalent) covering the winter melting period based on direct observations of snow-covered sections. The in situ cross-sectional measurements of snow depth and snow water equivalent showed large decreases with increasing temperature and were comparable with values calculated via the degree-day method. Moreover, snow cover and forest floor albedo decreased gradually with time throughout the observational period. Increasing snow cover melt of both the canopy and forest floor significantly impacted the canopy albedo. The disappearance of snow cover increased the shortwave absorption by approximately 30% due to increasing tree exposure. The observational data in this study can be used to validate land surface models for more accurate estimations of northern forest albedo.

R3-P10

Monitoring of snow physical parameters by spectral radiation measurements using ground-based optical instrument in Ny-Ålesund, Svalbard

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Snow albedo is an important physical parameter that significantly affects snow melting and the radiative energy budget on the Earth's surface. The snow albedo is generally high and plays a role in protecting against the absorption of shortwave radiation entering the snow surface. However, the snow albedo varies with the snow condition and/or the seasonal variation and controls the melting rate. Thus, the monitoring of snow albedo is a useful way to see the change in snow cover and melt timing in high latitudinal regions, which is an informative indicator of climate change. Becherini et al. (2021) [1] found from more than three-decade daily mean broadband albedo in Ny-Ålesund, Svalbard that a great inter-annual variability of albedo was confirmed especially in the melting season. However, snow physical parameters that control the snow albedo were not well understood. In general, snow albedo depends strongly on snow grain size and light absorbing snow impurities including dust and soot from atmospheric aerosol deposition. In this study, we have monitored the snow grain size and the concentration of light absorbing snow impurities in Ny-Ålesund since 2012, which were retrieved from spectral albedo measured by the ground-based spectral radiometer system for albedo and flux (GSAF) using a look-up table method [2]. The GSAF was installed near the baseline surface radiation network (BSRN) station located in the south of the village Ny-Ålesund. The results show that surface snow grain size remained in a range of 50 – 500 μm in the accumulation season (March to April) and then increased to over 1000 μm after early/middle May in the melting season. Mean snow grain size in the accumulation season could be increased year to year. The concentration of light absorbing snow impurities (here BC-equivalent concentration) varied from 0.01 to 0.1 ppmw and remained at a relatively low concentration in the accumulation season (~0.05 ppmw) and increased in the melting season (~0.1 ppmw). The possible processes which cause the seasonal variation in the snow impurity concentration would be differences in the deposition of atmospheric aerosols and an increase of impurities with snow melting enhancement and sublimation and/or evaporation of surface snow in the melting season.

References

[1] Becherini *et al*., *Bull. Atmos. Sci. Tech*. **2** (2021) doi:10.1007/s42865-021-00043-8
[2] Tanikawa *et al*., *J. Geophys. Res*. **125** (2020) doi:10.1029/2019JD031858

R4-P01

Snow accumulation inferred from a GPR survey around the Southeastern Dome, Greenland Ice Sheet

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Snow accumulation is a component that is still poorly constrained over the Greenland Ice Sheet. We performed ground-penetrating radar (GPR) measurements around the Southeastern Dome (SE-Dome) of the Greenland Ice Sheet during a shallow ice core drilling campaign from May to June 2021 (Iizuka *et al*., 2021). GPR-derived firn structure was compared with ice core density, dates, and melt layers to reconstruct the snow accumulation around the SE-Dome. Numerous internal reflection horizons (IRHs) were observed, which were related to the ice core records (Fig. 1). We detected these IRHs automatically and calculated spatio-temporal snow accumulation rate around the SE-Dome. The calculated accumulation rates are ranged between 0.6 and 1.4 m w.e. a^{-1}, which agreed with previously reported snow accumulation at a neighboring ice core site (Furukawa *et al*., 2017). Although, the calculated snow accumulation varied not only in time but also in location. We discuss possible mechanisms of spatio-temporal variations in accumulation around SE-Dome at the conference.

References

[1] Iizuka, Y., *et al*. Glaciological and meteorological observations at the SE-Dome site, southeastern Greenland Ice Sheet. *Bul. Glaciol. Res.,* **34** (2016)
[2] Furukawa, R., *et al*. Seasonal-scale dating of a shallow ice core from Greenland using oxygen isotope matching between data and simulation. *J. Geophys. Res-Atmos.* **122** (2017)

R4-P02

The current state and future directions of the polar regional climate model NHM−SMAP

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The Greenland ice sheet has experienced a significant loss of ice mass since the early 1990s. It is estimated that the contribution by the reduction of the ice sheet surface mass balance to the total mass loss has been increasing during the period. Therefore, it is urgent to understand the snow/ice–atmosphere interaction over the ice sheet in detail. These motivated us to develop a high horizontal resolution (5 km) polar regional climate model combining the Japan Meteorological Agency Non-Hydrostatic atmospheric Model and the physical snowpack model Snow Metamorphism and Albedo Process (NHM–SMAP) [1]. The model has contributed to estimate not only the ice sheet surface mass balance [1, 2] but also cloud radiative effects [3] and rainfall [4] over the ice sheet under the recent rapidly warming climate condition. Recently, NHM–SMAP has also been applied in the Antarctic ice sheet and High Mountain Asia. Through these studies, NHM–SMAP as well as SMAP have demonstrated high reliability regarding the snow/ice–atmosphere interaction. As a ripple effect of our recent attempts, the SMAP model has been used for the Japan Meteorological Agency operational analysis and forecasts of snow over Japan since 2022 October (https://www.jma.go.jp/bosai/en_snow/). In this contribution, we review recent studies that utilized NHM–SMAP, and the current state of the model development. In addition, we also discuss future directions of the model.

References

[1] M. Niwano, et al. NHM–SMAP: spatially and temporally high-resolution nonhydrostatic atmospheric model coupled with detailed snow process model for Greenland Ice Sheet, *The Cryosphere*, **12** (2018)
[2] X. Fettweis, et al. GrSMBMIP: intercomparison of the modelled 1980–2012 surface mass balance over the Greenland Ice Sheet, *The Cryosphere*, **14** (2020).
[3] M. Niwano, et al. Cloud-driven modulations of Greenland ice sheet surface melt, *Sci. Rep.*, **9** (2019).
[4] M. Niwano, et al. Rainfall on the Greenland ice sheet: present-day climatology from a high-resolution non-hydrostatic polar regional climate model, *Geophys. Res. Lett.*, **48** (2021)

R4-P03

Numerical modeling of biological processes on snow and glacier surfaces in the Arctic region

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Biological processes on snow and glacier surfaces in the Arctic region play a key role causing albedo reduction called as "Bio-albedo effect" due to blooms of snow and glacier phototrophs. Because the bio-albedo effect varies temporally and spatially due to their biological properties including growth, death and migration, the biological processes need to be separated from accumulation processes of the other impurities such as aeolian mineral dust and black carbon. In addition, different processes causing the bio-albedo effect, which are known as red snow, dark ice and cryoconite holes, are observed in the Arctic snowpacks and glaciers. To understand the bio-albedo effect quantitatively, a numerical model to reproduce such biological processes as well as a physically based albedo model should be established. We recently established several numerical models: the snow algae model to simulate red snow phenomena caused by snow algal blooms (Onuma et al., 2020; 2022a), the glacier algae model to simulate dark ice phenomena caused by glacier algal blooms (Onuma et al., 2022b) and the cryoconite hole model to simulate vertical dynamics of cryoconite holes (Onuma et al., In prep.). In this study, we simulate spatio-temporal changes in algal abundance and bio-albedo effect in Greenland Ice Sheet since 2000 using regional climate or land surface models coupling with the established models. The simulated spatio-temporal changes are validated using a polar-orbit satellite, Global Change Observation Mission for Climate (GCOM-C) which carries an optical sensor capable of multi-channel observation at wavelengths from near-UV to thermal infrared wavelengths (380nm to 12μm). The detailed discussion will be presented at the symposium.

References

[1] Y. Onuma, N. Takeuchi, S. Tanaka, N. Nagatsuka, M. Niwano and T. Aoki, Physically based model of the contribution of red snow algal cells to temporal changes in albedo in northwest Greenland. *The Cryosphere*, **14**, 2087-2101. doi:10. 5194/tc-14-2087-2020 (2020)
[2] Y. Onuma, K. Yoshimura and N. Takeuchi, Global simulation of snow algal blooming by coupling a land surface and newly developed snow algae models, *Journal of Geophysical Research: Biogeosciences*, **127 (2)**, e2021JG006339. doi:10.1029/2021JG006339 (2022a).
[3] Y. Onuma, N. Takeuchi, J. Uetake, M. Niwano, S. Tanaka, N. Nagatsuka and T. Aoki, Modeling seasonal growth of phototrophs on bare ice on the Qaanaaq Ice Cap, northwestern Greenland. *Journal of Glaciology*, 1-13. doi:10.1017/jog.2022.76 (2022b)

R4-P04

Early melt onset drives dark ice exposure on the Greenland Ice Sheet

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Continuous monitoring of the Greenland Ice Sheet (GrIS) surface condition is important to understand the influence of recent albedo reduction on the radiative budget and mass balance of the ice sheet. Expansion of bare ice and dark ice area is one of the factors for significant albedo reduction on the edge part of the GrIS surface. Satellite remote sensing is the one of the most useful tools for the widely and continuous monitoring such as GrIS, the expansionary trend of the bare ice and dark ice extent has been revealed from the analysis using MODIS satellite images (Shimada et al., 2016). However, the behavior of the GrIS surface state before the 2000 has not been investigated. In this study, we aim to investigate the annual variation in the bare ice and dark ice area during melting season from 1979 using a long-term satellite data set. The long-term dataset of the bare ice and dark ice distribution on the GrIS was developed using three optical space-borne sensors: AVHRR, MODIS and SGLI. These sensors have near-infrared wavelength band used for bare ice detection and red wavelength band used for dark ice detection. For bias correction between these sensors, the classification thresholds for AVHRR and SGLI were adjusted to MODIS based on the Cohen's Kappa coefficient. The 40-year variations of the bare ice and dark ice extent using the adjusted thresholds showed positive trends in the whole region of the GrIS (Figure 1). Bare ice extent was gradually expanded from 1979, however dark ice extent was rapidly expanded from 2000 to 2012 and remained high since then. In comparison with surface melt extent derived from passive microwave observation, the bare ice and dark ice extents were positive correlated significantly with surface melt extent. Considering melt duration, the dark ice extent showed a strong positive correlation with melt extent which experienced longer melting. Microwave observation showed the melt onset became earlier from 2000s, it is possible that the early melt onset drives dark ice exposure on the GrIS in recent years.

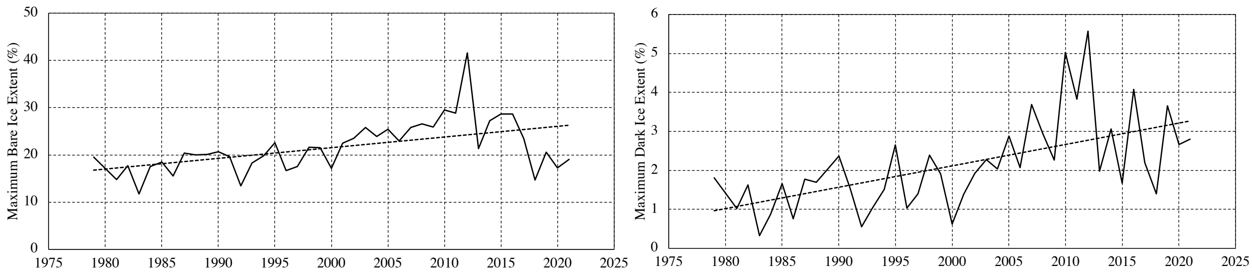

Figure 1. Annual variations of the bare ice (left) and dark ice extent (right) from 1979 to 2021.

References
[1] Shimada, R., N. Takeuchi and T. Aoki, Inter-annual and geographical variations in the extent of bare ice and dark ice on the Greenland ice sheet derived from MODIS satellite images, *Font. Earth Sci.* **4** (2016)

R4-P05

Changes in stripe patterns of dark regions in the southwestern Greenland Ice Sheet

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On the Greenland Ice Sheet, the bare ice surface is exposed at the marginal parts of the ice sheet during summer. In the bare ice area, dark colored ice, called a dark region, appears at the same locations every year. The dark region expands particularly in the southwestern part of the ice sheet over a distance of about 500 km from north to south. In recent years, the area of the dark region has expanded. The expansion of the dark region reduces surface albedo of the ice sheet and promotes absorption of solar radiation, which accelerates melting of the ice and leads to loss of the ice sheet mass. Therefore, it is important to understand the factors that affect the area of the dark region. Field observations and satellite image analyses have shown that the dark region is formed by the deposition of light-absorbing impurities such as dust and snow/ice microorganisms on the ice surface. High-resolution satellite images show that the dark region consists of stripe patterns extending in parallel with the ice sheet margins. However, it is still unclear why dust and snow/ice microorganisms accumulate on the ice surface to form stripe patterns, and what is the relationship between the patterns and expansion of the dark region. The purpose of this study is to analyze the changes in stripe patterns of the dark region in the southwestern part of the Greenland Ice Sheet using satellite images, and to discuss the factors that cause the changes in the dark region.

The bare ice area of the Greenland Ice Sheet can be divided into two areas, which are the white and dark regions. The white region is defined as the area where the surface appears to be bright and tends to distribute the downstream of the bare ice area. The dark region is defined as the area where the surface appears to be dark and tends to distribute the upstream of the bare ice area. Three Landsat-8 OLI satellite images acquired on 10-July, 26-July, and 11-August, in 2019, were used in this study. A transect line across the white and dark regions was selected to be analyzed with satellite images. A profile of Band 4 (Red Band) reflectance along the transect line was obtained using a geographic information system application (QGIS).

The profile of reflectance along the transect line shows that the reflectance was mostly constant in the white region, while it largely varied in the dark region. Based on the reflectance, the dark region was further divided into three areas: dark stripe, white stripe, and intermediate-stripe. The comparison of the reflectance profiles among the three images in July and August revealed that there was little change in reflectance in the white region while there was a significant change of reflectance in the dark region in mid-July. In the dark region, the reflectance of intermediate-stripe particularly decreased but those of dark and white stripes decreased slightly. Results show that the change in reflectance of the bare ice surface varies from area to area: the reflectance did not change in the white region, changed slightly in the dark and white stripes, and changed significantly in the intermediate-stripes in the dark region during the melting season. The reason for the significant decrease in reflectance in the intermediate-stripe may be due to the growth of microbes such as glacier algae promoted by more abundant nutrient supply from the ablating ice, and/or to the surface ice structure that aggregate surface impurities on the bare ice surface.

Temporal variations of radiant fluxes and surface energy balance from 2012 to 2020 at the SIGMA-B site on Qaanaaq Ice Cap, northwestern Greenland

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Mass loss in the low-elevation coastal ice cap is significantly higher than in the inland ice cap in the warming climate[1]. It is especially important to quantitatively verify a long-term variation of climate conditions and surface mass balance near the equilibrium line. Here, we investigated the interannual variation of surface energy balance and surface melting rate at the SIGMA-B site (77.518° N, 69.062° W; 944 m a.s.l.) to understand the present condition of the snow/ice surface and its accumulation/ablation process based on the ground meteorological observation data obtained over several years at the site.

We have observed the following meteorological elements; air temperature, relative humidity, wind direction, wind speed, atmospheric pressure, upward/downward shortwave and longwave radiations, and snow depth observed by an automatic weather station at the SIGMA-B site on the Qaanaaq ice cap located in northwest Greenland. Data from July 2012 to August 2020 were used for the analysis in this study. The surface energy balance was calculated using Eq. (1), including the following energy components: net shortwave radiation ($SW_{net} = (1-\alpha)SW_d$), net longwave radiation ($LW_{net} = \varepsilon LW_d - \varepsilon\sigma T_s{}^4$), sensible heat flux ($H$), latent heat flux ($\iota E$), sensible heat flux by rainfall (Q_R), subsurface heat flux (Q_S), and energy used for melting (Q_M). Turbulent energy fluxes (H and ιE) were calculated using the aerodynamic bulk method, and Q_S was calculated by the polar regional climate model NHM-SMAP[2]. The melting amount was calculated using Q_M. Radiant flux absorbed by the snow surface (R) is defined as a total of SW_{net} and downward longwave radiation absorbed by snow (εLW_d). This study defined the direction of energy transport to the snow/ice surface as positive.

$$Q_S + Q_M = (1-\alpha)SW_d + \varepsilon LW_d - \varepsilon\sigma T_s{}^4 + H + \iota E + Q_R, \quad (1)$$

The amounts of surface melting in 2014/15, 2018/19, and 2019/20 were large; 919, 968, and 887 [mm w.e.], respectively, which were more than 1.4 times higher than the observation period average. The year with the largest summer means SW_{net} was 2019/20 (85.4 W m^{-2}), followed by 2014/15 (84.3 W m^{-2}). On the other hand, the year with the largest summer means εLW_d and R were 2018/19 (εLW_d: 271.4, R: 347.1 W m^{-2}). Because downward longwave radiation increases under overcast conditions due to the additional black body radiation from cloud-cover, the snow surface was also possibly heated by a large amount of R, with relatively more cloudy conditions continued in the 2018/19 summer than in the other two summers. Considering the largest surface melting occurred in the 2018/19 summer, not only the contribution of shortwave radiation from clear skies but also that of longwave radiation is important for surface melting.

References

[1] Noël, B. et al. (2017) *Nat. Comm.*, 8 (14730).

[2] Niwano, M. et al (2018). *Cryosphere*, 12(2), 635–655.

R4-P07

Mass balance and surface elevation change of Qaanaaq Ice Cap in northwestern Greenland from 2012 to 2022

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Peripheral glaciers and ice caps in Greenland contribute to 13 % of the global glacier mass loss from 2000 to 2019 [1]. Despite the importance of these glaciers and ice caps, in-situ glaciological studies are sparse particularly in northern Greenland. To fill the gap in data, we have conducted surface mass balance and surface elevation measurements on Qaanaaq Glacier, an outlet glacier of Qaanaaq Ice Cap in northwestern Greenland (Figure 1a) [2]. Annual surface mass balance was measured from 2012 to 2022 at six locations (243 to 968 m a.s.l.), whereas the surface elevation was surveyed in 2012, 2019 and 2022 with a global positioning system along the central flowline of the glacier (Figure 1b). The cumulative specific mass balance from 2012 to 2022 averaged over the ice cap was −4.02 ± 0.22 m w.e. The most negative specific mean mass balance was observed in 2014/15 (−1.08 ± 0.04 m w.e. a^{-1}), which we attribute to relatively high summer temperature (positive degree day sum of 208 °C d) in 2015 and a small amount of snow accumulation during the winter of 2014/15 (0.27 ± 0.11 m w.e. a^{-1}). The glacier surface elevation dropped with a rate greater in 2019–2022 (−0.87 m a^{-1}) than in the earlier period of 2012–2019 (−0.61 m a^{-1}). Our results showed that glaciers and ice caps in the Qaanaaq region are rapidly losing mass over the last decade and its rate has increased over the last three years.

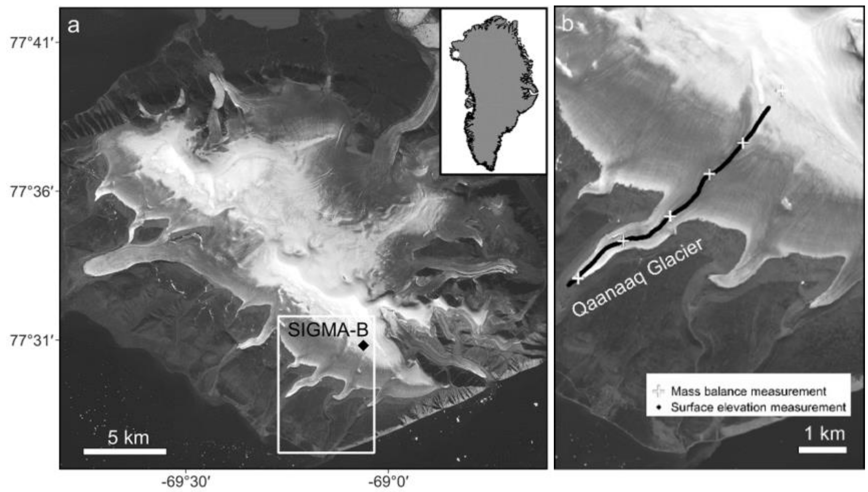

Figure 1. (a) Satellite image of Qaanaaq Ice Cap (Landsat 8, 25 July 2020). The box indicates the area shown in (b). The location of the weather station (SIGMA-B) [3] is indicated by ◆. (b) Satellite image of Qaanaaq Glacier. The mass balance observation sites are indicated by +, and the surface elevation was measured along the black line.

References

[1] IPCC, Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change, *Cambridge University Press*, In Press (2021)
[2] Sugiyama et al., Initial field observation on Qaanaaq ice cap, northwestern Greenland, *Annals of Glaciology*, **55**(66), 25–33 (2014)
[3] Aoki et al., Field activities of the “snow impurity and glacial microbe effects on abrupt warming in the Arctic” (SIGMA) project in Greenland in 2011–2013, *Bulletin of Glaciological Research*, **32**, 3–20 (2014)

Meltwater discharge from Qaanaaq Glacier in the summer 2022

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Under the influence of air temperature rise in the Arctic, glacial meltwater discharge has been increasing in Greenland. An unprecedented amount of discharge caused flooding, which resulted in damages of infrastructures in the coastal settlements in Greenland. For example, floods occurred in 2015 and 2016 at an outlet stream of Qaanaaq Glacier in northwestern Greenland. This event destroyed road connecting a village and airport, demonstrating the serious impact of climate change on society in the Arctic. After the flood events, we began measurements of the stream discharge to investigate a link between recent climate change and the flooding. Based on the measurements from 2017 to 2019, we performed a glacier runoff model and demonstrated that the floods were caused by the intensive melt of the glacier in 2015, whereas by a heavy rain event in 2016(Kondo et al., 2021). In the summer 2022, the stream from Qaanaaq Glacier flooded again on 17 July, highlighting the need for further research in the region. With this background, we performed discharge and glacier melt measurements in the summer 2022. Discharge from Qaanaaq Glacier was measured at 2.0 km from the glacier from 20 July to 26 August (Fig. 1). Water level of the stream was recorded every 10 min with a pressure sensor (HOBO U20-001-04) fixed within the water in the stream. To quantify the discharge, water current was measured with an electromagnetic current meter (YOKOGAWA ES-7603). The discharge measurements were repeated 31 times during the study period, so that observed water level variations were converted to discharge time series by using an empirical relationship between water level and discharge. Meteorological data were obtained from Qaanaaq Airport located at 16 m a.s.l. (Fig. 1). During the observation period, the discharge varied within a range from 0.21 to 2.72 $m^3 s^{-1}$ (Fig. 2). The lowest discharge was observed on 22 August when the daily mean air temperature dropped to 3.9 °C (Fig. 2). On 17 July, the day of the flood event, air temperature increased to 11 °C. This is the highest daily mean temperature during the summer 2022, suggesting the flood event was likely due to intensive glacier melt. Glacier runoff model is planned to investigate the processes driven the flood 2022.

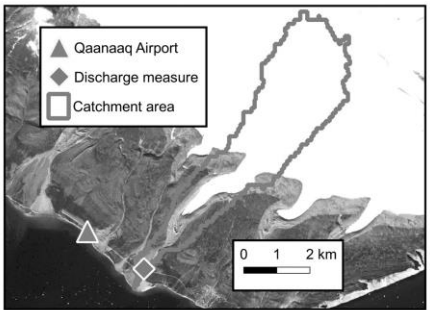

Figure 1. Sentinel-2 image of the study site on 9 September 2022

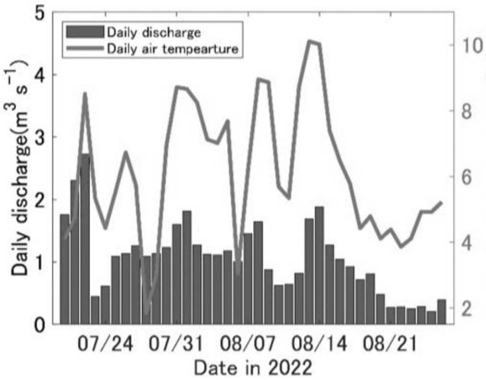

Figure 2. Daily discharge of the stream from Qaanaaq Glacier (left) and daily mean temperature at Qaanaaq Airport (right)

References

[1] Kondo K, Sugiyama S, Sakakibara D, Fukumoto S, Flood events caused by discharge from Qaanaaq Glacier, northwestern Greenland, *Journal of Glaciology* **67**(2021)

Drone survey for precise DEM construction and supraglacial stream mapping on Qaanaaq Glacier, northwestern Greenland

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Greenland is currently affected by the rapidly warming climate in the Arctic, which causes melt increase and retreat of glaciers situated along the coast. To better understand the processes driving the glacier change, we have been studying Qaanaaq Ice Cap in northwestern Greenland since 2012. As a part of the field campaign in the summer of 2022, we conducted drone observations over Qaanaaq Glacier, an outlet glacier of the ice cap. The survey took place for seven days between July 14 and August 11. A drone (DJI phantom4pro V2.0) was operated at 120 m above the glacier to take images with a resolution of 33 mm per pixel. Six painted wooden plates were distributed around the glacier, which were surveyed with kinematic GNSS positioning to improve the accuracy of the drone survey. Repeated surveys were carried out at an elevation of 720 m a.s.l. over an area of 9.14×10^5 m^2 (Figure 1) to monitor changing glacier surface features. 677 images were acquired during each of six surveys. The images clearly indicate the evolution of supraglacial streams, which are considered to be important for ice melt as well as glacier hydrology. The images were processed with software (Agisoft Metashape) to generate an orthorectified mosaic image and construct a DEM. By differing DEMs from July 26 to August 10, surface elevation change over a 15-day period was investigated (Figure 2). Relatively large changes up to ~2.9m were observed at the glacier/bedrock interface and along a supraglacial stream. The DEM will be compared with surface elevation data previously obtained by in-situ GPS survey and satellite remote sensing to quantify the mass loss of the glacier over the last decades.

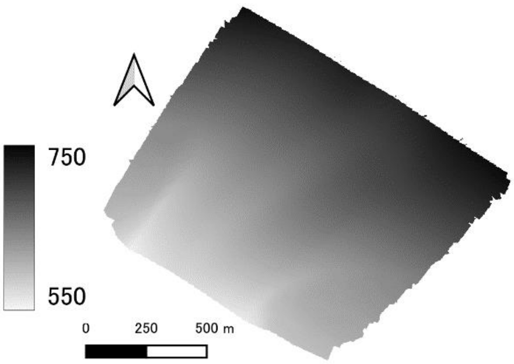

Figure1.DEM of Qaanaaq Glacier on August 10 constructed from the drone survey.

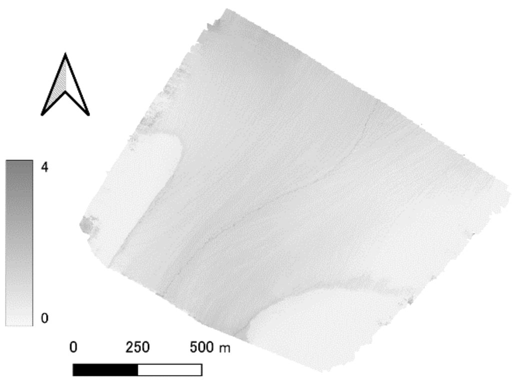

Figure 1.Difference between DEMs on July 26 and August 10.

Ground penetrating radar survey on Qaanaaq Glacier in northwestern Greenland

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To monitor the changes in peripheral glaciers and ice caps in Greenland, we have been running field observations on Qaanaaq Ice Cap in northwestern Greenland (77º28' N, 69º14' W) since 2012 now under the ArCS II project (2020–2025). Qaanaaq Ice Cap has an area of 289 km^2 with an elevation range of 30–1110 m. In the summer 2022 (18th July–12th August), we performed a GPR (ground penetrating radar) survey on Qaanaaq Glacier, an outlet glacier of the ice cap (Figure 1). The GPR measurement was performed using a GPR system (SIR-4000, 3200 MFL) manufactured by GSSI, Inc. The system consists of a controller, transmitter, receiver and 2.4 m long antennae. The central frequency of the radar wave was 40 MHz. In the survey, reflection waves received within a time range of up to 2700 ns were recorded, which corresponds to an ice depth up to 226 m given a wave propagation velocity in the glacier of 168 m s^{-1}[1]. The measurement was carried out along 14 survey routes, i.e. seven sections perpendicular to the ice flow direction, one long section passing six mass balance stakes and four additional sections along the side margins of the glacier (Figure 1). The total length of the survey routes was 21.1 km.

Figure 2 shows the reflection image obtained along the uppermost transverse section (Figure 1). The maximum depth measured along the section was 155 m. A clear v-shaped depression was observed on the bed at 1000 m from the eastern margin of the survey section (Figure 2). Results obtained at other transverse profiles suggested that this depression continues downstream. At about 800 m from the eastern margin, strong reflections were recorded within the glacier from the surface to the bed (Figure 2). Based on our in-situ observation on the glacier, we attribute these englacial reflections to meltwater in a crevasse.

The GPR data provided information (ice thickness, bed geometry and englacial structures) which are important to study physical processes of the glacier as well as to quantify the ice volume. We plan further analysis of the data to understand the englacial and basal hydrology in polythermal glaciers in the Arctic.

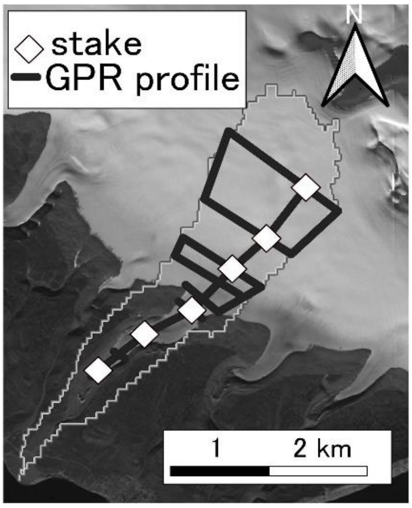

Figure 1. GPR survey routes and mass balance stake locations on Qaanaaq Glacier.

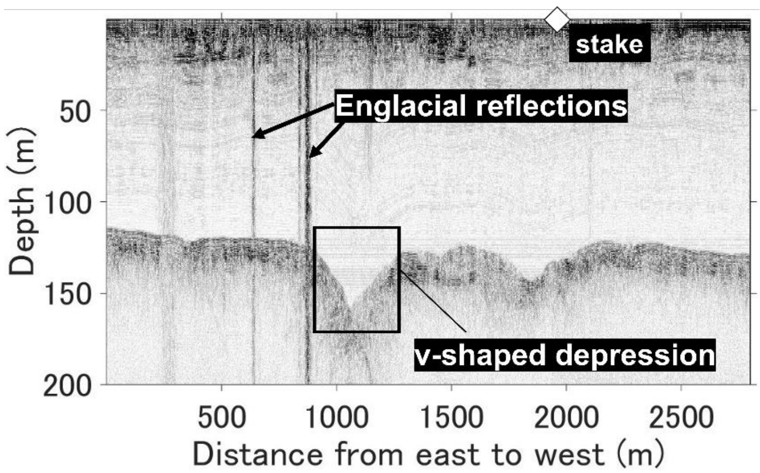

Figure 2. GPR profile along the section 1 in Figure 1.

References

[1] S. Sugiyama, D. Sakakibara, S. Matsuno, S. Yamaguchi, S. Matoba and T. Aoki, Initial field observations on Qaanaaq ice cap, northwestern Greenland, *Annals of Glaciology,* **55(66), 25-33** (2014)

The prevalence of chytrid infection of glacier algae on a glacier in Alaska

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There are diverse microbes on snow and ice of glaciers worldwide. Snow and glacier algae, which are photosynthetic microbes, grow on glaciers and often have dark-colored pigments in their cells. Blooming of such algae can darken the surface of glaciers and can accelerate their melting. Therefore, it is important to understand population dynamics of algae to evaluate their contribution of darkening of the glacier surface. Snow and glacier algae are often observed to be infected with chytrid fungus (Figure 1). Chytrids are a group of fungi which produce zoospores having flagellum. Parasitic chytrids are known to have a great impact on aquatic ecosystems, controlling population dynamics of host species and sometimes causing host extinction (Kagami et al., 2006). However, the impacts of parasitic chytrids on snow and glacier algae and glacial ecosystems are still unclear. This study aims to describe morphology and distribution of chytrids, and the prevalence of chytrid infection of algal cells in various habitats (snow and ice surfaces and cryoconite holes) on Gulkana Glacier in Alaska, USA.

Microscopic observation revealed there were mainly five morphological types of chytrids infecting the algal cells of *Ancylonema nordensholdii*, *Ancylonema alaskana*, *Chloromonas* sp., and *Sanguina* sp. on this glacier. The type of chytrids was distinctive among the algal species, indicating that each type of chytrid can infect specific algal species. The prevalence of chytrid infection varied among the different types of habitats on the glacier. It was significantly higher in cryoconite holes than on the ice surface. This is probably due to static environment of melt water in cryoconite holes, which allow the chytrid zoospores actively moving and finding the host in the water. These results indicate that chytrid infection possibly control the population of all algal species causing glacier darkening and changes of the dynamics of cryoconite holes may affect the prevalence of chytrid infection on the surface of glaciers.

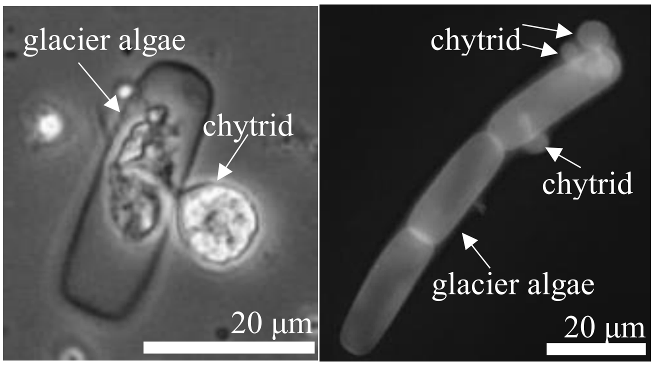

Figure 1. Chytrids infecting glacier algal cells.

References
[1] M. Kagami, T. B. Gurung, T. Yoshida and J. Urabe, To sink or to be lysed: Contrasting fate of two large phytoplankton species in Lake Biwa, Limnology and Oceanography 51, 2775-2786 (2006)

R4-P12

Dating and insoluble particle analysis of a shallow ice core drilled at EGRIP, Greenland

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Temporal variations in concentration and size distribution of mineral dust on the Greenland ice sheet are related to temporal variations in ground surface conditions on their source regions. For example, decreasing snow-covered areas on the Greenland coast due to warming can increase soil areas and mineral dust emissions on the coast, thus increase mineral dust fluxes and concentrations on the Greenland ice sheet. Mineral dust originated from distant source regions (e.g., Asian arid regions) is dominated by fine particles, while that from the Greenland coastal regions contains coarse particles. Thus, the size distribution of mineral dust deposited on the ice sheet can be used to evaluate their source regions. We analyzed a shallow ice core drilled at the East Greenland Ice Core Project (EGRIP) site to estimate past temporal variations in ground surface conditions of the source regions of mineral dust. In this study, we will report the results of the dating and insoluble particle analysis of the ice core.

The ice core was analyzed using a continuous-flow analysis (CFA) system at NIPR. Stable water isotope ratios ($\delta^{18}O$ and δD) and elemental concentrations (Na, Mg, Al, Si, S, K, Ca, and Fe) were measured by a water isotope analyzer (Piccaro, L2130-i) and an ICP-MS (Agilent technologies, 7700), respectively. For insoluble particle analyses, a portion of meltwater was collected using a fraction collector at a depth interval of 0.12 m. Concentrations and size distributions (0.6–18 μm) of insoluble particles in the collected samples were measured by a Coulter counter (Beckman Coulter, Multisizer 4e). Additionally, for tritium measurements, ice core samples at depths of 13–15 m were cut and melted. Tritium measurements of the samples were conducted using a scintillation counter (ParkinElmer, Quantulus 1220).

Depth profiles of $\delta^{18}O$ and δD did not show seasonal variations at depths deeper than 7 m. This result is consistent with a previous ice core study at EGRIP [1]. Na and Ca concentrations showed clear seasonal variations at all depths. Therefore, we dated this ice core by annual layer counting. A tritium peak was found at a depth of 14.1 m, thus we regarded this depth as year 1963. Sulphur showed high peaks at depths of 23.3 m, 39.8 m, 44.7 m, 83.7 m, and 105.5 m. We assumed those peaks to be the signatures of Katmai (1912), Tambora (1815), Laki (1783), Kuwae (1458), and Samalas (1257) eruptions. Based on those results, we estimated that the ice core covers about the past 1000 years. In presentation, we will also report results of insoluble particle analysis.

References

[1] P. Vallelonga et al., Initial results from geophysical surveys and shallow coring of the Northeast Greenland Ice Stream (NEGIS), *The Cryosphere* **8** (2014)

R4-P13

Variations in mineralogy of dust in ice cores obtained from Greenland over the past 100 years

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To reconstruct past variations in the sources and transportation processes of mineral dust in northwestern Greenland, we analyzed the morphology and mineralogical composition of dust in the SIGMA-D ice core (77.64N, 59.12W, 2100 m a.s.l) from 1915 to 2013 using scanning electron microscope (SEM) and energy-dispersive X-ray spectroscopy (EDS). The ice core dust consisted mainly of silicate minerals and that the composition varied substantially on multi-decadal and inter-decadal scales, suggesting that the ice core minerals originated from different geological sources in different periods during the past 100 years. The multi-decadal variation trend differed among mineral types. Kaolinite, which generally formed in warm and humid climatic zones, was abundant in colder periods (1950–2004), whereas mica, chlorite, feldspars, mafic minerals, and quartz, which formed in arid, high-latitude, and local areas, were abundant in warmer periods (1915–1949 and 2005–2013). Comparison to Greenland surface temperature records indicates that multi-decadal variation in the relative abundance of these minerals was likely affected by local temperature changes in Greenland. Trajectory analysis shows that the minerals were transported mainly from its west coast during the two warming periods. This was likely due to an increase in dust sourced from ice-free areas as a result of shorter snow/ice cover duration in the Greenland coastal region during the melt season caused by recent warming. Meanwhile, ancient deposits in northern Canada, which were formed in past warmer climates, seem to be the best candidate during the colder period (1950–2004). Our results suggest that SEM-EDS analysis can detect variations in ice core dust sources during recent periods of low dust concentration [1].

To reveal spatial variation in the sources of minerals on the Greenland ice sheet, we have also analyzed dust from the northeastern Greenland ice core (EGRIP: 75.62N, 35.96W, 2708 m a.s.l) during the past 100 years. The results showed that the particle size, mineral composition, and compositional variations of the EGRIP ice core dust differed significantly from those of the SIGMA-D, indicating that the sources and transport processes of the minerals were different between the two ice cores. The detailed discussion will be presented at the symposium.

References

[1] N. Nagatsuka, K. Goto-Azuma, A. Tsushima, K. Fujita, S. Matoba, Y. Onuma et al., Variations in mineralogy of dust in an ice core obtained from northwestern Greenland over the past 100 years, Clim. Past, **17** (2021)

Abrupt shifts in terrestrial aerosol deposition in Greenland during Dansgaard-Oeschger events 9-13

K. Goto-Azuma[1,2*], N. Moteki[3], J. Ogata[1], K. Fukuda[1], M. Hirabayashi[1], Y. Komuro[1], I. Oyabu[1], K. Kitamura[1], S. Fujita[1, 2], Y. Ogawa-Tsukagawa[1], T. Mori[4], S. Ohata[5], Y. Kondo[1], M. Koike[3], K. Kawamura[1, 2], S. O. Rasmussen[6], D. Dahl-Jensen[6]

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During the last glacial period, Greenland experienced 25 times of abrupt climatic fluctuations, known as Dansgaard-Oeschger (DO) events. High-resolution records of ions and stable isotopes of water from the NGRIP and NEEM ice-cores have revealed the amplitudes, sequences, timings and durations of DO events, and provided the information on changes in terrestrial environments and those in atmospheric and oceanic circulations [1-3]. However, previous studies focused on either limited DO events or limited aerosol species. For better understanding of the mechanisms and impacts of DO events, we investigate DO events 9-13 (depth: 1909.6 - 2084 m) using the continuous high-resolution records of $\delta^{18}O$, δD, microparticles, black carbon (BC), FeO_x, and 8 elements (Na, K, Mg, Ca, Fe, Al, Si and S) obtained from a deep-ice core drilled at EGRIP, North East Greenland. Our preliminary data show that concentrations and sizes of BC, concentrations of microparticles, and concentrations of the 8 elements increased during stadials and decreased during interstadials, suggesting that deposition of marine and terrestrial aerosols onto the Greenland Ice Sheet changed between stadials and interstadials. The composition of mineral dust also changed accompanying the changes in concentrations, suggesting changes in dust sources.

References

[1] J. P. Steffensen et al., High-resolution Greenland ice core data show abrupt climate change happens in few years, Science, 321 (2008)
[2] E. R. Thomas et al., Anatomy of a Dansgaard-Oeschger warming transition: High-resolution analysis of the North Greenland Ice Core Project ice core, J. Geophys. Res., 114 (2009)
[3] T. Erhardt et al., Decadal-scale progression of the onset of Dansgaard–Oeschger warming events, Clim. Past, 15 (2019)

Atmospheric CH_4 concentration during the Holocene reconstructed from the NEEM (Greenland) and Dome Fuji (East Antarctica) ice cores

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Methane (CH_4) is an important greenhouse gas, whose atmospheric concentration has been increasing due to human activities for the last few centuries. Orbital-scale variations of atmospheric CH_4 correlate with climatic precession, because the size of wetlands and their CH_4 production rate respond to Northern Hemisphere (NH) summer insolation, through the variations in temperature and rainfall on NH landmasses. The signs of temporal trends of CH_4 concentration and NH summer insolation broadly agree with each other for the last three interglacial periods and the first half of the Holocene, but they are opposite for the latter half of the Holocene (decreasing insolation and increasing CH_4). Several hypotheses have been proposed for this divergence of trends, including those proposing early anthropogenic sources or natural Southern Hemisphere sources. Inter-polar difference (IPD) of CH_4 concentrations may provide constraints on the latitudinal CH_4 source distribution and its relationship with climate. For precise reconstruction of IPD, time resolution and analytical precision of CH4 data are important. Here, we show the CH_4 concentrations in the NEEM (Greenland) and Dome Fuji (Antarctica) ice cores with high precision (reproducibility is ~±3 ppb), and the CH_4 IPD during the Holocene to discuss the possible causes for the Holocene CH_4 variations.

Characterization and discrimination of tundra plant leaves by Attenuated Total Reflection Fourier Transform Infrared spectroscopy

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The chemical property of leaves is an indispensable aspect of functional trait of tundra plants as it represents the biochemical features explaining not only their response to environmental change but also their effects on ecosystem function. Understanding chemical properties of leaves is thus crucial for the understanding of arctic terrestrial ecosystems, where plant growth is strongly limited by such environmental factors as low temperature, low moisture, low nutrient availability, and a short growing season. The attenuated total reflection Fourier transform infrared (ATR-FTIR) spectroscopy is a powerful tool of investigating functional traits of plants, but its applicability to tundra plant leaves was yet to be addressed. The present study aimed at applying the ATR-FTIR measurement to characterize biochemical fingerprint of tundra plant leaves and to discriminate it between plant species. We used a total of 50 samples each for live and dead leaves from 14 plant species of shrubs, forbs, graminoids, and mosses collected in the proglacial field near Oobloyah Bay, Ellesmere Island, Nunavut, Canada [1]. The ATR-FTIR measurement allows complex assemblages of organic constituents to be displayed as distinctive spectral features in the mid infrared range (4000-400 cm^{-1}). The ATR-FTIR spectra in the fingerprint region of live and dead leaves from 14 tundra plant species showed a variability in overall appearance between plant species and a degree of similarity between live and dead leaves of the same plant species. At least 16 peaks were obvious in the spectra of live and dead leaves of 14 plant species. Of these, four highest peaks were found between 1575 and 1637 cm^{-1}, 1406 and 1452 cm-1, 1313 and 1325 cm^{-1}, and 1022 and 1058 cm^{-1} and are attributed to chemical features of lignin, cellulose, and/or oxalate. The overall spectra in the fingerprint region were significantly different between plant species both for live and dead leaves (PERMANOVA, d.f. =13, $P<0.001$). Cluster and principal component analyses showed that leaves of *Oxyria digyna* and other forbs had distinctive spectral characteristics attributable to the content of oxalate and other putative compounds. The spectra of shrubs had greater values of relative height at 1575 and 1637 cm^{-1} and 1406 and 1452 cm^{-1} than those of graminoids and mosses. This difference is due to the fact that contents of lignin relative to cellulose were generally greater in shrubs than in graminoids and mosses. In conclusion, the ATR-FTIR spectroscopy can detect a suite of organic components that characterize live and dead leaves of tundra plant species. Such spectral measurements can be used as a tool to describe functional traits of plants [2].

References

[1] Osono, T., Mori, A., Uchida, M., Kanda, H., 2006. Chemical property of live and dead leaves of tundra plant species in Oobloyah Valley, Ellesmere Island, high arctic Canada. Mem. Natl. Inst. Polar Res. Spec. Issue 59, 144-155.
[2] Mori, A.S., Osono, T., Cornelissen, H., Craine, J., Uchida, M., 2017. Biodiversity-ecosystem function relationships change through primary succession. Oikos 126, 1637-1649.

Populations and leaf-trait variations of two Labrador-tea species across permafrost gradients in interior Alaska

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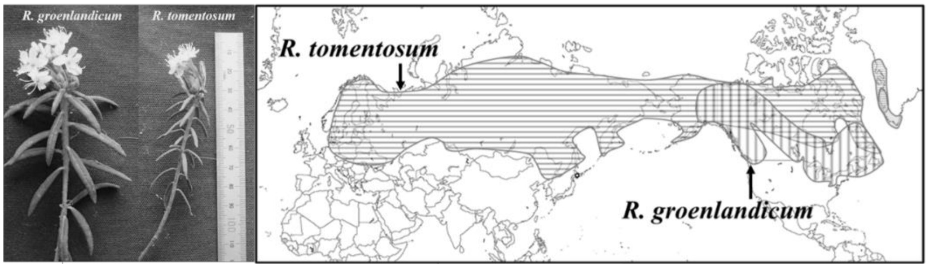
Permafrost is one of the most significant environmental factors determining circumpolar ecosystems, and the influences of permafrost thawing due to recent rapid global warming on circumpolar vegetation have been a concern. However, it has not been examined how understory shrubs that dominate such circumpolar ecosystems adapt to permafrost conditions. We focused on two Labrador-tea species (Ericaceae: *Rhododendron* subsect. *Ledum*) inhabiting a wide range of circumpolar ecosystems: *R. groenlandicum* and *R. tomentosum* (Fig. 1). Their populations, leaf traits, and environmental habitats were examined across two permafrost gradients in discontinuous permafrost regions in interior Alaska. In both species, the numbers of ramets were significantly associated with soil water content and canopy openness rather than active layer depth, but the trends were contrastive. *Rhododendron tomentosum* was more common under lighter wetter permafrost conditions, whereas *R. groenlandicum* was more dominant under darker drier less-permafrost conditions. Compared to *R. groenlandicum, R. tomentosum* had smaller leaves, higher leaf mass per area (LMA), higher leaf dry matter content (LDMC), and higher sapwood area per total shoot leaf area (Huber value) (Fig. 2). This suggested that the leaves of *R. tomentosum* were more conservative than those of *R. groenlandicum*. As for the intraspecies variations, both species had more conservative leaves in the sites under greater permafrost influences. Therefore, habitat segregation due to permafrost may occur between the two Labrador-tea species in the discontinuous regions in interior Alaska, and more conservative leaves can be adaptive under the permafrost conditions.



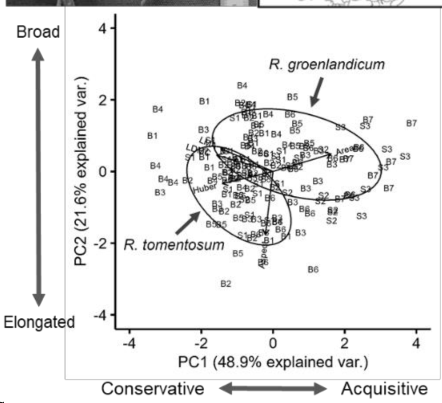


Figure 1 (upper): Typical shoots and distributions of *R. groenlandicum* and *R. tomentosum* (based on [1]).

Figure 2 (left): Principal component analysis of leaf traits in the two species.

References
[1] Hultén E. Flora of Alaska and neighboring territories: a manual of the vascular plants. Stanford University Press (1968)

Methane emission from tree stems in interior Alaska

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Methane (CH_4) is a greenhouse gas and wetland is a major source of CH_4. To estimate CH_4 dynamics in terrestrial ecosystems, CH_4 flux has been measured near the land surface in various ecosystems. Recently, it is reported that CH_4 in wetland soil is emitted from tree stem and the amount of CH_4 emission is not small compared with CH_4 emission from the soil. However, most of all studies are conducted in temperate and tropical region. The purpose of this study is to evaluate the seasonal changes and the amount of CH_4 emission from boreal trees, such as black spruce, white spruce, and birch in interior Alaska. The study was conducted on a north-facing slope (CS) and the bottom of the slope (CB) in the Caribou Poker Creek Research Watershed (65°14'N, 147°49' W) of the University of Alaska Fairbanks (UAF), and a riparian forest (SL) surrounding Smith Lake in UAF. Each three black spruces and birches at CS, six black spruces at CB, and each tree black spruces, white spruces and birches at SL were selected for measuring stem CH_4 fluxes. Box stainless steel chambers (H 15cm, W 7cm, D 7cm) or plastic chamber surrounding the stems (L 10cm, 15cm in diameter) were put on the bottom of each tree stem. The CH_4 flux was measured in every month from May to September with soil temperature, moisture, and soil CH_4 flux. To determine the CH_4 flux, a 40-mL gas sample was collected from the chamber into a 30-mL vacuum glass bottle sealed with a butyl rubber stopper and plastic cap at 0, 20, 40 and 60 min after the lid was closed. The CH_4 concentration in the bottles was determined using a gas chromatograph in Japan, and after that, the flux was calculated. The stem CH_4 flux was negligible small at CS, and small amount of CH_4 emission was observed at CB and SL. The seasonal changes of CH_4 emission was not clear, but the highest emission from the spruce at CB and SL was observed in July or August. The CH_4 emission rate in this studies were smaller than those reported temperate and tropical region. At CS, the CH_4 uptake into the soil was observed, but CH_4 emission was observed at CB and SL. Therefore, it is considered that the source of CH_4 emitted from the stem is mainly derived from soil. The CH_4 emission from black spruce was the highest at SL among the three sites due to high water table. Thus, CH_4 production in the soil and water table in summer time are important factor of stem CH_4 emissions.

Total carbon and nitrogen stocks of the degrading Ice Complex permafrost at Yukechi, central Yakutia

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The studies of total carbon (C) and nitrogen, both their organic and inorganic species, were conducted at the Yukechi Ice Complex study site, central Yakutia, at depths down to 2.5 m. In the soil profile, three distinct layers were observed : the active layer, from the surface down to 1.2 m, the protective (shielding) layer, from 1.2 m to 2.0 m, and permafrost below 2.0 m (Table 1). Total stock of biogenic elements in the investigated Ice Complex section is 40.8 kg m^{-2}, of which 38.7 ± 0.2 kg m^{-2} of total carbon (TC), and 2.13 ± 0.01 kg m^{-2} of total nitrogen (TN). The active layer holds about 53% of the TC stock, and about 58% of TN stock, are held in the active layer; the shielding layer holds 31% TC stock and 25% TN stock. Below the shielding layer, permafrost between 2.0 and 2.5 m holds 16% TC stock and 17% TN stock. The prevalent species in TC stock is carbon detritus, 40% of the TC content in the active layer, and labile carbon accounts for 18%. The low content of labile organic matter in the shielding layer and upper permafrost indicates the accumulation of Ice Complex deposits proceeded with poorly decomposed organic material (Table 1).

Table 1. Total carbon (TC) and nitrogen (TN) stocks on the Yukechi Ice Complex soils

Layer (cm)	Stocks (kg m^{-2})		Content (%)		C/N
	TC	TN	TC	TN	
A	2	1	3	0	21
S	1	0	1	0	20
P	6	0	1	0	20
T	38.7	2.13	1.7	0.1	20

Carbon-to-nitrogen ratio, which is an indicator of the humus enrichment with nitrogen, is 21 in the active layer and descends by one point in the lower layers. This indicates soils depleted in nitrogen, and indirectly implies a low mineralization degree of the organic matter in studied permafrost soils. High carbon and low nitrogen content of the soil contributes to the weak microbial decomposition of incoming and conserved organic material. This is due to an inhibited ammonification in nitrogen-poor boreal environments. During short summer, only minor part of the organic matter decomposes into carbon dioxide, water and mineral salts. As a result, a layer of weakly decomposed plant and animal remains accumulates on the soil surface, forming an organogenic horizon.

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Lagging Effect of Stem Respiration on Temperature in Sub-Arctic Species, Interiro Alaska

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Boreal forests account for roughly one third of the carbon sequestered in terrestrial ecosystems, and the high-latitude boreal ecosystem they make up has been consequently vulnerable to recent climate change. This study investigated stem CO_2 emissions of Alaska paper birch, balsam poplar, white spruce, and black spruce in the mixed boreal forest stands of interior Alaska. Stem CO_2 emissions, temperatures of air and soil, and PAR (photosynthetically active radiation) displayed explicit diurnal variations during the observation period. Simulated stem CO_2 emission, normalized to air temperature, elucidated >61 % of measured stem CO_2 emission for the four stands. Temperature is an important driver in regulating stem CO_2 emissions measured in these four species, further suggesting temperature dependency. And responses from stem CO_2 emission to temperature and PAR are associated with the thickness of their tree bark, reflecting different lag times of 0.0-3.5 hours for temperature and 4.5-7.5 hours for PAR. This reveals that stem CO_2 emissions depended on temperature and PAR, which may represent the difference in heat transfer to the stem from the thickness of the bark. Just after observations of the four stands, stem CO_2 emissions of four different-aged black spruce stands were also monitored, and seasonal variations in stem CO_2 emissions and temperature tended to decrease with time during the growing season in Subarctic boreal forest, interior Alaska.

Table 1. Lagged time (hours) for best fit on temperature and PAR for four stands in interior Alaska

Variables	Paper birch	Balsam poplar	White spruce	Blakck spruce
Air temperature	1.5	3.5	3.0	2.0
Stem temperature	1.5	3.5	2.0	1.0
Soil temperture	0.5	1.5	1.5	0.0
PAR	4.5	7.5	6.5	5.5

Interrelationships of CO_2, CH_4, and N_2O fluxes in Snow-Covered Temperate Soils, Northern Japan

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We describe the interrelationships of the concentrations, fluxes, and production rates of CO_2, CH_4, and N_2O in a northern Japanese cold temperate grassland soil underlying snowpack during the winter of 1996/7. Relationships of CO_2-CH_4 fluxes and CO_2-N_2O fluxes through the snowpack showed positively linear correlations, demonstrating that winter CO_2 emissions explained 96% and 77% of the variability of CH_4 oxidations and N_2O emissions, respectively. These findings provide significant information for the modification of local and regional terrestrial ecosystem models in temperate region in assessing the contribution of winter fluxes of greenhouse gases to the annual fluxes. The predicted winter CH_4 oxidation and N_2O emission in Northern Hemisphere (>35°N) correspond to at least 15% and 13% of total CH_4 oxidations in natural soils and N_2O emissions in natural temperate soils, respectively. Also, temporal variations of soil CO_2 and N_2O production rates represent similar trend during the early winter of 1997; however, the variations of these production rates show different patterns after February. Although the soil moisture was not measured in this study, we suggest the possibility that the production rates of CO_2 and N_2O in soil underlying the snowpack significantly depend on soil oxygen content, which is also highly affected by environmental conditions (i.e., ambient and soil temperatures, snow depth deposited, and snow-melting water). After a heavy snowfall of more than 30 cm during the middle of February 1997, the soil temperature suddenly rose above the freezing point (see Figure 3, Kim and Tanaka, 2002). The increase of downward snow melting water to the soil that resulted from the insulation effect by the heavy snow accumulation may have influenced the higher N_2O production rates after February.

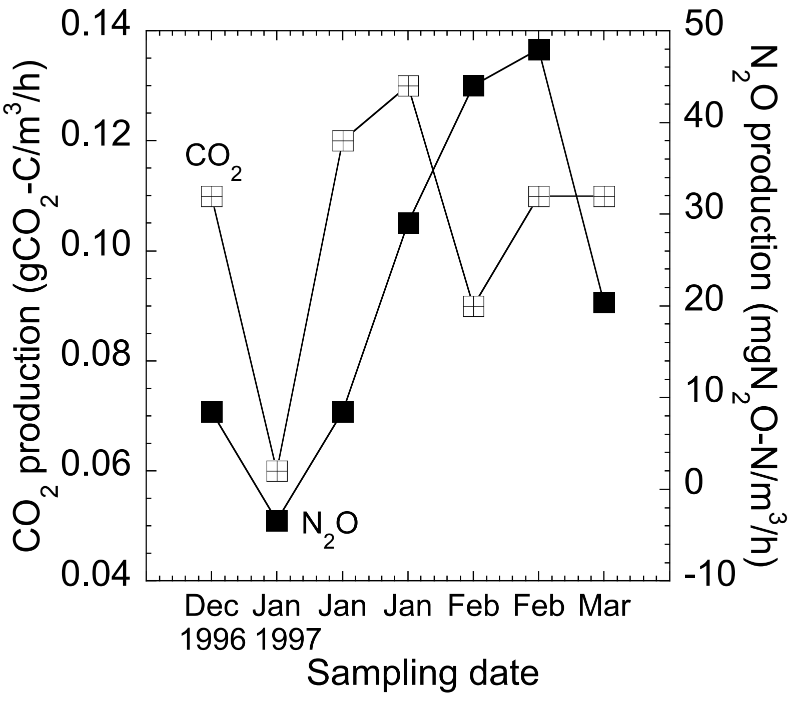

Figure 1. Production rates of CO_2 and N_2O

Methane observations at the terminus of glaciers in Alaska

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Methane, even a small amount, has a high greenhouse effect on the atmosphere. The main source of methane emissions is thought to be wetlands, Ruminates, rice paddies, frozen ground, and so on. Although glacier areas have not been considered as a source, large amounts of methane release have recently been observed at glacier terminus in Greenland and Iceland, associated with methane-saturated meltwater runoff (Burns et al., 2018; Lamarche-Gagnon et al., 2019). A similar amount of methane released from mountain glacier terminuses in the world could make a greater impact on atmospheric methane concentrations than previously thought. In this study, Field observations were conducted to investigate methane emissions from a small mountain glacier area.

The study area is four glaciers in Alaska. Observations were conducted at the terminus of the glaciers in 2019, 2021, and 2022. Methane concentration in the atmosphere was measured by the chamber method (Morishita et al., 2015) and a portable gas analyzer G4301 (Picarro, Inc.). Also, dissolved methane concentration in the discharge water was measured with the headspace method. In addition, water quality was measured for discharge water.

Measurements at the ground surface in 2019 (Konya et al., 2022) showed that the concentrations were similar to those in the atmosphere. On the other hand, some of the measuring points showed higher concentrations than in the atmosphere in 2021-2022, which suggests the emission of methane at the glacier terminus.

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References

[1] Burns, R., Wynn, P. M., Barker, P., McNamara, N., Oakley, S., Ostle, N., Stooo, A. W., Tuffen, H., Zhou, Tweed, F., S., Chesler, A., Stuart, M., Direct isotopic evidence of biogenic methane production and efflux from beneath a temperate glacier, *Scientific reports*, **8** (2018)

[2] Konya K., Iwahana, G., Sueyoshi, T., Morishita, T., Abe, T., Methane flux around the Gulkana Glacier terminus, Alaska summer 2019, *Polar Data Journal* **6** (2022).

[3] Lamarche-Gagnon, G., Wadham, J.L., Sherwood Lollar, B., Arndt, S., Fietzek, P., Beaton, A., D., Tedstone, A., J., Telling, J., Bagshaw, E., A., Hawkings, J., R., Kohler, T., J., Zarsky, J., D., Mowlem, M., C., Anesio1, A., M., Stibal, M., Greenland melt drives continuous export of methane from the ice-sheet bed, *Nature* **565** (2019).

[4] Morishita, T., Noguchi, K., Kim, Y., Matsuura, Y., CO2, CH4 and N2O fluxes of upland black spruce (Picea mariana) forest soils after forest fires of different intensity in interior Alaska. *Soil science and plant nutrition* **61** (2015).

R5-S8-P08

Winter Soil Temperature and Growing Season Net CO_2 Exchange in Eastern Siberian Larch Forests

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Winter temperature variation in the high northern latitudes likely affects ecosystem CO_2 exchange in the subsequent growing season. Changes in the winter soil freezing process can alter soil CO_2 efflux in the warm season via the activity of soil carbon decomposer and below- and above-ground plant productivity [1]. To explore how the soil freezing process affects CO_2 exchange in the subsequent growing season in permafrost boreal forests, we analyzed forest-atmosphere CO_2 exchange data observed by the eddy covariance method. We used CO_2 flux data obtained at two larch-dominated forests mixed with birch and willow in the middle of the Lena basin, eastern Siberia. The lag correlation of monthly mean CO_2 flux and meteorological variables showed that the spring CO_2 fluxes in May significantly correlated with air temperature in April and May, before and during photosynthesis onsets. The spring CO_2 flux was also correlated with the start date of net CO_2 uptake. Namely, when the start date of net CO_2 uptake was early, the cumulative CO_2 uptake (net ecosystem production; NEP) in the spring was large. Additionally, summer gross primary production (GPP) positively correlated with the soil temperature of the preceding winter and soil water content before the soil freezing. We thus concluded that winter soil (not air) temperature affects ecosystem CO_2 fluxes in the subsequent growing season (especially summer rather than spring) via the soil freezing process. Because soil water content before the soil freezing affects winter soil temperature via the release of latent heat during freezing, the period when the soil temperature is nearly constant around 0 °C (zero-curtain period) becomes longer in the wetter soil condition. Indeed, one of the studied forests experienced highly wet soil conditions in the second half of the 2000s [2], and the zero-curtain period of the forest soil became more prolonged than before. We further need to disentangle how interannual CO_2 exchange in permafrost boreal forests interacts with active layer soil conditions.

References

[1] J.L. Campbell, H. Laudon, Carbon response to changing winter condition in northern regions: current understanding and emerging research needs, *Environ. Rev.* **27** (2019)
[2] T. Ohta, et al., Effects of waterlogging on water and carbon dioxide fluxes and environmental variables in a Siberian larch forest, 1998–2011, *Agric. For. Meteorol.* **188** (2014)

R5-S8-P09

Temporal and spatial patterns of remote sensing reflectance of understory vegetation in a sparse black spruce in interior Alaska

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The increasing trend in temperature over the past decade in Arctic-Boreal regions is two times higher than that in the whole northern hemisphere. In this regions, there is still big knowledge gaps in the understanding of how boreal forests respond to abrupt warming and alter the greenhouse gas flux exchanges. The majority of boreal forests in interior Alaska, underlain by permafrost, is covered with sporadic black spruce stands, where understory plants significantly contribute to NEP. Airborne and satellite remote sensing helps to understand the seasonal and spatial variations in understory plants, however, due to the limited ground accessibly, little are known about the precise spectral patterns of typical understory landscapes, where moss, lichen, shrubs are coexisted. In this study, we measured spectral reflectance data from various understory plant communities in a black spruce forest in interior Alaska and investigated how seasonal and spatial patterns in reflectance were associated with understory plant communities. The results shows the seasonal patterns in reflectance and NDVI varied with plant communities. The seasonality is mainly driven by the phenology of shrubs regardless of evergreen or deciduous. We also analyzed ground-based data as match-up information to compare with remote sensing data (e.g. AVIRIS-NG) and distribution of ground surface displacement from InSAR analyses.

Ecological and physiological features of the process of photosynthesis of Asian white birch (*Betula platyphylla*) in Central Yakutia

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Many works have been devoted to the ecological and physiological features of the process of photosynthesis of woody plants in Siberia. Unfortunately, studies on the photosynthesis of broad-leaved trees, namely, Asian white birch in South Yakutia, have hardly been carried out. There are only data from episodic studies in Central Yakutia in an average productive forest and the results of phytotron studies abroad [1–3].

To fill this gap, we set the following goal: research - the study of the ecological and physiological features of the process of photosynthesis of flat-leaved birch (Bétula platyphýlla) in Central Yakutia.

Field work was carried out from June 7 to August 13, 2018 at the forest scientific station "Elgeeii" of the IBPC SB RAS in South-Eastern Yakutia and from June 4 to September 9, 2021 at the forest scientific station "Spasskaya Pad'" of the IBPC SB RAS located on the left bank of the river Lena, 30 km north of the city of Yakutsk.

To measure carbon dioxide and light curves, an LI-6400 infrared gas analyzer with OS version Open 6.1.4 (LI-COR, USA) and LCi-SD (ADC BioScientific Ltd.) were used to measure the daily course of photosynthesis.

The maximum value of photosynthesis in birch in South-Eastern Yakutia was 31.2 μmol m^{-2} s^{-1} at a CO2 concentration of 1500 ppm, and carbon dioxide saturation is observed in the range from 480 to 700 ppm. In Central Yakutia, the maximum assimilation value is 19.6 μmol m^{-2} s^{-1} at a CO2 concentration of 1500 ppm, carbon dioxide saturation is observed at 500-600 ppm.

The average maximum intensity of photosynthesis in Asian white birch (with PAR equal to 1500 μmol m^{-2} s^{-1}) in South-East Yakutia is 10.2 μmol m^{-2} s^{-1}, the light saturation plateau is reached at 400 μmol m^{-2} s^{-1}. While in Central Yakutia this indicator was 8.2 μmol m^{-2} s^{-1} with PAR equal to 1500 μmol m^{-2} s^{-1}, light saturation starts from 500 μmol m^{-2} s^{-1}.

In South-Eastern Yakutia, the seasonal maximum of birch leaf photosynthesis is observed at the end of the second decade of June, which is in good agreement with the rate of utilization of triose phosphate (TPU) photosynthesis products. In Central Yakutia, the relationship between the seasonal maximum and the rate of utilization of triose phosphate (TPU) photosynthesis products is not observed.

References

1. T. Koike, T. T. Lei, T. Chr. Maximov, R. Tabuchi, K. Takahashi1 and B. I. Ivanov 1996. Comparison of the photosynthetic capacity of Siberian and Japanese birch seedlings grown in elevated CO 2 and temperature. ATree Physiology 16, 381-385.
2. Maximov T.C. [et al.] Gas exchange measurements on some major tree species in Siberian permafrost region in summer. Proc. of Second Symposium. – Sapporo, 1994. – P. 47-51
3. Koike T. [et al.] Photosynthetic characteristics of Dahurian larch, Scotch pine and White birch seedlings native to eastern Siberia raised under elevated CO_2 / Eurasian J. For. Res. – 2000. – Vol. 1. – P. 31-37.

Snow cover impacts greenhouse gas dynamics in subarctic, alpine catchments

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High-latitude environments are disproportionately affected by global warming and are changing more rapidly than any other region of the Earth. Cryospheric changes such as snowpack reduction are known to be strongly coupled with the entire hydrologic cycle. However, relatively little is known about the nexus between snow cover changes and source water contributions and associated biogeochemical cycling in Northern aquatic systems. To better understand the rapid changes occurring in cold region environments, we obtained field- and satellite-derived data from two sub-arctic catchments (one glaciated, one unglaciated) in the north-western corner of the Hardangervidda mountain plateau (South Central Norway). During 2020 and 2021, we sampled and analyzed various water sources including streams, lakes, groundwater, snow and ice for environmental tracers (major ions, stable water isotopes, radon-222) and greenhouse gases (GHG; CO_2, CH_4 and N_2O). Combining the environmental tracer data with a Bayesian end-member mixing modelling approach [1] allowed us to assess which water sources contribute to streams and lakes. Moreover, we used the noble gas radon to assess hyporheic exchange flow and short water residence times [2]. To estimate snow cover anomalies in 2020 and 2021 compared to a five-year mean, we retrieved fractional snow cover durations (fSCDs) from 2016 to 2021 by merging Sentinel-2 and Landsat 8 imagery over the study area and applied a spectral unmixing algorithm [3]. According to the satellite-derived data, 2020 was exceptionally snow-rich, while 2021 was a snow-poor year. Our results show distinct differences in greenhouse gas dynamics between the two years depending on water sources and catchment. This work helps to hone our understanding of the response of water source partitioning and associated biogeochemical cycling to climate change-induced alterations in the snowpack.

References

[1] Popp, A. L., Scheidegger, A., Moeck, C., Brennwald, M. S., and Kipfer, R.: Integrating Bayesian groundwater mixing modeling with on-site helium analysis to identify unknown water sources, Water Resources Research, 55, 10 602–10 615, https://doi.org/10.1029/2019WR025677 (2019)

[2] Popp, A. L., Pardo-Alvarez, A., Schilling, O., Musy, S., Peel, M., Purtschert, R., Hunkeler, D., B. P., and R., K.: A framework for untangling transient groundwater mixing and travel times, Water Resources Research, https://doi.org/10.1029/2020WR028362 (2021)

[3] Aalstad, K., Westermann, S., & Bertino, L.: Evaluating satellite retrieved fractional snow-covered area at a high-Arctic site using terrestrial photography. Remote Sensing of Environment, 239, 111618, https://doi.org/10.1016/j.rse.2019.111618 (2020)

R5-S8-P12

Regional Carbon Cycle Assessment Processes 2 (RECCAP2): CO_2 uptake in the Arctic Ocean

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The Arctic Ocean faces with rapid warming and sea ice retreat, and at present is a net sink for atmospheric CO_2. As a contribution of the Regional Carbon Cycle Assessment Processes 2 (RECCAP2), we present synthesized estimates of the Arctic Ocean CO_2 uptake and their uncertainties from state-of-the-art pCO_{2w} data based products, ocean-biogeochemical models and atmospheric inversions. For the period of 1985−2018, the Arctic Ocean is a net sink of CO_2 of 103 ± 19 TgC yr^{-1} in the data products, 92 ± 30 TgC yr^{-1} in the ocean-biogeochemical models, and 29 TgC yr^{-1} in the atmospheric inversion. 30−50% of the Arctic Ocean CO_2 uptake occurs in the Barents Sea, 15−25% in the Baffin Bay, 10−35% in the western Greenland Sea, 10% in the Central Basin, and the remaining 0−20% in the other regions. The CO_2 absorption peaks in late summer−early autumn, and is low in winter because of the sea-ice cover inhibiting air-sea fluxes. Annual mean CO_2 uptake increased at a rate of 29 ± 11 TgC yr^{-1} dec^{-1} in the data products, 10 ± 4 TgC yr^{-1} dec^{-1} in the ocean-biogeochemical models, and 5 TgC yr^{-1} dec^{-1} in the atmospheric inversion. Uncertainty was large especially in pCO_{2w} in the East Siberian Sea and the Laptev Sea.

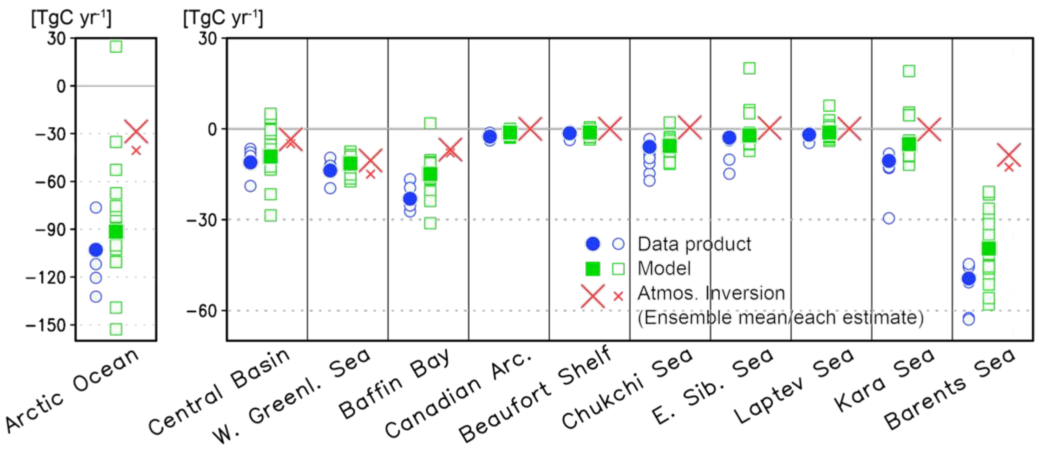

Figure 1. Annual mean CO_2 flux from 1985 to 2018 of ensemble mean (large or closed) and each estimate (small or open; blue circle, data products; green square, ocean-biogeochemical models; red cross, atmospheric inversions). Value from each estimate is eliminated if more than 20% in the area have no data.

R6-P01

Degradation of phthalates and camphor by the deep-marine halophilic bacteria *Halomonas titanicae* and their relevance to the order Oceanospirillales

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Halomonas is a genus of halophilic and halotolerant, gram-negative, rod-shaped, aerobic protobacteria, tolerating moderate (3 – 15 % (w/v)) to extreme (~32%) concentrations of NaCl [1]. Among these, *Halomonas titanicae* strain BH1^{T} has been isolated from rusticles on the wreck of the RMS Titanic, at a depth of 3,784 meters in the North Atlantic Ocean [2]. Our protein BLAST inferred that *Halomonas titanicae* has gene clusters for the degradation of phthalates and phthalate esters and a gene for the degradation of camphor. Camphor was heavily used as a plasticizer until the 1910s [3], while phthalate esters are a category of plasticizers that have been heavily used since the 1920s [4] and are currently under scrutiny for their potential antiandrogenic effects [5]. So far, very little is known about the evolution of this operon in Gammaproteobacteria, and in particular, in marine bacteria. Our phylogenetic analysis based on both the phthalate degradation *pht* genes and the camphor degradation gene *camA* in Gammaproteobacteria indicated that there are horizontal gene transfers within the order Oceanospirillales in the camA gene tree. Furthermore, 10 % disodium phthalate added in SW-10 medium [2] significantly improved the growth rate of *H. titanicae*, and the expression of the genes *pht2*, *pht3*, *pht4* and *pht5* positively correlated with the concentration of disodium phthalate. We then investigated the evolution of the phthalate degradation genes and the gene involved in camphor degradation elsewhere in the order Oceanospirillales to better understand its relevance in Halomonas.

References

[1] Kim, K. K., Lee, J.-S., & Stevens, D. A. (2013). Microbiology and epidemiology of *Halomonas* species. *Future Microbiology*, *8*(12), 1559–1573. https://doi.org/10.2217/fmb.13.108

[2] Sánchez-Porro, C., Kaur, B., Mann, H., & Ventosa, A. (2010). Halomonas titanicae sp. Nov., a halophilic bacterium isolated from the RMS Titanic. *International Journal of Systematic and Evolutionary Microbiology*, *60*(12), 2768–2774. https://doi.org/10.1099/ijs.0.020628-0

[3] Duncan, R. (1911). *Some Chemical Problems of Today*.

[4] IHS Chemical Economics Handbook: Plasticizers (2008) https://ihsmarkit.com/products/plasticizers-chemical-economics-handbook.html (Book)

[5] Albert, O., & Jégou, B. (2014). A critical assessment of the endocrine susceptibility of the human testis to phthalates from fetal life to adulthood. *Human Reproduction Update*, *20*(2), 231–249. https://doi.org/10.1093/humupd/dmt050

R6-P02

Sea ice melt timing and ammonium concentration can alter autumn phytoplankton composition in the Pacific Arctic

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Associated with sea-ice reduction, physical and geochemical changes have been demonstrated in the Pacific Arctic [1], and phytoplankton can quickly respond to those changes. However, details of the phytoplankton community at the species level are not fully examined. Through this study, we investigated the phytoplankton community in the Pacific sector of the Arctic Ocean during October 2019 and 2020 in order to reveal the main hydrographic drivers to change the phytoplankton dominant species by comparing the contrasting years. Diatoms were the dominant taxon, comprising 13–100% of phytoplankton cell density. Cluster analysis of abundances divided the phytoplankton community into six groups (A-F), with the distribution pattern well associated with bottom depth. Based on DistLM analyses, the most significant hydrographic driver was ammonium to restrict the community composition throughout the study region. In the south Chukchi Sea, several groups were present even in the narrow area due to the inflow of different types of water masses through the Bering Strait. In the ice edge region (Canada Basin and Chukchi Plateau), sea ice-associated species (*Nitzschia* spp.) were dominant in both years. In the northern Chukchi Sea and slope, the inter-annual difference in the phytoplankton community was clearly observed; group B was dominant in 2019, but group C was in 2020. Comparing the groups, group B was characterized by one month earlier sea ice melt timing, warmer (+2.7°C), and a six times higher abundance of diatom *Proboscia alata.* Longer no ice period and warmer condition might provide their dominance because this species is capable to utilize urea as a nitrogen source in low nutrient concentrations. This study demonstrated that sea ice melt timing and nutrients (especially ammonium) affect the phytoplankton community during autumn, which potentially induces changing carbon cycle and pathway in the food web of the Pacific Arctic.

We thank the captain, officers, crew, and researchers on board the R/V *Mirai*. This work was partially conducted for the Arctic Challenge for Sustainability II (ArCS II) project.

References

[1] E. Carmack and F. McLaughlin, Towards recognition of physical and geochemical change in Subarctic and Arctic Seas, *Progress in Oceanoglaphy* **90** (2011)

R6-P03

Biological features of *Calanus glacialis* in the Pacific sector of the Arctic Ocean during autumn in 2019

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Calanus glacialis, a dominant species on zooplankton biomass in the Pacific Arctic Ocean, is widely distributed in the shelf area, and play an important role in connecting primary production and higher trophic levels. In this species, two different populations on genetics (the Bering Sea and Arctic Basin populations) exist [1], but little information on their biological features is available for each population. In this study, we investigated *C. glacialis* from September to November 2019 to reveal geographic variation in population structure, body size, feeding activity, and fatty acid. The abundance of *C. glacialis* was high on the slope and low on the shelf. Since body size (prosome length) was well described by Bělehrádek equation throughout the sampling region, their size was restricted by *in-situ* temperature. A clear difference in the size between shelf and basin is suggesting that geographic variation in body size is consistent with the distribution of two genetic populations. Cluster analysis based on hydrographic parameters divided four regions: southern shelf, northern shelf, slope, and basin. The southern shelf was dominated by copepodite stage 5 (C5) with low lipid accumulation. This population is considered to be transported by Pacific Water from the Bering Sea. In the northern shelf, C4 and C5 were dominant with high gut pigment, which suggests that they were actively grazing before diapause. Additionally, the population exhibited a high composition of fatty acids originating from dinoflagellates compared to results in the pan-Arctic Ocean. The slope population was showing the highest abundance with the dominance of C4, and a high amount of diatom-derived EPA. These features were attributed to the upwelling of their population and of nutrients supporting diatom growth. In the basin, early copepodite stages of composition were distinctly higher than those in previous studies due to an inflow of individuals from adjunct regions. This population could not grow to a sufficient stage for diapause before freezing up season because of low temperature and primary production.

We thank the captain, officers, crew, and researchers on board the R/V *Mirai*. This work was conducted for the Arctic Challenge for Sustainability II (ArCS II) project.

References

[1] R. J. Nelson, E. C. Carmack, F. A. McLauglin and G. A. Cooper, Penetration of Pacific zooplankton into the western Arctic Ocean tracked with molecular population genetics, *Marine Ecology Progress Series* **381** (2009)

R7-P01

Statistical study of high energy electron precipitation based on Arase satellite - EISCAT collaborative observation data

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We have conducted more than 150 collaborative observations (~600 hours in total) between the Arase satellite and EISCAT radar since March 2017. The obtained collaborative observation data have been used to publish papers based on detailed data analysis on high-energy electron precipitation into the arctic ionosphere [1] and molecular ion upflow from the arctic ionosphere [2]. However, the overall characteristics of many collaborative events have not been systematically analyzed and summarized.

In this paper, we report statistical results of the relationship between wave and particle data observed by the Arase satellite and ionospheric electron density data obtained with the EISCAT Tromsø radar. Their results are summarized as follows:

(1) When the amplitude of the lower-band chorus (LBC) waves is above ~18 pT, magnetospheric electrons with energies above ~160 keV undergo pitch angle scattering, and become significantly ionized at altitudes between 65-100 km.

(2) The relationship between resonance energies of pitch angle scattering and electron density increases due to energetic electron precipitation suggests that pitch-angle scattering of energetic electrons by LBC waves propagating at higher latitudes (~20 deg) rather than in the magnetic equatorial plane occurs frequently.

References

[1] Y. Miyoshi et al., Penetration of MeV electrons into the mesosphere accompanying pulsating aurora, Scientific Reports, 11 (2021).

[2] M. Takada et al., Low-altitude ion upflow observed by EISCAT and its effects on supply of molecular ions in the ring current detected by Arase (ERG), Journal of Geophysical Research: Space Physics, doi:10.1029/2020JA028951 (2021).

R7-P02

Studies of pulsating aurorae: simultaneous observations with the Arase satellite and optical instruments in the Arctic

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Pulsating aurora (PsA) is one of the major types of aurora often seen in the lower latitude part of the auroral region in the morning side. PsA is known to have two distinct periodicities. One is the main pulsation whose period ranges from a few to a few tens of seconds. The other is so-called internal modulation which is ~3 Hz luminosity modulation during the ON phase of main pulsation. Previous studies indicated that ~50% of PsA are accompanied by the internal modulation (i.e., internal modulation is often seen, but not always observed during PsA). Recent coordinated ground/satellite observations of PsA suggested that these two periodicities are closely associated with the intensity modulation of whistler mode chorus waves in the morning side magnetosphere. In particular, the association between the main pulsation and bursts of chorus was confirmed by several recent papers [1, 2]. However, it has still been under debate which characteristics of chorus waves control the existence/absence of internal modulation. This talk will be focused on several results from recent coordinated ground/satellite observations of PsA [3, 4] since the launch of the Arase satellite. Especially, we will introduce conjugate high-time resolution measurements of fine-scale temporal/spatial variations of chorus waves in space and PsA seen from the ground.

References

[1] Nishimura, Y. et al. Identifying the driver of pulsating aurora. Science **330**, 81–84 (2010)
[2] Kasahara, S. et al. Pulsating aurora from electron scattering by chorus waves. Nature **554**, 337–340 (2018)
[3] Ozaki, M., Miyoshi, Y., Shiokawa, K. et al. Visualization of rapid electron precipitation via chorus element wave–particle interactions. Nat Commun 10, **257** (2019)
[4] Hosokawa, K., Miyoshi, Y., Ozaki, M. et al. Multiple time-scale beats in aurora: precise orchestration via magnetospheric chorus waves. Sci Rep **10**, 3380 (2020)

Relationship between pulsating auroral electrons and duct propagation of chorus waves: Simultaneous observations with EISCAT, ground-based all-sky imagers and Arase

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Auroras are classified into two broad categories: the discrete aurora, which has a distinct arc-like shape, and the diffuse aurora, which has an indistinct patchy shape. Most of the diffuse auroras are known to show a quasi-periodic luminosity modulation called pulsating auroras (PsA). Magnetospheric electrons causing PsA are generally scattered through wave-particle interactions with chorus waves and precipitate into the ionosphere, being referred to as "PsA electrons". Recent studies demonstrated that sub-relativistic electrons originating from the radiation belt precipitate into the ionosphere during intervals of PsA. This fact suggests that the loss process of such highly energetic electrons in the magnetosphere can be visualized by observing the shape/distribution of PsA and the energy of PsA electrons at the ionospheric counterpart. In order to test and further validate this visualization method, it is crucial to understand the relationship between the morphology of PsA and the energy of PsA electrons, although past studies have not sufficiently examined in this regard. In this study, the Arase satellite, ground-based all-sky imagers, and the European Incoherent SCATter (EISCAT) UHF radar were used in combination to carry out simultaneous magnetically conjugate observations of PsA. We investigated the relationship between the morphology of PsA and the energy of PsA electrons by using this data set. The results demonstrates that the estimated energy of PsA electrons tended to change in accordance with the transition of the morphology of PsA. Specifically, when the boundary of the patch structure was distinct, the energy of the corresponding PsA electron exceeded 10 keV. We hypothesize on the basis of these observational results that the morphology of PsA and the change in the energy of PsA electrons are controlled by the existence of "ducts," which are tube-like regions where the electron density is lower or higher than the surrounding area. Those duct structures guide chorus waves along the magnetic field, allowing them to propagate to higher magnetic latitudes. In order to test this hypothesis, we have analyzed the PWE data obtained from Arase to infer the spatial structure of electron density in the source region of PsA. In this presentation, we show the observational results and discuss the factors controlling the morphology of PsA and the energy of PsA electrons by showing the electron density estimates in the magnetospheric.

R7-P04

Studies of nightglow emissions in the mesopause above northern Scandinavia

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The polar mesopause region (80-100 km) is the most sensitive environmental region of the Earth's atmosphere that is subject to human and natural variabilities both on short and long-term perspectives. Due to a specific environment of the mesopause region (very low temperatures and strong dynamical variability in summer time) a number of aerosol layered phenomena occur in the mesopause region as such noctilucent clouds (NLC) and polar mesosphere summer echoes (PMSE). We have recently studied these phenomena by using optical imagers installed both on the ground and stratospheric balloons as well as with ESRAD, EISCAT and Mara VHF radars located in northern Scandinavia and Antarctica [1].

We currently focus us on studies of airglow emissions coming from the hydroxyl and molecular oxygen layers in the polar mesopause region above northern Scandinavia. Nightglow emissions will be measured with a novel infrared imaging instrument (called the OH imager) that will measure infrared emissions of selected lines in the hydroxyl OH(3-1) band and O_2 IR A-band to produce emission intensities and temperature maps in the mesopause above Kiruna (northern Scandinavia). The neutral temperature will be determined using the brightness ratio of two rotational lines $P_1(2)$ and $P_1(4)$ in the OH(3-1) band.

Significance of the proposed project is determined by unique observations of the OH and O2 airglow emission layers, which will allow us to obtain the following information on atmospheric processes at the polar mesopause region:
(1) To validate temperature and characteristics of atmospheric gravity waves as will be measured by the upcoming EISCAT_3D radar project and Swedish MATS satellite mission.
(2) To study regular variabilities of the mesopause region such as: solar thermal tides, lunar gravitational tides, multi-year variations, quasi-biennial oscillations.
(3) To study irregular variabilities of the mesopause region such as: atmospheric gravity and planetary waves on daily and seasonal scales, sudden stratospheric warming effects, response of airglow emissions and temperature to geomagnetic disturbances and solar activity.
(4) To study artificial wave disturbances due to rocket launches from Esrange and Plesetsk.
(5) To conduct long-term measurements of the polar mesopause temperature (at least for 10 years) in order to establish long-term potential changes in the mesopause environment as evidence of the evolution in the Earth's climate system.

Acknowledgement

The OH imager is part of Kiruna Atmosfärs- and Geofysiska Observatorium (KAGO) at the Swedish Institute of Space Physics (IRF-Kiruna) and will be put into the operation in late 2022. The project obtained financial support from the Swedish Research Council in 2021 (Vetenskapsrådet, grant No 2021-00360).

References

[1] P. Dalin, H. Suzuki, N. Pertsev, V. Perminov, D. Efremov, P. Voelger, V.L. Narayanan, I. Mann, I. Häggström, M. Zalcik, O. Ugolnikov, J. Hedin, J. Gumbel, R. Latteck, G. Baumgarten, Studies of noctilucent clouds from the stratosphere during the SONC balloon-borne experiment in 2021, *Journal of Atmospheric and Solar-Terrestrial Physics* **240**, 105959, doi.org/10.1016/j.jastp.2022.105959 (2022).

R7-P05

A new spectroscopic and imaging observation of short-wavelength infrared aurora and airglow (1.00-1.35 μm) at Longyearbyen (78.1°N, 16.0°E) coordinated with EISCAT Svalbard radar

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A new ground-based optical observation of aurora and airglow in short-wavelength infrared (SWIR) is being planned in Longyearbyen (78.1°N, 16.0°E) coordinated with EISCAT Svalbard Radar (ESR). Two state-of-the-art instruments, a SWIR imaging spectrograph and a monochromatic imager, have been developed to focus on study on dayside magnetosphere-ionosphere-atmosphere coupling processes in the high polar regions.

The 2-D imaging spectrograph, NIRAS-2, has a fast optical system and high spectral resolutions to challenge twilight/daytime aurora measurements from the ground. It is designed for SWIR wavelength from 1.00 to 1.35 microns in which sky background intensity is weaker than in visible. It covers strong auroral emissions in N_2^+ Meinel band (0-0) and N_2 1st Positive bands (1-2, and 0-1). Its field-of-view (FOV) and angular resolution are 55 degrees and 0.11 degrees per pixel, respectively. If a 30-microns slit is used, spectral bandpass around 1.1 microns are 0.53 nm and 0.21 nm with two different gratings (950 lpmm and 1500 lpmm). In a test observation, we successfully measured airglow emissions of OH (4,1), (5,2), (6,3), (7,4), and (8,5) bands in 1.02-1.33 microns, and O_2 IR band at 1.27 μm. We expect that the spectrograph can detect auroral variations with sufficient time resolutions shorter than 30 seconds. For upper mesosphere, OH (8,5) band was measured with good quality, and rotational temperature can be estimated with 10-min resolutions and errors less than 3 K.

In addition to the NIRAS-2, we have been developing the brand-new SWIR camera, NIRAC, focusing on aurora emissions in N_2^+ (0-0) band. The camera consists of a few commercial SWIR lenses for security/defense purposes, plano-convex lenses, a custom optical filter (center: 1112.76 nm, FWHM: 13.8 nm) and an InGaAs FPA (640 × 512 pixels). The FOV is 92 × 73 degrees and slightly wider than that of the spectrograph. In a test observation, we successfully identified horizontal structures of OH (5,2) band airglow layers with 30-seconds exposures.

The instruments are going to be installed at The Kjell Henriksen Observatory/The University Centre in Svalbard (KHO/UNIS) in November 2022. Taking geographical advantage of the observatory, 24-hours continuous observations can be expected near the winter solstice. We are going to address the following scientific goals: dayside reconnections and wave-particle interactions monitored by auroral emissions, energetic particle precipitation impacts on OH chemistry in the upper mesosphere, atmospheric waves variability, and its connection to ionospheric disturbances in E-F regions.

R7-P06

Spectroscopic observation of OH airglow in 1.1-1.3 μm in the polar region

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Recently, near-infrared OH airglow observations using InGaAs FPA (Focal Plane Array) have been reported [1,2]. The OH airglow intensity in the near-infrared region (~1.6 μm) is stronger than that in the visible, and thus more advanced airglow observations (e.g., with higher time resolution) can be expected. The number of observations using the near-infrared OH bands are low, especially in the polar region. In addition, auroral contamination is one of difficulties in airglow observations in the polar region. For example, there is a report that temperature measurements using the OH (3,1) band (~1.5 μm) at Syowa Station, Antarctic (69.0°S, 39.6°E) included an underestimation of the temperature possibly by ~40 K due to auroral contamination [3]. On the other hand, it is suggested that the auroral contamination would be neglected in ~1.3 μm corresponding to OH (8,5) band. Therefore, the validity of temperature measurement with 1.3-μm OH airglow needs to be evaluated.

In this study, we plan to conduct spectroscopic observations of the OH airglow in ~1.3 μm using NIRAS-2 (Near-InfraRed Aurora and airglow Spectrograph-2) at KHO/UNIS, Longyearbyen (78.2°N, 16.0°E), and also examine the estimation method of OH rotational temperature under auroral activity in the polar region. We will also investigate the variations of OH atmospheric airglow spectra and OH molecular density under auroral activity. Moreover, simultaneous observations with the EISCAT Svalbard Radar will be performed to compare the ion temperature and neutral atmosphere temperature.

NIRAS-2 is an imaging spectrograph, which has a wide FOV of 55 degrees with a resolution of 0.11 degrees, and its spectral resolution is variable with combinations of three slits, 30-, 60-, and 90-μm, and two volume phase holographic gratings, 950- and 1500-lpmm. OH airglow observations are mainly performed using the low-dispersion 950-lpmm grating with 60-μm slits. The wavelength range is from 1195 to 1350 nm, targeting the OH (7,4) and (8,5) bands and O_2 IR band with a spectral resolution of 1.1 nm. The preliminary test observation in NIPR, Tokyo, showed that the signal-noise ratio is better than its predecessor, NIRAS [3]. The temperature data, estimated from the OH (8,5) band in the 10-minute integration, were well comparable with those from NRLMSIS 2.0. The estimated temperature error was typically a few K, which is significantly less than that from NIRAS.

NIRAS-2 is going to be installed at KHO/UNIS, Longyearbyen in November 2022. Spectroscopic observations will then be carried out, and this paper will present the initial report on the OH airglow observations by NIRAS-2.

References
[1] Schmidt et al., J Atmos Solar Terr Phys 102:125–139 (2013)
[2] Pautet et al., Appl Opt 26:5934–5943 (2014)
[3] Nishiyama et al., Earth, Planets and Space, 73, 30 (2021)

Coordinated observations of energetic electron precipitation by subionospheric VLF/LF radio propagation with other groundbased facilities

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VLF/LF subionospheric radio propagation is a useful technique to investigate energetic electron precipitation (EEP) with energy of >100keV. This technique contributes to reveal not only loss processes of trapped radiation belt electrons but also chemical processes in the lower thermosphere and mesosphere. We constructed a radio observation network called OCTAVE (Observation of Condition of ionized Atmosphere by VLF Experiment) in North America and Northern Europe. Advantages of this technique are monitoring capability and fine time resolution. This is useful for investigating localized EEP through coordinated observations with other ground facilities. From simultaneous observations of EEP with pulsating and proton auroras, we found that EEPs were correlated with pulsations of both auroras [1][2]. These results are evidence that EEPs occur through pitch angle scattering of the trapped electrons with bursts of whistler mode chorus and electromagnetic ion cyclotron waves. EEP sometimes shows correlations with ultra-low frequency (ULF) waves observed by ground magnetometers and HF radars, suggesting that whistler mode waves which cause EEP are modulated by ULF waves [3]. It is difficult to obtain the electron energy directly from the subionospheric propagation technique. This disadvantage could be compensated by applying electromagnetic field calculation to the subionospheric propagation. Recently, we installed a new radio receiver at northern Finland. We plan to compare EEP with incoherent scatter radar and millimeter spectroscopic observations to investigate capability of the subionospheric propagation for estimating the electron energy and chemical influences of EEP to the atmosphere, respectively.

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References

[1] F. Tsuchiya et al., Energetic electron precipitation associated with pulsating aurora observed by VLF radio propagation during recovery phase of substorm on 27 March 2017, *Geophysical Research Letters* https://doi.org/10.1029/2018GL080222 (2018)
[2] A. Hirai et al., Temporal and Spatial Correspondence of Pc1/EMIC Waves and Relativistic Electron Precipitations Observed with Ground-Based Multi-Instruments on 27 March 2017, *Geophysical Research Letters* https://doi.org/10.1029/2018GL080126 (2018)
[3] T. Miyashita et al, ULF Modulation of Energetic Electron Precipitations Observed by VLF/LF Radio Propagation, *Radio Science Bulletin*, **372** (2020)

R7-P08

The 10-year summary of the sodium lidar at Tromsø, and its future plan

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We will report a brief summary of our activities using the sodium lidar at Tromsø (69.6N, 19.2E) over 10 years, and its future plans. The sodium lidar at Tromsø [1, 2] has been operated for about 10 years since October 2010. For the first two winters, we have observed neutral temperature and sodium density between about 80 and 110 km. Since October 2012, wind measurements have been conducted together with the both measurements. By now, we have obtained about 4200 hr of temperature and sodium density data and about 3100 hr of wind data. It is possible to derive the temperature between 30 and 50 km in the upper stratosphere, although the time resolutions are not good (a few hours). Utilizing these temperature and wind data together with data obtained by co-located EISCAT radars, MF and meteor radars, photometers, and optical imagers, we have studied several topics such as gravity waves, sporadic sodium layers, variations of the sodium density by auroral particle precipitation, and atmospheric instabilities. Although the lidar operation was not made for 3 years due to the pandemic of COVID-19, we have been conducting experiments and developments in Japan for a future extension of the capability of the sodium lidar.

References

[1]Nozawa, S., T. D. Kawahara, N. Saito, C. M. Hall, T. T. Tsuda, T. Kawabata, S. Wada, A. Brekke, T. Takahashi, H. Fujiwara, Y. Ogawa, and R. Fujii (2014) Variations of the neutral temperature and sodium density between 80 and 107 km above Tromsø during the winter of 2010-2011 by a new solid state sodium LIDAR, *J. Geophys. Res., 119*, doi:10.1002/2013JA019520, 441-451

[2]Kawahara, T.D., S. Nozawa, N. Saito, T, Kawabata, T.T. Tsuda, and S. Wada (2017) Sodium temperature/wind LIDAR based on laser-diode-pumped Nd:Yag lasers deployed at Tromsø, Norway (69.6°, 19.2°), *Optics Express, 25*, A491-A501

R7-P09

Ultra-narrowband Optical Filter Development for the Na lidar Observation at Tromsø

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Wintertime Na wind/temperature lidar observations of the MLT region have been continued at Tromsoe (69.6°N 19.2°E), Norway. The laser transmitter is based on injection-seeded Nd:YAG lasers, so it is significantly robust with a high laser emission (4W) at 589 nm. The lidar can measure neutral temperature, northward and eastward winds, and Na density. The total observation time is over 3,000 hours from 2010 to 2018, with temperature and wind accuracies of 1 K and 1 m/s, respectively, with height and time resolution of 1 km and 1 hour.

The upgrade of the lidar is in process for the daytime observation. An ultra-narrowband magneto-optical filter, called a Faraday filter, is under construction to reject high background noise in daytime conditions. The bandpass characteristic is relatively narrow about 10 GHz (10 pm) at 589 nm which is about 1/100 of commercial bandpass filters. We also apply the filter for nighttime Na observations in the thermosphere, which is expected to be a very faint signal comparable to background noise. The new optical design of the lidar receiver with the filter is in process.

The lidar observation of temperature and winds needs a high-resolution transmission profile of the filter. There are two essential points; to make the robust filter itself and to construct a scannable single-mode 589 nm laser at the lab. We constructed a prototype Faraday filter with a commercial Na glass cell with permanent solid magnets (245 mT) between two polarizers. Preliminary transmission profiles at different cell temperatures are obtained. In this talk, we discuss the validity of the profiles with simulation.

A self-build FPGA-based data acquisition system for Tromsø sodium lidar

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The sodium (Na) resonance scattering lidar is a laser sensing system to detect Na that is distributed in the upper mesosphere and lower thermosphere mainly from 80 to 110 km altitudes. The Tromsø Na lidar, which is one of the cutting-edge Na lidar systems, has the capability of five-directional observation with a highly stable and high repetition laser diode (LD)-based laser system. The laser repetition rate is 1 kHz, which corresponds to 1 ms of the inter-pulse period (IPP), and therefore the height coverage of the lidar observation is 0-150 km. Thus, the Tromsø Na lidar system is designed for Na distributing at 80-110 km. On the other hand, after the development of the Tromsø Na lidar, the recent observations from other Na lidars revealed low-density Na events at upper altitudes (above 110 km, up to 170 km). Such Na events at upper altitudes can provide good opportunities to extend the observation height range to the thermosphere, but the current Tromsø Na lidar system is insufficient to observe such Na events because of the limitation in the height coverage of 0-150 km.

To improve the height coverage of the Tromsø Na lidar, in the present study, we propose a time-delay five-directional laser pulse transmission method. In the current system, five pulses are split by power from the 1-kHz laser pulse, and these pulses are transmitted to each direction at the same time. In the proposed method, the 1-kHz laser pulses are transmitted to five directions with time delays. As the result, the laser repetition rate for a single direction can be down to 200 Hz, which corresponds to 5 ms of the IPP, and the height coverage can be 0-750 km. Furthermore, the laser pulse is not split by power, and thus signal-to-noise ratio (SNR) can be also improved. This SNR improvement would be helpful for observations of such low-density Na events at upper altitudes. To realize this proposed method, a high-speed data acquisition system including a function of precise time-delay control is needed, and thus we have been working on a self-build field-programmable gate array (FPGA)-based data acquisition system for Tromsø sodium lidar. In the presentation, we will describe our proposed method, and report the current status in the development of our self-build system.

Polar mesospheric cloud observations by the Advanced Himawari Imager onboard the Japanese geostationary-Earth-orbit meteorological satellite Himawari-8

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To advance polar mesospheric cloud (PMC) observations by Advanced Himawari Imager (AHI) onboard the Japanese geostationary-Earth-orbit (GEO) meteorological satellite Himawari-8, we have developed a PMC detection method for application to the Himawari-8/AHI full-disk images. The PMC detection method consists of two steps: the detection of stronger PMC signals in the first step and the detection of weaker PMC signals in the second step. By using this two-step detection, we eliminate false detections as much as possible and enhance detection sensitivity. As a result, the PMC detection sensitivity by Himawari-8/AHI is well comparable to that by Cloud Imaging and Particle Size (CIPS) onboard Aeronomy of Ice in the Mesosphere (AIM). By analyzing the detected PMC data, various PMC variations such as quasi-5-day waves and mid-latitude extensions can be revealed. Among them, we focus on interhemispheric coupling, specifically a relationship between PMC occurrence rates in the summer hemisphere and sudden stratospheric warmings in the winter hemisphere.

Polar Educators International and the Third Arctic Science Ministerial (2021): A Landmark for Polar Education

M.P. Casarini, J. Dooley and S. Weeks

Polar Educators International

Polar Educators International (PEI), established in 2012 as a legacy of the International Polar Year (IPY), is a unique network of scientists, researchers, teachers, and educators, connecting polar science, education and the global community to provide a deeper understanding of current polar sciences to a global audience. [1]

In 2020 PEI was invited to participate in the Third Arctic Science Ministerial (ASM3), co-hosted by Iceland and Japan. The main theme was Knowledge for a Sustainable Arctic; PEI supported one of the four sub-themes, "Strengthen": preparing the next generation through capacity building, education, networking, and resilience.

PEI proposed to deliver three educational programmes:

1. An international conference, PEI2022-Iceland, the fifth of a biennial series of polar education workshops started in 2013. "Stories in Ice: Connect, Learn, Act" took place in Höfn, Iceland, on 11-15 April. Co-developed by educators and researchers, with indigenous representatives, it focused on the human story of the changing Arctic, and its impact on our environment and culture. In hybrid form, it was attended in person by 33 educators and researchers from 11 countries, including Arctic indigenous communities, in person and online.
2. A Global Conversation between educators, Arctic researchers and Indigenous Knowledge holders as a series of world café events online, in order to initiate polar education and engagement at the beginning of the Arctic science process.
3. Arctic researchers and educators collaborating to update the IPY publication *Polar Science and Global Climate: An International Resource for Education and Outreach*, published in 2010, known as the "Polar Resource Book" (PRB). PEI is collaborating with APECS (Association of Polar Early Career Scientists), SCAR (Scientific Committee on Antarctic Research), and IASC (International Arctic Science Committee), our partners in creating a new, updated and open access resource which will continue to inspire educators, science communicators, students and emerging polar researchers with a shared commitment to outreach and education.

The ASM3 document, signed by Ministers from 25 nations, the European Union, and 6 Arctic Indigenous Peoples Organisations, at the National Institute of Polar Research (NIPR) in Tachikawa, Japan, on May 8-9, 2021, stated:

"We therefore intend to cooperate through the following actions: Recognize the urgent need and identify gaps in support, capacity building, education, and networking, both in the Arctic and the wider global Arctic research community, and provide pathways of assistance. Encourage participation and active engagement in existing international Arctic education frameworks such as the Association of Polar Early Career Scientists (APECS), Polar Educators International (PEI), and University of the Arctic (UArctic)."

Through the work and dedication of PEI members and its Executive Committee it is our aim to continue to increase collaboration between scientists, educators, and people living in the Arctic, thus creating a society where the challenges of change in the Arctic, mainly caused by climate change, will be better known, understood, and shared.

References

[1] H.A. Roop, G. Wesche, P.F. Azinhaga, B. Trummel, J.C. Xavier, Building collaborative networks across disciplines: A review of Polar Educators International's first five years. *Polar Record* **55** (2019)

S2-P01

Baroclinic Blocking

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Blocking events present persistent midlatitude atmospheric circulation anomalies that block the prevailing westerly winds, thereby causing extreme weather events. On weather charts, the associated anticyclonic circulation at the surface and aloft appear vertically aligned. Because of their apparent lack of vertical tilt, they have been studied from a quasi-stationary barotropic viewpoint. However, it is shown in this work that blocking events often have such structure that anomalies in geopotential height and temperature are horizontally out-of-phase (Fig. 1) which allows blocking anomalies to produce fluxes of heat against the climatological-mean gradients. These fluxes contribute to amplifying and maintaining blocking-related temperature anomalies. This process, which represents the baroclinic conversion of energy from the climatological-mean flow to the blocking-related anomalies, is shown to be one of the leading energy sources through a comprehensive analysis of blocking energetics. Depending on the location, this energy source is comparable to or even greater than the feedback forcing by migratory cyclones and anticyclones which is often considered the main maintenance mechanism of blocking. In contrast, the baroclinic energy conversion and feedback from high-frequency eddies in summer are more comparable in magnitude.

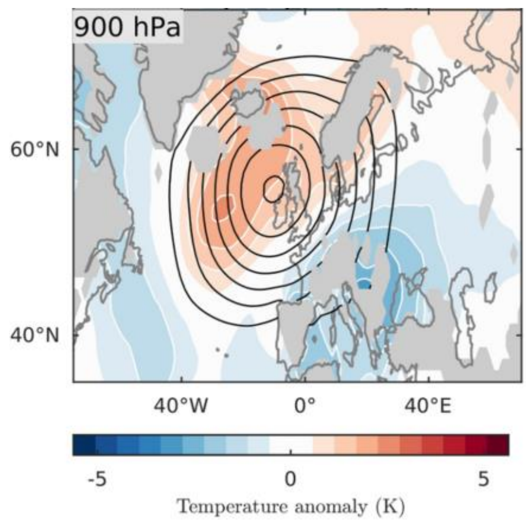

Figure 1. Excerpt from Fig. 5 of Martineau et al. (2022)[1] illustrating the typical structure of height (contours) and temperature (shadings) anomalies associated with European blocking events.

References

[1] P. Martineau, H. Nakamura, A. Yamamoto, Y. Kosaka, Baroclinic Blocking. Geophys. Res. Lett. 49, 6298–6305 (2022)

S2-P02

Interannual-to-decadal modulation of wintertime sub-seasonal variability over the Eurasia-East Asian sector

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Wintertime subseasonal variability over the Eurasian continent is often accompanied by intense cold air outbreaks in East Asia (e.g., Takaya and Nakamura, 2005). On interannual-to-decadal timescales, the wintertime subseasonal variability of surface air temperature (SAT) can be modulated by the longer timescale variability of the tropospheric seasonal mean state (e.g., Martineau et al., 2020). As remote influence from the Arctic to Eurasia/East Asia has been reported on the interannual time scale (e.g., Mori et al. 2014), it is of scientific interest and societal importance whether the low-frequency variability in teleconnection from the Arctic to East Asia could modulate the occurrence of shorter time-scale cold events over Eurasia and East Asia. The objective of this study is thus to examine the interannual-to-decadal modulation of the wintertime sub-seasonal variability at the surface over Eurasia and East Asia.

We defined subseasonal variability of SAT (SAT-SSV) for each year as a standard deviation of 10-60 days band-passed filtered SAT during a winter season from December through February and applied an EOF analysis to SAT-SSV derived from two sets of atmospheric reanalysis data: JRA55 and ERA-20C. Spatio-temporal structures of the two leading modes for the overlapped period correspond well with each other between the two reanalysis products. The two modes of the SAT-SSV exhibit zonally elongated patterns at different latitudes across the Eurasian continent, which correspond well to horizontal gradients of the seasonal-mean SAT. The SAT-SSV modes are also associated with seasonal mean, upper tropospheric circulation anomalies that extend circumglobally in the northern hemisphere. The seasonal mean circulation anomalies associated with the 1st mode of SAT-SSV are similar to Arctic Oscillation, whereas those associated with the 2nd mode of SAT-SSV display regional signatures of the North Atlantic Oscillation and Warm Arctic-Cold Eurasia patterns.

References

[1] K. Takaya, H. Nakamura., Mechanisms of Intraseasonal Amplification of the Cold Siberian High, *Journal of Atmospheric Sciences* **62** (2005)
[2] P. Martineau, H. Nakamura, Y. Kosaka, B. Taguchi, M. Mori, Modulations of North American and European Weather Variability and Extremes by Interdecadal Variability of the Atmospheric Circulation over the North Atlantic Sector, *Journal of Climate* **33** (2020)
[3] M. Mori, M. Watanabe, H. Shiogama, J. Inoue, M. Kimoto, Robust Arctic sea-ice influence on the frequent Eurasian cold winters in past decades, *Nature Geoscience* **7** (2014)

Interannual Variation of the Warm Arctic-Cold Eurasia Pattern Modulated by Internal Atmospheric Variability Examined by a Large Ensemble Experiment

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Along with the rapid Arctic warming and sea ice decline, especially over the Barents-Kara Seas (BKS), extreme cold winters have occurred frequently in the midlatitude in particular near Central Eurasia. The pattern with two distinct winter temperature anomalies centered over the Barents-Kara Seas and Central Eurasia is known as the Warm Arctic-Cold Eurasia (WACE) pattern. Previous studies [1-2] suggested inconsistent role of BKS sea ice loss and internal atmospheric variability in the formation of recent Eurasian cold winters in part of the WACE pattern. The inconsistency might be owing to large internal variability in the midlatitude circulation which could perturb the observed linkage between sea ice loss and the cold winters in Eurasia. A large ensemble simulation with different initial condition conducted by an atmospheric circulation model could allow us to distinguish the internal atmospheric variability and the forced response to external forcing.

This study analyzed a large ensemble historical experiment from "Database for Policy Decision-Making for Further Climate Change" (d4PDF) to investigate the role of BKS sea ice on the relationship between the WACE pattern and the internal atmospheric variability. Empirical Orthogonal Function was applied to both observed and historical simulated the winter (December-February) surface air temperature anomaly over the Eurasia continent during 1979/1980–2019/2020 to obtain the WACE pattern and index as the second leading mode. Then twenty out of one hundred ensemble members were selected considering the similarity and dissimilarity of the interannual variation of the simulated WACE index against the observed one (i.e., ten members with highest and lowest correlation relative to observation, respectively). Results indicate that the Ural Blocking and North Atlantic Oscillation are two of key internal atmospheric variability processes controlled the interannual variation of the WACE pattern. Besides the role of local sea ice loss, the recent observed winter warming trend over the BKS is partly caused by the combined effect of Ural Blocking and positive phases of the North Atlantic Oscillation, which supporting warm temperature advection transport from the midlatitude to the Arctic. The recent observed winter cooling trend over Central Eurasia is dominantly caused by Ural Blocking with increasing contribution accompanied with the decreasing of the sea ice.

References

[1] P Zhang, Y Wu, I Simpson, K Smith, X Zhang, B De, P Callaghan (2018) A stratospheric pathway linking a colder Siberia to Barents-Kara Sea sea ice loss. Science Advance 4.(7):eaat6025

[2] R Blackport, J Screen (2021) Observed statistical connections overestimate the causal. effects of Arctic sea ice changes on midlatitude winter climate. Journal of Climate 34:3021–3038

S2-P04

A hemispheric extreme warm winter in 2019-20 enhanced by the highest sea surface temperature around mid-latitude

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In 2020 winter, most mid latitudes in the Northern Hemisphere was the historically warmest (Fig. 1a). The warmth was spreading zonally around all the mid latitudes throughout the season. Zonal-mean sea surface temperature in the mid latitudes was also unprecedently warm (Fig. 1b). It was substantially different from the recent localized extreme weathers, which were smaller both in temporal and spatial scales than 2020. The global warming might have turned into reality. Here we show that synchronized chain interaction between the warm seas and the warm atmosphere amplified the anomalousness of the warm winter using data analyses and simple numerical experiments. The chain is as follows; the warm seas built up in the previous autumn made overlying air warm, then the warmed air penetrated inland by westerlies, the warm air over the land further flew to the ocean, which again warms the seas. The zonal oceanic warming in mid-latitudes might shift the climate dynamics to a new state. This air-sea chain was responsible for unprecedently positive phase of Arctic Oscillation, which is a good measure of the zonal mean extreme warmth.

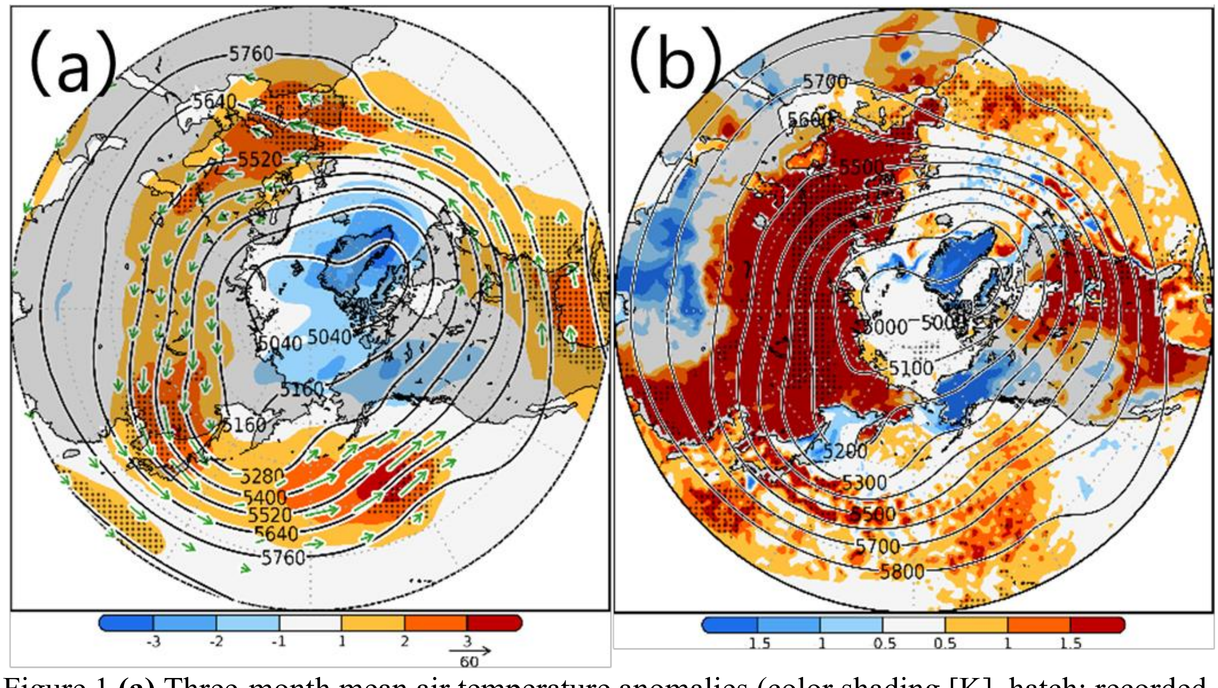

Figure 1 **(a)** Three-month mean air temperature anomalies (color shading [K], hatch: recorded the highest since 1979) at 500 hPa, and geopotential height (contours [m]) at 500hPa in winter 2020 between 1 January and 31 March. **(b)** same as Fig. 1a, but sea surface temperatures (ocean area) and ground temperature (land area).

S2-P05

Winter atmospheric trends over East Asia analyzed for individual surface pressure patterns

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The observed surface temperature increase is stronger over land than oceans and is most pronounced in the Arctic [1]. The warmer Arctic reduces the cold air that leaks to mid-latitude in winter [2]. These effects of global warming are often seen in linear trends of seasonal mean atmospheric conditions. Our study investigated the linear trends of the atmospheric conditions for various surface pressure patterns in East Asia. The classification of surface pressure patterns based on self-organizing maps (SOMs) [3] revealed that surface air temperature around Japan under the specific surface pressure pattern that induces strong cold air advection (#010 in Fig. 1) showed a stronger warming trend than the trend for its seasonal mean. This indicates that warming is more accelerated under the condition that brings cold surges around Japan. In addition, increasing trends in precipitable water vapor around Japan were found for the pressure pattern in which low pressure brings warm air advection (#024 in Fig. 1). These results suggest that the effects of climate change are significant under certain pressure patterns and its trend differs from that of the seasonal mean.

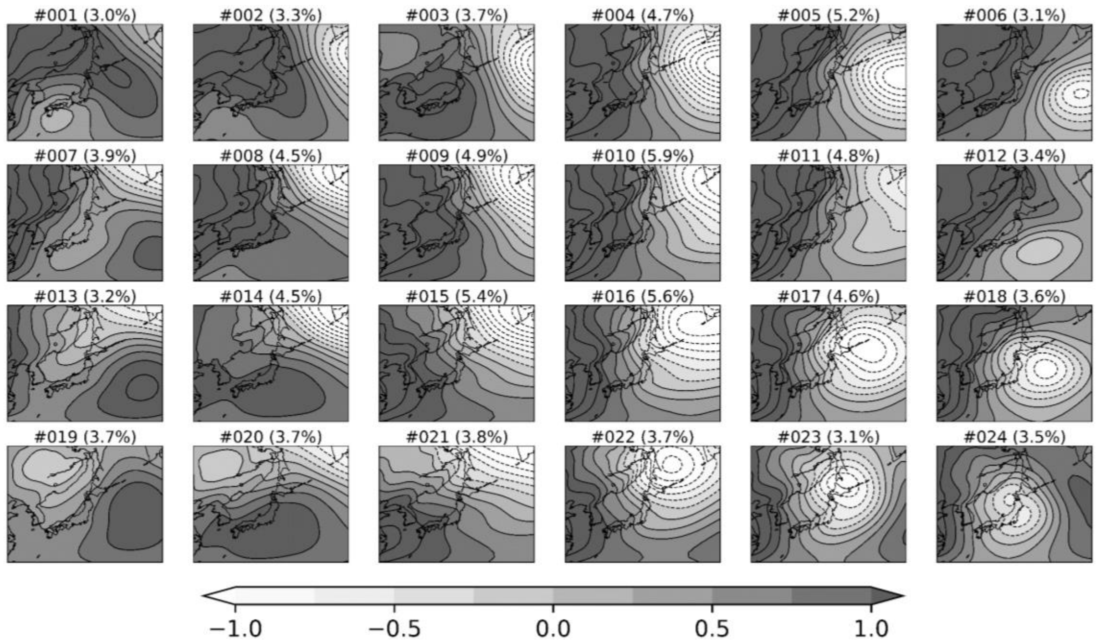

Figure 1. Composite of standardized sea level pressure patterns in winter on 6 × 4 SOMs.

References

[1] Masson-Delmotte, Valérie, et al., 2021. Climate change 2021: the physical science basis. *Contribution of working group I to the sixth assessment report of the intergovernmental panel on climate change* **2**.

[2] Kanno, Y., Abdillah, M.R. and Iwasaki, T., 2016. Long-term trend of cold air mass amount below a designated potential temperature in Northern and Southern Hemispheric winters using reanalysis data sets. *Journal of Geophysical Research: Atmospheres*, **121(17)**, pp.10–138.

[3] Kohonen, T., 1982. Self-organized formation of topologically correct feature maps. *Biological Cybernetics*, **43**, pp. 59–69.

Lagged remote effect from tropical ocean on sea ice variability in the Sea of Okhotsk

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The Sea of Okhotsk is a unique sea, where sea ice spreads to the lowest latitudes in the world. Sea ice extent in the Sea of Okhotsk varies remarkably from year to year controlled by various factors. One of the important factors is a remote effect. Previous studies showed that the sea ice extent in the Sea of Okhotsk increased in years of El Niño events, however, the lagged effect from the tropical ocean has not been considered. Tropical ocean has the significant-lagged impact on other regions such as the tropical Indian Ocean (TIO) capacitor effect (Xia et al., 2009). The TIO capacitor effect is a phenomenon in which the influence of the tropical Pacific Ocean appears in the TIO with a lag of 2-3 months. We therefore examined the lagged relationship between the tropical ocean and sea ice variability in the Sea of Okhotsk using statistical analysis. We found that sea ice extent in the Sea of Okhotsk was increased in the next winter after the La Niña events (Fig. 1a). We suggest the hypotheses that a process of relationship between La Niña and the variability of the sea ice extent in the Sea of Okhotsk in next winter are as follows: 1) In the La Niña winter, anomalous convection near the Philippine Sea persisted until half a year later in the summer. 2) Anomalous convection excites the Pacific-Japan teleconnection pattern, which are related to low pressure anomalies near Siberia (Fig. 1b) and low temperature anomalies in the soil. 3) The low temperature anomalies in the soil around Siberia persist until early winter, bringing cold air to the Sea of Okhotsk and increasing sea ice. Some of these process were also confirmed by numerical model experiments.

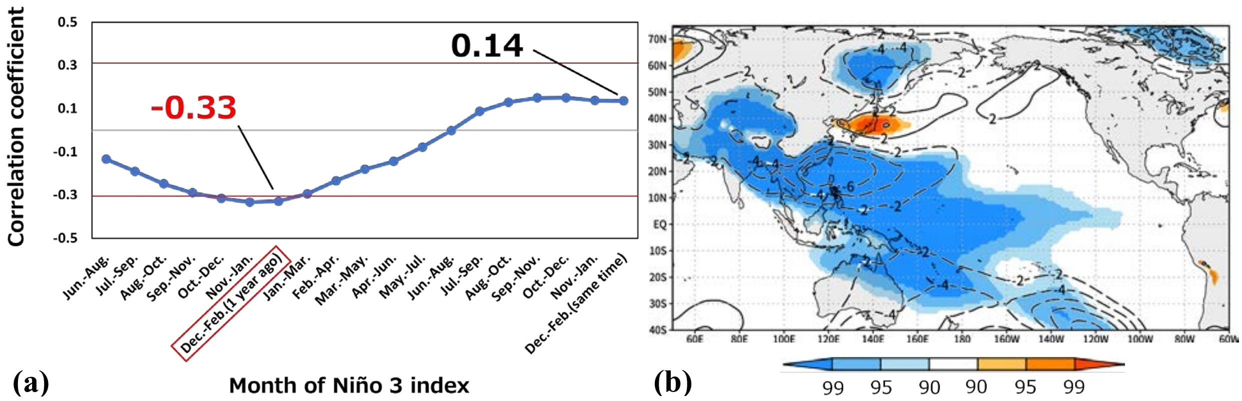

Figure 1. **(a)** Time series of lagged correlation coefficients between the Sea of Okhotsk sea ice extent and the Niño 3 indices. The red line indicates a confidence level of 95%. **(b)** Regression between the three months averaged OLR index in the Philippine Sea from June to August with the geopotential height of 850 hPa in the same time. Contours indicate regression coefficients (m). Color shading indicates confidence levels.

Reference

Xie, S.-P. et al. 2009：Indian Ocean Capacitor Effect on Indo–Western Pacific Climate during the Summer following El Niño. *Journal of Climate*, **22(3)**, 730-747.

S2-P07

Impact of the Pacific sector sea ice loss on the sudden stratospheric warming characteristics

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[4] *Niigata University, Niigata, Japan*

The extent of sea ice coverage over the Arctic Ocean has dramatically declined over the past few decades. The anomalously warm Arctic surface associated with the Arctic sea ice loss has been linked to the mid-latitude surface cooling in the subsequent boreal winter. Several studies have suggested that this linkage could involve the wintertime stratospheric circulation by enhancing the upward planetary wave (PW) activity and weakening the polar vortex. Temperature anomalies induced by the vortex weakening could subsequently descend into the troposphere on time scales of weeks to months, potentially leading to cold air outbreaks (CAOs) over the continents. Cases studies based on observations or model simulations even suggested that the enhanced wave flux could be strong enough to cause the demise of the polar vortex associated with the sudden stratospheric warming (SSW) phenomenon.

The atmospheric response to Arctic sea ice loss remains however a subject of much debate. Most studies have focused on the sea ice retreat in the Barents-Kara Seas and its troposphere-stratosphere influence. Here [1], we investigate the impact of large sea ice loss over the Chukchi-Bering Seas on the sudden stratospheric warming (SSW) phenomenon during the easterly phase of the Quasi-Biennial Oscillation through idealized large-ensemble experiments based on a global atmospheric model with a well-resolved stratosphere. Although culminating in autumn, the prescribed sea ice loss induces a near-surface warming that persists into winter and deepens as the SSW develops. The resulting temperature contrasts foster a deep cyclonic circulation over the North Pacific, which elicits a strong upward wavenumber-2 activity into the stratosphere, reinforcing the climatological planetary wave pattern. While not affecting the SSW occurrence frequency, the amplified wave forcing in the stratosphere significantly increases the SSW duration and intensity, enhancing cold air outbreaks over the continents afterward.

References

[1] J. Zhang, Y. Orsolini, V. Limpasuvan, J. Ukita, Impact of the Pacific sector sea ice loss on the sudden stratospheric warming characteristics, *npj Clim Atmos Sci* **5,74** (2022)

S2-P08

Arctic Sea ice loss and Eurasian cooling in winter 2020-21

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Anomalous coldness was observed over midlatitude Eurasia in December 2020 and over subpolar Eurasia in January 2021. The former was accompanied by the Warm Arctic and Cold Eurasia (WACE) pattern, while the latter by the negative phase of the Arctic Oscillation (AO). A set of large ensemble experiments with an atmospheric general circulation model suggests a contribution of reduced Arctic Sea ice to the midlatitude cooling and WACE pattern in December 2020. The tropical and extratropical sea surface temperature (SST) anomalies, however, contribute to warming over midlatitude Eurasia. In January 2021, neither the sea ice nor SST anomalies can explain the subpolar Eurasian cooling and the negative AO in our experiments.

S3-P01

Global carbon budgets estimated from long-term observations of the atmospheric CO_2 mole fraction, isotopic ratio of CO_2 and O_2/N_2 at Ny-Alesund, Svalbard

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To elucidate contributions of the terrestrial biosphere and the ocean to the CO_2 cycle on the earth's surface, we have conducted systematic observations of the CO_2 mole fraction, carbon isotopic ratio of CO_2 ($\delta^{13}C$) and oxygen to nitrogen ratio ($\delta(O_2/N_2)$) in the atmosphere at NyÅlesund, Svalbard since 1991, 1996, 2001, respectively [1]. The CO_2 mole fraction shows clear seasonal cycles superimposed on the secular increase with an average rate of 2.0 ppm yr^{-1} for the period 1996–2020. On the other hand, $\delta^{13}C$ and $\delta(O_2/N_2)$ decrease secularly at an average rate of −0.024 ‰ yr^{-1} for 1996–2020, and −22.6 per meg yr^{-1} for 2001–2020, respectively. Based on the observed secular trends of the CO_2 mole fraction and $\delta(O_2/N_2)$ (O_2-method), the average terrestrial biospheric and oceanic CO_2 uptakes during 2001–2017 were estimated to be 1.5 ± 0.8 and 2.5 ± 0.6 GtC yr^{-1}, respectively. By using the observed CO_2 and $\delta^{13}C$ ($\delta^{13}C$-method), the corresponding CO_2 uptake of 1.2 ± 0.8 and 2.8 ± 0.6 GtC yr^{-1} were obtained for the same period. The terrestrial biospheric CO_2 uptake derived by the $\delta^{13}C$-method showed large inter-annual variability in association with El Niño events. On the other hand, the oceanic uptake increased secularly with less inter-annual variability during 1996–2017. The oceanic CO_2 uptake of the decadal periods (2001–2010, 2004–2013 and 2008–2017) estimated by the O_2-method also showed an increasing trend. These uptake rates and the increasing trends estimated in this study agree with those reported by the Global Carbon Project (GCP) [2] within the estimation uncertainty. In this presentation, temporal variations of the CO_2 mole fraction, $\delta^{13}C$ and $\delta(O_2/N_2)$ observed at Ny-Ålesund up to 2020 will also be presented.

Acknowledgements:
We are grateful to the Norwegian Polar Institute staffs for their careful air sampling at Ny-Ålesund.

References

[1] Goto, D., Morimoto, S., Ishidoya, S., Aoki, S., Nakazawa, T. (2017), Terrestrial biospheric and oceanic CO_2 uptakes estimated from long-term measurements of atmospheric CO_2 mole fraction, $\delta^{13}C$, and $\delta(O_2/N_2)$ at Ny-Ålesund, Svalbard, *J. Geophys. Res. Biogeosci.*, **122**, doi:10.1002/2017JG003845.
[2] Friedlingstein, P., Jones, M. W., O'Sullivan, M., Andrew, R. M., Bakker, D. C. E., Hauck, J., ⋯ Zeng, J. (2022), *Earth Syst. Sci. Data*, **14**, 1917–2005, https://doi.org/10.5194/essd-14-1917-2022

S3-P02

Evaluation of black carbon in the Arctic region using the WRF/CMAQ simulation on the Northern Hemisphere scale

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Black carbon (BC) emitted into the atmosphere from fuel combustions and biomass burning efficiently absorbs solar radiation and heats the atmosphere directly; therefore, it is an important short-lived climate forcing factor (SLCF). Accumulated BC over snow and ice promotes their melting. Consequently, BC is a major heating driver especially in the Arctic region. Observed surface BC concentrations in the Arctic region indicated a typical seasonal variation such as increasing from winter to early spring and decreasing during the warmer season with similar large interannual variabilities. However, the monitoring period was different at each station. The interannual variabilities of BC concentrations might be caused by differences in the air-mass transport patterns from the source regions and the occurrence of forest fires in Siberia and Alaska over the years. To investigate the primary factors in the differences between the higher BC year and the lower BC year, hemispheric scale air quality simulation has been performed for 2015 and 2016 by WRF/CMAQ model using HTAPv2.2 and GFASv1.2 inventories. It was found that the model could reasonably capture the concentration levels and seasonal patterns of observed BC at Barrow[1] and Ny-Alesund[2] in 2015 (Figure 1). Furthermore, compared with onboard observations by the research vessel Mirai promoted as part of the Arctic Challenge for Sustainability project (ArCS), the timing of the inflow of polluted air masses from the Asian continent was relatively well reproduced by the model simulation and confirming the BC transport from Asia through the western North Pacific to higher latitudes. We will discuss the primary factors for higher BC concentrations in the Arctic region through a comparative analysis with the 2016 case under the lower BC condition.

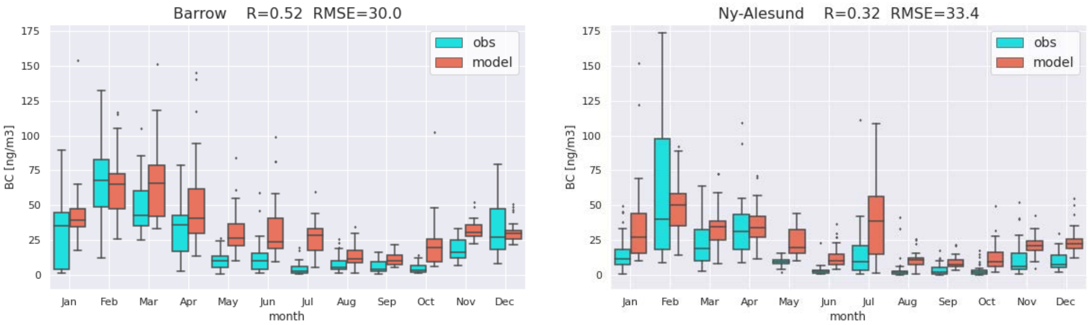

Figure 1. Boxplot of observed (blue) and simulated (red) daily mean BC mass concentrations at the Arctic, Barrow and Ny-Alesund sites in 2015.

References

[1] Koike, M. , Oshima, N. , Ohata, S. , Zhao, Y. , Kondo, Y., 2018, Mass concentration of BC (black carbon) measurment by COSMOS at Barrow in Alaska., 1.00, Arctic Data archive System (ADS), Japan, https://ads.nipr.ac.jp/dataset/A20180402-001
[2] Koike, M. et al., 2018, Mass concentration of BC (black carbon) measurment by COSMOS at Ny-Alesund., 1.00, Arctic Data archive System (ADS), Japan, https://ads.nipr.ac.jp/dataset/A20180402-008

S3-P03

Variations of organic aerosols at Fukue Island as affected by the large-scale lockdown due to COVID-19

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[2]*Chubu University, Japan*

Carbonaceous aerosols are one of the most important components affecting the Earth's radiative forcing. Although it is quite clear that black carbon is a prominent climate forcer, the role of organic aerosol is controversial. It had been considered to cool the Earth's surface until the light-absorbing fraction, brown carbon, was found to cause warming. Specifically, even these carbonaceous aerosols are mainly emitted from the midlatitude region, they could be transported to the Arctic region and accelerate Arctic warming. The emission of black carbon in China increased before 2010 and decreased after that (Kanaya et al., 2020). However, the temporal trend of organic carbon (OC) is ambiguous due to its diverse sources, such as fossil fuel combustion, biomass burning, direct emissions from biogenic sources, and secondary formation by the oxidation of volatile organic compounds. To better understand the characteristics of carbonaceous aerosols and their effects on climate, we collected aerosol samples and analyzed carbonaceous components since late 2019 at Fukue Island, western Japan. Due to the spread of COVID-19, China implemented a large-scale lockdown in major cities from late January to early April in 2020. As a result, economic activities are largely restricted, where emissions of carbonaceous aerosols would possibly change. In this work, we found that during the lockdown period, carbonaceous aerosols decreased in February and rebounded in April at Fukue (Figure 1). The sources of OC and $PM_{2.5}$ were evaluated using the organic tracer method and positive matrix factorization method, respectively. OC and $PM_{2.5}$ from oxidation of aromatic hydrocarbons in the lockdown period decreased by 34% and 19% than the previous month, respectively, indicating decreased anthropogenic activities from transport and industry sectors. Meanwhile, OC and $PM_{2.5}$ from biomass burning increased by 39% and 6% in the lockdown period, respectively, indicating the continuous effects of biomass burning from domestic sector. Our findings provide information to better understand the dynamics and emission controls of carbonaceous aerosols in East Asia.

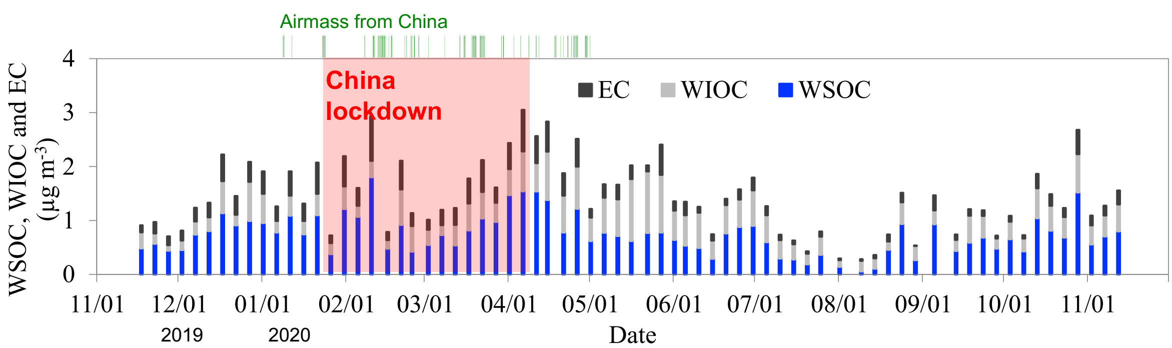

Figure 1. Temporal variation of elemental carbon (EC), water-insoluble organic carbon (WISC) and water-soluble organic carbon (WSOC) in $PM_{2.5}$ aerosols at Fukue from late 2019 to 2020.

Reference

Kanaya, Y., Yamaji, K., Miyakawa, T., Taketani, F., Zhu, C., Choi, Y., Komazaki, Y., Ikeda, K., Kondo, Y., and Klimont, Z.: Rapid reduction of black carbon emissions from China: evidence from 2009–2019 observations on Fukue Island, Japan, *Atmos. Chem. Phys.* **20**, 6339–6356 (2020)

Shipborne observations of black carbon aerosols in the Arctic Ocean during summer and autumn 2016–2020

Yange Deng[1]*, Hiroshi Tanimoto[1], Kohei Ikeda[1], Sohiko Kameyama[2], Yuko Omori[3], Jinyoung Jung[4], Young Jun Yoon[4], Eun Jin Yang[4] and Sung-Ho Kang[4]

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Black carbon aerosol (BC) is considered an important contributor to the fast climate warming and snow and sea ice melting in the Arctic. However, the concentration level and origins of the Arctic BC are not well understood. We made shipborne observations of BC mass concentration (m_{BC}) using light absorption methods in the Arctic Ocean as well as western North Pacific in July to October in the years of 2016 to 2020. The arithmetic mean values of m_{BC} in the Arctic were comparable to those obtained in NOAA Barrow Observatory in Alaska during the same period using the same technique [1]. The background m_{BC} in the Arctic was estimated to be less than 10 ng m^{-3}. Nine BC episodes - defined as periods when 1-hr m_{BC} was continuously higher than 10 ng m^{-3} for more than 18 hours - were identified. Furthermore, BC-tagged tracer simulations were conducted using a global chemistry transport model (GEOS-Chem v13.1.2) [2]. On average, the model reproduced 53 % of the observed variations of m_{BC}. According to the model, 67–89 % of BC in the Arctic during the observation periods was from biomass burning emissions. Biomass burning aerosols from Siberia were likely to be the main contributor to two distinct BC episodes that were well reproduced by the model. As an example, the observational and model results as well as the latitude of ship during the cruise in 2018 are shown in Figure 1.

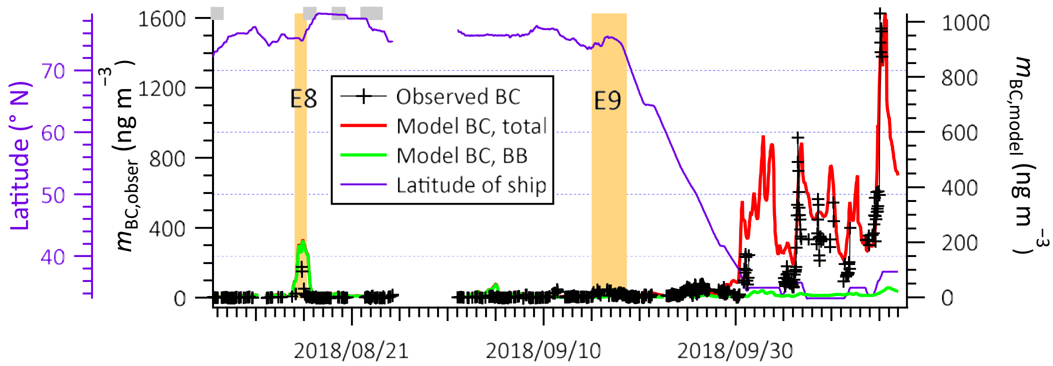

Figure 1. Time series of observed and model-simulated m_{BC}, and latitude of the ship positions during the cruise in 2018. Brown shades indicate BC Episodes. Grey shades indicate periods used for the calculation of background m_{BC}.

References

[1] S. Ohata et al., Arctic sea ice change in winter, Black carbon mass concentrations and aerosol light absorption coefficients measured at Arctic sites, 1.01, *Arctic Data archive System (ADS), Japan* (2021)
[2] K. Iketa et al., Tagged tracer simulations of black carbon in the Arctic: transport, source contributions, and budget, *Atmospheric Chemistry and Physics* 17, 10515–10533 (2017)

S4-P01

Spatial and temporal variations of surface seawater carbonate properties in the western Arctic Ocean: Results from the R/V *Mirai* observations

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To understand marine carbon cycle in a high-latitude region, since the 1990's, we have conducted observations of surface seawater partial pressures of CO_2 (pCO_2) and total dissolved inorganic carbon (TCO_2) in the western Arctic Ocean (north of 60°N) mostly in summer, using the R/V *Mirai* of JAMSTEC. From the pCO_2 and TCO_2 data, surface seawater properties such as total alkalinity (TA), pH, calcite (Ωc) and aragonite (Ωa) saturation states, and buffer factor were calculated. At the time of writing this abstract, we obtained 5425 data on these surface seawater properties from the R/V *Mirai*'s cruises in 2000, 2002, 2017, 2018, 2019, and 2021. Preliminary results of linear trend analysis showed that the pCO_2, TCO_2, TA, Ωc, Ωa, and buffer factor had statistically-significant trends: e.g., 1.9 μatm year^{-1} and 2.6 μmol kg^{-1} year^{-1} for pCO_2 and TCO_2, respectively. However, good-of-fitness tests were insignificant, except for TCO_2. High spatial variations of each property seem to be one of the reasons causing the low good-of-fits of the linear trends. For example, surface seawater Ωa revealed high spatial variations ranging from 2.60 to 0.81, and large differences of the Ωa even in a same cruise. It is important to consider physical and biogeochemical dynamics in the ocean, which strengthen the spatial variations, when detections of linear trends are attempted. At the time of the presentation, we will introduce updated results.

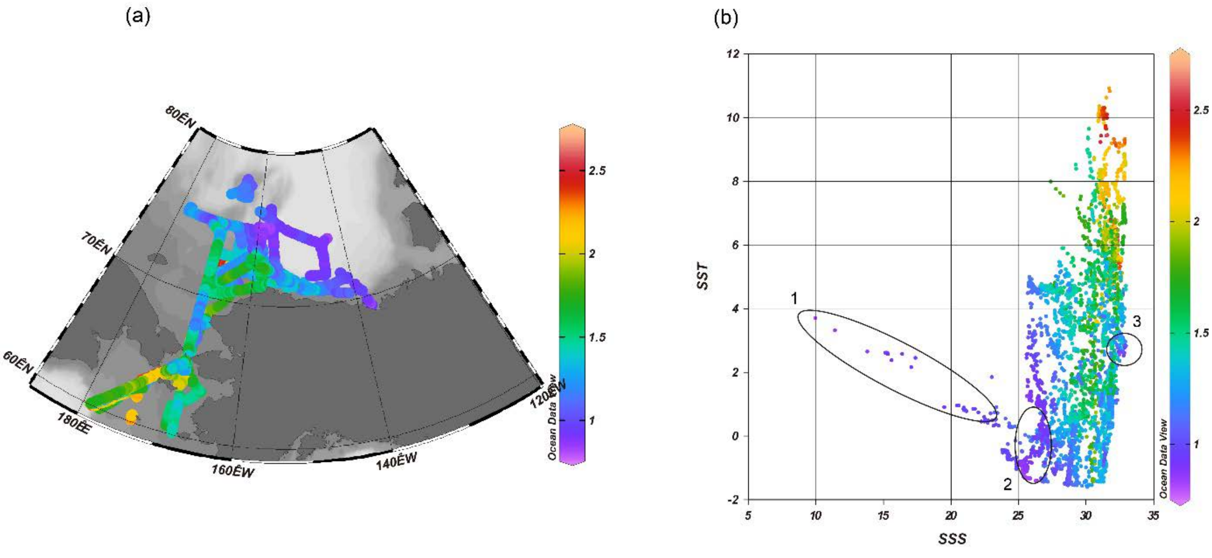

Figure 1. (a) Distributions of Ωa in the western Arctic Ocean. (b) T−S diagram with Ωa, which is the same as in Fig. 1a. The ellipses 1, 2, and 3 illustrate seawaters of Ωa < ~1.0. The seawaters with ellipse 1 were found in the easternmost area in the region, probably influenced by the discharge of the Mackenzie River, while the seawaters with ellipse 2 were found in the Canada Basin or slope regions of the basin. The seawaters with ellipse 3 were observed in the Chukchi Sea shelf.

Seasonal variation in nutrient concentration of the Pacific-origin water from the Chukchi Sea to the Canada Basin

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[2] *Japan Agency for Marine-Earth Science and Technology, Japan*

The Pacific-origin waters flowing through the Bering Strait is the main transporter of nutrients to the Canada Basin and to the whole Arctic Ocean. The depth to which nutrients enters are critical for photosynthetic organisms and thus for the ecosystem of the Canada Basin. In resent years, freshening of nutrient-rich Winter Pacific Water (PWW) and warming of nutrient-depleted Summer Pacific Water (SWW) are observed in the Bering Strait. These changes density of Pacific waters and alter the fate of nutrients entering in the Canada Basin. In order to understand nutrient concentration of Pacific Water in different seasons and processes determining it, we have conducted a mooring observation in the Barrow Canyon, at the entrance to the Canada Basin from September 2021 to September 2022. A nitrate sensor and a water sampler were deployed at 43 m, together with other sensors such as CTD, oxygen, and fluorescence, to monitor water properties of low salinity variety of the Pacific Water that should enter shallow layer of the Canada Basin. In our presentation, we will show preliminary results of these observations.

During the one-year observation, salinity varied from 29.7 to 32.6, and temperature varied from -1.8 to 5.8℃. During the winter months, salinity largely fluctuated between 29.9 to 32.3, while temperature was within 1℃ above the freezing point. Nitrate concentration increased from ~0 in summer to 10~20 μM in winter. Nitrate in winter water is as high as nutrient maximum layer found in the Canada Basin, though salinity is much lower (mean S=31.4, compared to S=33.1 for nutrient maximum layer). Relationships between nitrate and salinity or oxygen differed among months. Linear correlations were found in December, March, and April, and nitrate-oxygen relationship in these months were close to that expected from the Redfield ratio, indicating remineralization as the source of nitrate. The density ($\sigma\theta$) of high nitrate waters observed in winter ranged from 24.0 to 26.0, with the mean value of 25.2. Therefore, this water should enter the 50-100 m layer of the Canada Basin and can support biological production in the subsurface layer. This study shows the evidence that the low salinity variety of Pacific water formed in winter can transport significant amount of nitrate to the Canada Basin.

S7-P01

Stable Water Isotopes and Tritium Concentrations Reveal Seasonal Contributions of Ground Ice and Snow Meltwater to the Lena River Basin

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The water cycle in the Arctic region, especially in northern Eurasia, is drastically changing due to global warming [1]. To better understand the changing climate condition, it is crucial to assess the contribution of ground ice-melt water to Arctic river discharge. Stable water isotopes and tritium concentrations can help to detect the fraction of ground ice-melt water in Arctic river discharge [2]. Thus, we sampled river water around every 10 days at the Tabaga hydrological station located at the middle reach of the Lena River basin from April 2020 to March 2021. The stable isotope ratios of water and tritium concentration showed distinct seasonal variations, both were lower in winter and higher in summer. However, interrelation among water level, stable isotope ratios, and tritium concentrations showed complex seasonal variations; tritium concentrations were elevated during the higher water level season, while stable isotope ratios did not show such a clear signal. Because hysteresis was detected between tritium concentrations and stable isotope ratios, the seasonality of contributions of ground ice-melt water and snow-melt water to the Lena River discharge seems to differ. Consequently, to accurately assess the Lena River discharge in a changing climate, it is necessary to evaluate both ground ice-melt water and water rejuvenation through snow melt using a hydrological model which includes water age module [3].

This work was conducted as part of the HYPE-ERAS project funded by FORMAS (project DNR: 2019-02332), RFBR (project No. 20-55-71005), and JST (Grant No. JPMJBF2003) through the Belmont Forum Collaborative Research Action: Resilience in the Rapidly Changing Arctic. It was also supported by the Japan Society for the Promotion of Science KAKENHI (Grant Numbers 19H05668 and 21H04934).

References

[1] T. Hiyama et al., Recent interdecadal changes in the interannual variability of precipitation and atmospheric circulation over northern Eurasia, *Environmental Research Letters* **11** (2016)
[2] L. Lebedeva et al., Tritium in natural water of the Lena River basin, *Geography and Natural Resources* **43** (2022)
[3] H. Park et al., Contribution of water rejuvenation induced by climate warming to evapotranspiration in a Siberian boreal forest, *Front. Earth Sci.: Hydrosphere* **10** (2022)

S7-P02

Seasonal Variation of Stable Isotopes in Precipitation at Fairbanks, Alaska

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Global warming is progressing in recent years, especially in the high latitudes of the Northern Hemisphere. It is empirically known that stable isotope ratios in precipitation have a strong positive correlation with air temperature, well known as the temperature effect. So, stable oxygen isotope records are an important proxy for reconstructing past climate. The purpose of this study is to consider factors controlling the seasonal variation of stable isotopes in precipitation observed at the inland area of Alaska. Precipitation sampling was conducted at the University of Alaska Fairbanks from October 2017 to August 2021, totally 275 samples during the observation period. Temporal variations in daily $\delta^{18}O$ in precipitation and air temperature are shown in Figure 1. The monthly mean stable isotopic values were calculated weighted by the precipitation amount. As a result, the $\delta^{18}O$ and d-excess in precipitation ranged from -31.5‰ in winter to -11.9‰ in summer and from -10‰ in May-June to +12‰ in November-December, respectively, indicating clear seasonal variations. The positive correlation was found between $\delta^{18}O$ and temperature, the correlation coefficient was 0.76 with statistically significant. The slope of the regression equation was 0.27‰/°C, indicating a temperature effect. A significant positive correlation was obtained with a slope of the regression equation of 0.28‰/°C and a coefficient of determination of 0.30 for seasons other than summer, however, a significant correlation was not found only in summer. For further study, we would like to consider factors controlling stable isotopes in precipitation from atmospheric circulation fields and water vapor origins by using an isotope circulation model and back-trajectory analysis.

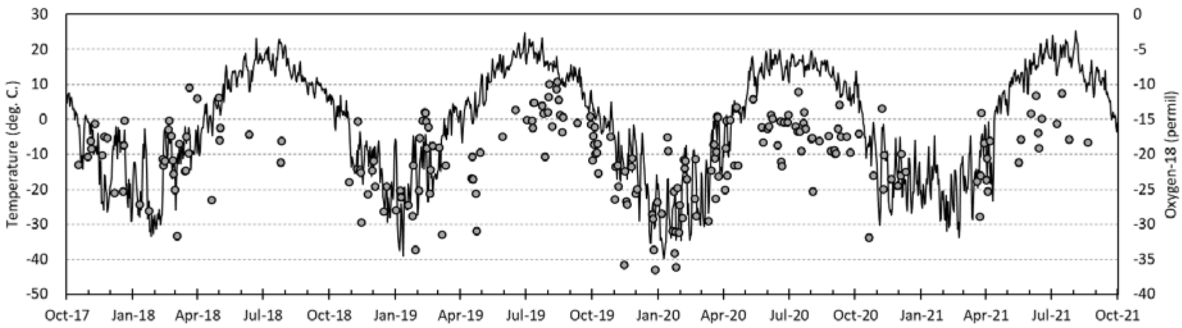

Figure 1. Daily $\delta^{18}O$ in precipitation (dots) and air temperature (line) observed at Fairbanks.

Freshwater budget of the Sea of Okhotsk and sea ice variability

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[3]*The University of Tokyo, Japan*

Like the Arctic Ocean, the Okhotsk is an enclosed sea with favorable conditions for sea ice formation. The low salinity layer formed by freshwater inflows prevents vertical mixing with deeper water and cold air from Siberia efficiently lowers water temperature at the sea surface. When people visit the Okhotsk coast for tourism in winter, it is announced that "the Amur River is the major freshwater inflow into the Okhotsk Sea and that is important for sea ice formation." Is that reasonable? Besides the Amur, there are other sources of freshwater inflows into the Sea; river discharge from surrounding land areas excluding the Amur basin, precipitation over the sea, and seawater exchanges between the surrounding ocean.

First, we quantitatively estimated the freshwater budget of the Sea of Okhotsk. Tachibana et al. (2008) investigated the water budget in the Amur River and we applied almost the same analysis method. We estimated moisture flux and net precipitation over the Okhotsk Sea using meteorological data (JRA-55) based on the atmospheric water budget. Figure 1 shows the seasonal cycle of moisture flux convergence (MFC). As expected, the MFC shows large values from May to August with a local minimum in June. The correlation and composite analyses indicated that the MFC and 850hPa geopotential height (z850) were negatively correlated during the summer months and positive anomalies of z850 emerged over the Okhotsk region. This implies that the Okhotsk High reduces the precipitation in June. We further examined linkages among net precipitation, moisture transport and atmospheric circulation over the region, and sea ice concentration (SIC), water temperature and salinity in the Sea. The results indicated that the MFC and SIC have a negative correlation and the associated atmospheric circulation anomalies indicate a weakening of the Aleutian Low.

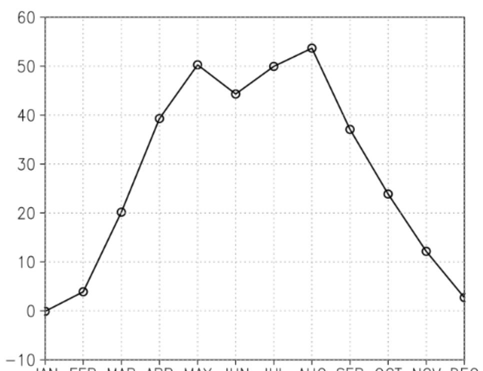

Figure 1. Climatological seasonal cycle of moisture flux convergence (MFC) over the Okhotsk Sea region. Unit is mm/month.

References
[1] Tachibana, Y., Oshima, K., and Ogi, M. (2008), Seasonal and interannual variations of Amur River discharge and their relationships to large-scale atmospheric patterns and moisture fluxes, J. Geophys. Res., 113, D16102, doi:10.1029/2007JD009555.

S7-P04

HYPE-ERAS: A Transdisciplinary View on Climate Change Impacts on Hydrology, Permafrost and Resilience in Eastern Siberian Arctic and Sub-Arctic

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[4]*Nagoya University, Japan*

HYPE-ERAS is a transdisciplinary research project aiming to improve the understanding of climate change impacts on flooding, river ice, permafrost thawing and river coastal communities in the Republic of Sakha (Yakutia). Surveys of local community perception and adaptation to climate change impacts show a growing concern for floods and droughts, shortening of ice cover periods and rivers getting shallower [1]. Trend analysis on river stream flow shows that increasing flows are more common in larger rivers, whereas smaller rivers that freeze to the bottom are more stable [2]. Hydrological model and isotope analyses indicate that increasing rainfall and permafrost thaw both contribute to the increasing flow [3]. A new dataset was developed characterizing the permafrost landscape in high resolution [4]. Satellite and drone based remote sensing was further used to detect and quantify land surface subsidence, landscape change and loss of agricultural land as a result of permafrost thaw [5]. Satellite altimetry was used to develop so-called “virtual stations” to extend the existing river gauging stations to new locations along the Lena river. A hydrological model forecasting system was developed using in-situ and remote sensing observations of river discharge, water level, ice thickness and river ice breakup dates. Re-forecast experiments for the period 2008-2021 showed that breakup days could be predicted with a median error of 4-5 days in the area of Yakutsk and with a median error of 6 days in the other areas of the Lena river. River discharge forecasts showed skill mainly in large and medium size river basins, where the probability of detecting high flow situations were higher than the false alarm ratio at the majority of stations.

This work was conducted in the HYPE-ERAS project which is funded by FORMAS (project DNR: 2019-02332), RFBR (project No 20-55-71005) and JST (Grant No. JPMJBF2003) through the Belmont Forum Collaborative Research Action: Resilience in the Rapidly Changing Arctic.

References

[1] V. Filippova, Adaptation of the indigenous peoples to climate change effects in Yakutia: Gender aspects, Polar Science, **26** (2020).
[2] L. Lebedeva et al., Streamflow Changes of Small and Large Rivers in the Aldan River Basin, Eastern Siberia, Water, **13** (2021).
[3] H. Park et al., Quantitative separation of precipitation and permafrost waters used for evapotranspiration in a boreal forest: A numerical study using tracer model. J. Geophys. Res.: Biogeosci., **126** (2021).
[4] A.A. Shestakova et al., Mapping the main characteristics of permafrost on the basis of a permafrost-landscape map of Yakutia using GIS. Land, **10** (2021).
[5] Y. Iijima et al., 2021. Thermokarst landscape development detected by multiple-geospatial data in Churapcha, Eastern Siberia. Front. Earth Sci., **9** (2021).

Multi-actor cooperation for sustainable development of cruise tourism in the Pacific Arctic: The Case of the Russian Far East

M. Lomaeva[1], J. Saunavaara[1*]

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This paper draws on the results of a fruitful collaboration with the Russian Far East universities and research institutions as well as their Russian partners, which was funded by the Japanese Ministry of Education and Science as part of Japan Arctic Research Network Center (J-ARC Net, 2016–22) and the Human Resource Development Platform for Japan-Russia Economic Cooperation and Personnel Exchange (HaRP, 2017–22) projects. It is a case study of cooperation between central and regional government bodies and other non-state actors (such as cruise operators, nature reserves, academia, indigenous communities etc.) for sustainable development of cruise tourism in the Russian Far East, both at the domestic and transnational levels [1].

This paper examines contributions of each type of stakeholders to domestic regulations (including self-regulation), commercial undertakings, and the assessment of cruise tourism impacts on wildlife and traditional lifestyles of indigenous communities. It also provides an overview of transnational channels and mechanisms for cooperation between the actors involved (which were established before the Russian invasion of Ukraine). Another aspect covered in this study is the significance of cruise tourism in the Russian Far East development strategies, from both the central and local government perspectives, and its (potential) conflicts with other interests and uses of these marine and coastal areas (*e. g.* security, commercial navigation, nature conservation, protection of the indigenous minorities of the North and the Far East etc.) [2, 3], and how they have been addressed.

In conclusion, we discuss the impacts of the Russian invasion of Ukraine on cruise tourism in the Russian part of the Pacific Arctic, and whether cruise tourism (along with environmental protection, search and rescue etc.) may serve as a basis for re-starting transnational cooperation with Russia's North Pacific neighbors in future, and what roles (in light of the experience gained before February 2022) various types of actors may be expected to play in this process. We are fully aware of great uncertainties with respect to the shape and time frame of future cooperation, which largely depend on further steps by the Russian central and regional governments.

References

[1] M. Lomaeva, J. Saunavaara, M. Tanaka, Prospects for sustainable development of the cruise industry in the Pacific Arctic: Outcomes of the Japan-Russia online workshop held on 8–9 December 2021, *Proceedings of the 36th International Symposium on the Okhotsk Sea & Polar Oceans 2022* 136–139 (2022).
[2] G. Gomilevskaya, G. Petrova, Sea tourism as a component of the tourist brand 'The Eastern Ring of Russia', The Territory of New Opportunities. *The Herald of Vladivostok State University of Economics and Service* 71–85 (2017).
[3] N. Agaeva, I. Shchetilina and E. Kovaleva, Cruise tourism as a factor of sustainable development of the territories of the Russian Federation, *E3S Web of Conferences 295, WFSDI 2021* 1–7 (2021).

The Strategic Orientation of Russian Fishing Industry after Ukraine : What Implications for the Arctic ?

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Months after the military incursion into Ukraine, the Russian government approved a new strategy for the development of national agro-industrial and fisheries sectors until 2030, by order *No. 2567 of September 8, 2022*, taking into account the economic situation that has developed under sanctions pressure from Western countries. Two main key goals were enumerated; first to strengthen national food security, and secondly to significantly expand agricultural and seafood products exports onto foreign markets. To reach these objectives simultaneously, increase in productivity from agricultural and fishery producers has been underlined as an absolute necessity. For that purpose, development of domestic shipbuilding and construction of coastal fish processing plants were assigned as priority tasks to Russian fishery complex.

The aim of this presentation is to understand the growing importance of Russian Federation's fishing industry in the new geopolitical context, resulted from the large-scaled military actions launched against Ukraine, and to analyze the geostrategic positioning of Far East and Arctic, the most abundant coastal regions with living marine resources, in Russia's updated fisheries policy orientation. Methodologically, based on geopolitical and geoeconomics approaches, the present work will be developed into two parts. The first one will be the explanation of both "Food security" and "State Income security (of foreign accuracy)", concepts for a territory-expanding State that is targeted by international isolation attempts from a bloc. The historical case of Japan in the early 1930's will be used as an illustration for a better understanding of Russia's current strategic situation. The second part will focus on contradictions that are questioned on several ongoing reforms of Russian fishing industry since the adoption of the new fisheries strategy. On one side, the Russian government seems to have decided to accelerate the development of the Northern Maritime Route, as an alternative to the Siberian railway to facilitate; (1) domestic seafood supplies from Far East and Arctic regions to the rest of Russian territories (including controversially acquired ones), and (2) increase of valuable seafood exports to foreign markets by taking advantage of the geographical proximity of both administrative entities to Europe and Asia. But it seems that traditional fisheries actors of both regions are being excluded from that strategy, since Russian government has presented a reform to the State Duma on October 2022, defining a new redistribution system of living marine resources, that may lead to an oligopolistic domination of fishing activities by a few numbers of great-scaled companies. The potential consequences of these reforms on Far East, and especially Arctic, will be discussed from "environmental" and "demographic" security angles.

A Research on New Dimensions of Science Diplomacy and the Changing Arctic in the Anthropocene

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The Arctic region has become a natural laboratory of the Anthropocene due to the detrimental effects of climate change. Often referred to as the 'Arctic paradox', the region both affects and is affected by anthropocentric impacts within the Earth System[1]. Besides, emerging economic opportunities owing to accelerated warming indicate a multilateral setting while highlighting the essence of the Anthropocene. Therefore, how environmental and societal transitions will be addressed becomes prominent for an effective governance process. While Arctic exceptionalism is considered as inefficient due to the current Russia-Ukraine conflict, some scholars still hold faith in the soft power of science and international scientific collaborations to address global challenges. Since science diplomacy had proven effective maintaining scientific collaborations and preventing conflicts even in the Cold War period[2], international research collaborations could become a means to open alternative channels for communication and maintain peaceful relations in the High North. On the other hand, recent studies investigate the duality of science diplomacy since international scientific interaction is shaped by collaboration and competition whereas national policy objectives of a state may contradict other states[3],[4]. In addition, the non-Arctic states' growing interest in Arctic research has evoked controversial views revealing the competitive aspects of science diplomacy. Accordingly, this study aims to examine whether science diplomacy may become an effective mediator for restoring constructive relationships within the changing Arctic.

Keywords: Anthropocene, Arctic Paradox, Science Diplomacy.

References

[1] National Research Council, The Arctic in the Anthropocene, The National Academies Press: Washington, (2014).

[2] Ruffini, P. B., What is science diplomacy?. In Science and Diplomacy: A New Dimension of International Relations. Springer, (2017).

[3] Ruffin, N., Ruland, A. L., Between global collaboration and national competition: unravelling the many faces of Arctic science diplomacy, *Polar Record* 58(20), (2022).

[4] Pedersen, T., The politics of research presence in Svalbard, *The Polar Journal*, (2021).

North Greenland Inuit materials collected 50 years ago at the Little World Museum of Man

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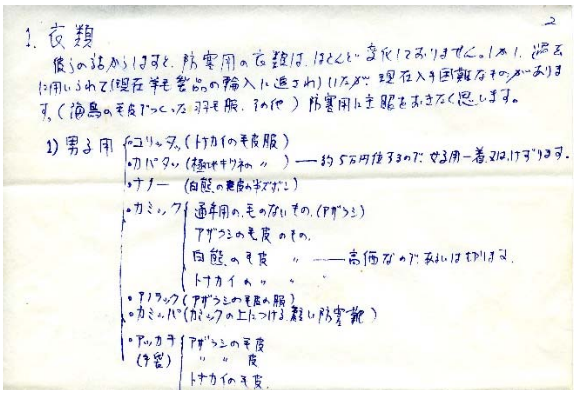
Ikuo Oshima, who has lived in Siorapaluk, North Greenland, from 1972 to the present, collected folk implements from 1972 to 1973 at the request of The Little World Museum of Man in Inuyama City, Aichi Prefecture. Mr. Oshima collected 164 pieces of folk implements and many other materials. Some folk implements, such as fur clothing and a kayak, are still displayed in the museum's exhibit room. However, letters, research notes, plans, and many photographs have not been available to the public. As a result of my research of pictures and notes, I found that there are still valuable materials, such as a photograph of a tent made of seal fur (Figure 1), which were no longer in use, even at that time. There was also a photo of the adventurer Naomi Uemura, who was living with Oshima at the time, dropping his dog sled into a crevasse and trying to pull it up. According to Oshima and the curators of the Little World, he was sent to Greenland even though he is not a researcher for the following reasons. At the time, the Little World was preparing to open and needed an exhibit that would be the park's centerpiece. Nihon University Alpine Club, which was Oshima's parent organization, had conducted an expedition to Greenland with relatively good local information, so they thought Oshima would be a good candidate.

Items in Little World's collection
-Folk implements (fur clothing, tanning tools, harpoons, knives, kayaks, dog sleds, figurines, etc.), 164 items
-Reversal films, about 1,000 items
-Photography notes
-Letters from Ikuo Oshima to Yoshio Onuki (current director of the Little World), 6 letters (Figure 2)
-Plans, 7 pages
-Research notes, 4 sheets

Figure 1. Seal fur tent



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1. 衣類

彼らの話からしますと、防寒用の衣類は、ほとんど変化しておりません。しかし、過去に用いられて(現在羊毛製品の輸入に追され)いたが、現在入手困難なものがあります。(海鳥の毛皮でつくった羽毛服、その他)防寒用に主眼をおきたく思います。

1) 男子用
・コリッタ(トナカイの毛皮服)
・カパタッ(極北キツネの 〃) —— 約5万円位するので せる用一着又はけずります.
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白熊の毛皮 〃 ——高価なので或いははぶきます.
トナカイの 〃 〃
・アノラック(アザラシの毛皮の服)
・カミッパ(カミックの上につける軽い防寒靴)
・アッカテ(手袋) アザラシの毛皮
〃 〃 皮
トナカイの毛皮.

Figure 2. Letter from Ikuo Oshima

References
[1] Oshima, I. (1989) Esukimo ni natta nihonnjin. Bungei Shunju , Tokyo.

S18-P01

Improvement of an Arctic Sea Route Search System to increase calculation speed

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In sailing in the Arctic Sea, it is essential to ensure a safe route to determine the shipping route based on the icebreaking capacity of the vessel and the sea ice conditions. If the ship is operated incorrectly, a collision with the ice could cause a serious accident. At present, such decisions depend on the experience of the crew. However, there are few opportunities to gain onboard expertise in sea ice areas. Therefore, training is required to supplement experience with actual past routes on the map. In addition to training, safer navigation would be possible if the support system supports secure and efficient navigation. Establishing a ship navigation support system for sea ice areas is an urgent issue for the development of the NSR.

This study has developed an Arctic Sea Route Search System that automatically calculates safe and efficient routes. This web application automatically obtains satellite data and calculates the optimal route according to the vessel's capabilities. The system is designed so that anyone can quickly get the optimal route by operating the GUI on the screen. The program uses the Ice Index method to estimate ship speed and the A* or θ* search method to find the optimal route. In this study, the calculation speed was improved by using GPUs for some of the calculations. The improved system resulted in calculation speeds that were 3.75 times faster on average and 7.04 times faster at the maximum compared to the previous system. We have verified the computation results by changing the search method. The validity of the algorithm was verified by comparison with AIS data. This web application will be useful for vessels that have used the NSR in the past for route confirmation and training.

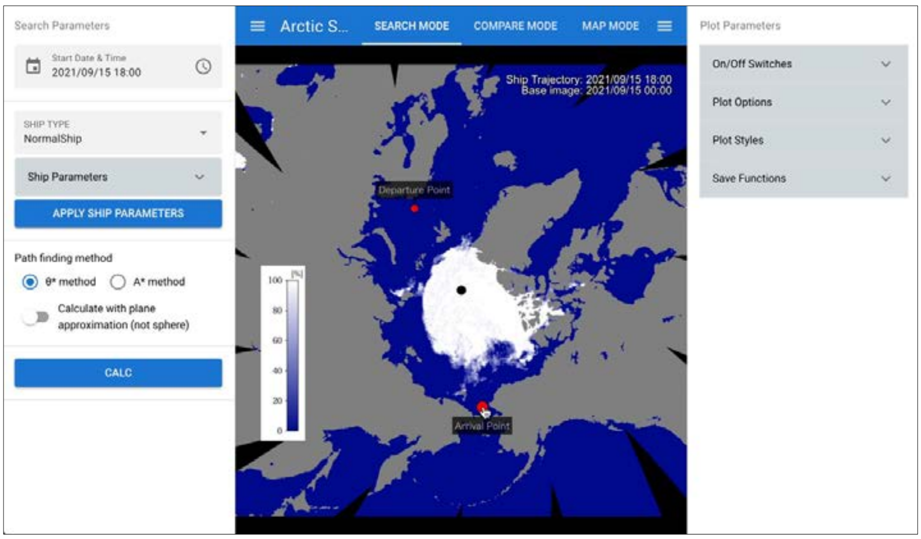

Figure 1. Snapshot of web application

References

[1] T. Sugimura, H. Yamaguchi, H. Yabuki, Development and Implementation of an Arctic Sea Route Search System. *Proc. ASME 2021 40th Intl. Conf. on Ocean, Offshore and Arctic Engineering,* **7**, (2021), https://doi.org/10.1115/OMAE2021-62238

S23-P01

Monitoring of polar snow by AMSR-E and AMSR2 satellite microwave observations

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Cryospheric change due to accelerated warming in the Arctic is a major concern (ACIA, 2005). Such a change influences the environment, resulting in atmospheric, oceanic, and terrestrial changes. Arctic research projects are sending field research groups and establishing observation sites at various places in this region. Satellite observations are available to support research planning, and evaluation of observation period and place, as these observations cover both time and space.

Observation of the melting of snow cover and ice sheets use of satellite microwave radiometers to detect moisture content in snow from microwave radiation. A method called XPGR (Cross-Polarization Gradient Ratio) has been used as a main observation algorithm since the late 1990s, and has been used in climate change research as an index of ice sheet melting. In addition, a method called Diurnal Amplitude variation (DAV) is used to observe the melting of snow cover on land. The advantages of DAV, which detects changes in surface snow, are that it is sensitive to short-term meteorological changes and captures short-term fluctuations (Alimasi, 2016). It is possible to conduct a comparative study of snow cover on land and on ice sheet. In this presentation, we examined the characteristics and precautions for using XPGR and DAV respectively. In addition, using meteorological reanalysis data, intercomparison with satellite observation, effectiveness of each method, and points to note were investigated. The data used are AMSR (2002-2011), AMSR-2 (2012-2021) and NCEP data for the same period. These methods can be applied across the polar regions.

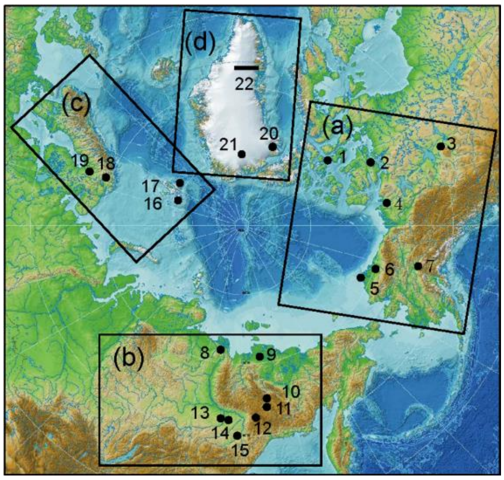

Figure 1. Arctic observation sites.

References

[1] Alimasi Nuerasimuguli and Hiroyuki Enomoto, 2017: Arctic snow monitoring through satellite microwave observations, - Estimation of snow cover and melting periods - (in Japanese), Seppyo, 79（1）17-30.

[2] ACIA, 2005: Arctic Climate Impact Assessment, Cam bridge University press, NY, 1042 pp

S23-P02

Developing a regional observing system for the pan-Arctic community

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The Svalbard Integrated Arctic Earth Observing System (SIOS) is a regional observing system for long-term in-situ and remotely sensed measurements in and around Svalbard addressing Earth System Science questions. SIOS research infrastructures are distributed all over Svalbard, in locations with permanent research settlements (Ny-Ålesund, Hornsund, Longyearbyen) as 'hot spots' of co-located measurements. These in-situ measurements are useful for various interdisciplinary research efforts, validation of global models and supporting current and future satellite missions for calibration and validation (Cal/Val) activities.

SIOS Knowledge Centre (SIOS-KC) is the hub of SIOS and provides several services. SIOS-KC connects scientists from around the world by facilitating access to research infrastructure and observations in and around Svalbard. Two of the integral products of SIOS are the data access portal and the observation facility catalogue. The former is a virtual data centre that aims to provide the means to find, download and use all Earth System Science data relevant to Svalbard. The latter allows for finding observation infrastructure that is active in the Svalbard region, but also provides information on facilities that are being planned or have been decommissioned. Further, SIOS-KC coordinates logistical services, remote sensing services, training, education programs, and produces an annual review report of the State of Environmental Science in Svalbard (SESS reports) in collaboration with SIOS member institutes. The SESS reports provide a framework for systematically enhancing the observation system in Svalbard to be a reliable and relevant data provider for the pan-Arctic community.

Figure 1. SIOS Logo

Using NEON Active Layer Sampling Methods for Pathogen Detection in Melting Permafrost

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Climate change impacts are disproportionately affecting the Arctic. Alongside warming temperatures, the region is experiencing unprecedented changes, such as carbon release, ecological and hydrological systems changes, and permafrost degradation [1]. Increased permafrost thaw represents a threat to human health due to the potential re-emergence and reanimation of frozen pathogens [2]. Several bacterial and viral pathogens can survive harsh conditions like freeze thaws and can be infectious upon reanimation. The National Ecological Observatory Network (NEON) offers open, standardized, environmental datasets from across the United States, including field sites in permafrost ecosystems [3]. The NEON Assignable Assets Program allows members of the community to leverage NEON's infrastructure and on-site field scientists to support their own research. NEON's field sites, staffing resources, and Battelle's experienced metagenomic sequencing laboratories provide a unique opportunity for identifying bacterial and viral pathogens present in permafrost melt that may reanimate in a warming climate.

Here we used NEON's arctic groundwater sampling protocol [4] to extract active layer meltwater from up to 8 locations at Toolik Lake (TOOK) and Caribou Creek (CARI) field sites. We examined NEON's historical thaw data to target sample windows that coincided with maximum annual thaw and liquid water presence. Samples were collected by NEON field scientists and were sequenced using Twist Biosciences Pan viral hybridization panel to detect any viral pathogens and 16S sequencing for detection of bacterial pathogens. Several microorganisms were identified in each sample, both nonpathogens and those with pathogenic potential. Future work will determine viability of pathogens identified in the meltwater to determine the risk potential with continuing climate change. Preliminary data suggests that NEON's sampling method proves an accessible, rapid, and inexpensive option for collecting samples for pathogen detection as warming temperatures continue to alter the arctic landscape.

References

[1] Stella, E., Mari, L., Gabrieli, J. et al. Permafrost dynamics and the risk of anthrax transmission: a modelling study. Sci Rep 10, 16460 (2020). https://doi.org/10.1038/s41598-020-72440-6.
[2] Miner et al. Emergent biogeochemical risks from Arctic permafrost degradation. Nat. Clim. Chang. 11, 809–819 (2021). https://doi.org/10.1038/s41558-021-01162-y
[3] NEON (National Ecological Observatory Network) Data Portal. https://data.neonscience.org
[4] Goodman, K. and Catolico, N. AOS Protocol and Procedure: SWC – Water Chemistry Sampling in Surface Waters and Groundwater. NEON.DOC.002905vH. NEON (National Ecological Observatory Network).

S23-P04

Data Management of Arctic Project in Japan

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Arctic is the region where the global warming is mostly amplificated, and the atmosphere - ocean - cryosphere - land system is changing. Active promotion of Arctic environmental research, it is large and responsible for observational data. Promotion of Arctic research in Japan, has not been subjected to independent in their respective fields.

In the National Institute of Polar Research, perform the integration and sharing of data across a multi-disciplinary such as atmosphere, ocean, snow and ice, land, ecosystem, model, for the purpose of cooperation and integration across disciplines, we build the Arctic Data archive System (ADS).

Arctic Data archive System (ADS), to promote the mutual use of the data across a multi-disciplinary to collect and share data sets, such as observational data, satellite data, numerical experiment data. Through these data sets, clarify of actual conditions and processes of climate change on the Arctic region, and further contribute to assessment of the impact of global warming in the Arctic environmental change, to improve the future prediction accuracy.

A new project of the Arctic research (ArCS II: Arctic Challenge for Sustainability II) has been started in 2020. ArCS II is a national flagship project funded by the Ministry of Education, Culture, Sports, Science and Technology (MEXT). The National Institute of Polar Research (NIPR), Japan Agency for Marine-Earth Science and Technology (JAMSTEC) and Hokkaido University are playing the key roles in this project and will continue to carry it out for approximately four-and-a-half years from June 2020 to March 2025. Arctic Data archive System (ADS) is responsible for the data management of this project.

On the other hand, the National Institute of Polar Research to operate the ADS, has acquired a wide variety of polar science data through Japanese Antarctic research expedition (JARE) and Arctic research project. The data has been published through “JARE date reports” and “NIPR Arctic Data Reports”. ADS has also started assigned data DOI as a system that provides a permanent link to published data. NIPR has targeted quality-controlled data as a condition for assigning data DOI. In addition to discussing the use of peer review frameworks in data journals to ensure data quality, the role of “JARE date reports” and “NIPR Arctic Data Reports” was reconsidered. NIPR has published a new data journal "Polar Data Journal" for the purpose of distributing quality-controlled actual data. ADS play a role as a main data repository for "Polar Data Journal". PDJ publication and ADS collaboration will contribute to the promotion of open science.

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