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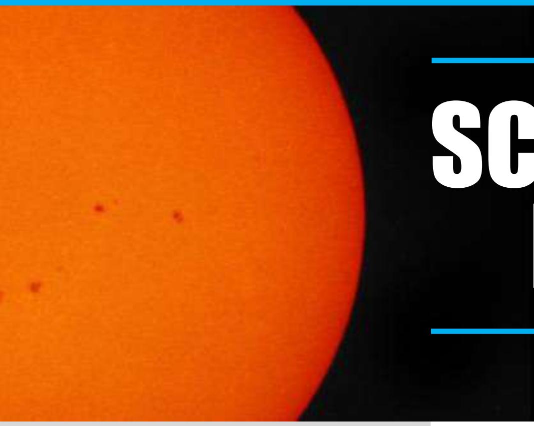

Inside this issue

Article 1:

COURSE: Cross-scale cOUpling pRocesses in the Solar-teErestrial system - The SCOSTEP's new program for 2026-2030 is drafted by the Next Scientific Program committee

Monica Laurenza

Monica Laurenza[1, 2] and the SCOSTEP's Next Scientific Program committee
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The committee nominated to define the Scientific Committee on Solar-Terrestrial Physics (SCOSTEP) Next Scientific Program (NSP) has identified *cross-scale coupling* as the overarching theme for conducting and promoting co-ordinated research and outreach activities in the upcoming period 2026-2030. The program is called COURSE: Cross-scale cOUpling pRocesses in the Solar-tErrestrial system, and is organised in three main scientific Focus Areas: 1) Sources of Space Weather and Space Climate: 2) Solar wind, Magnetosphere,

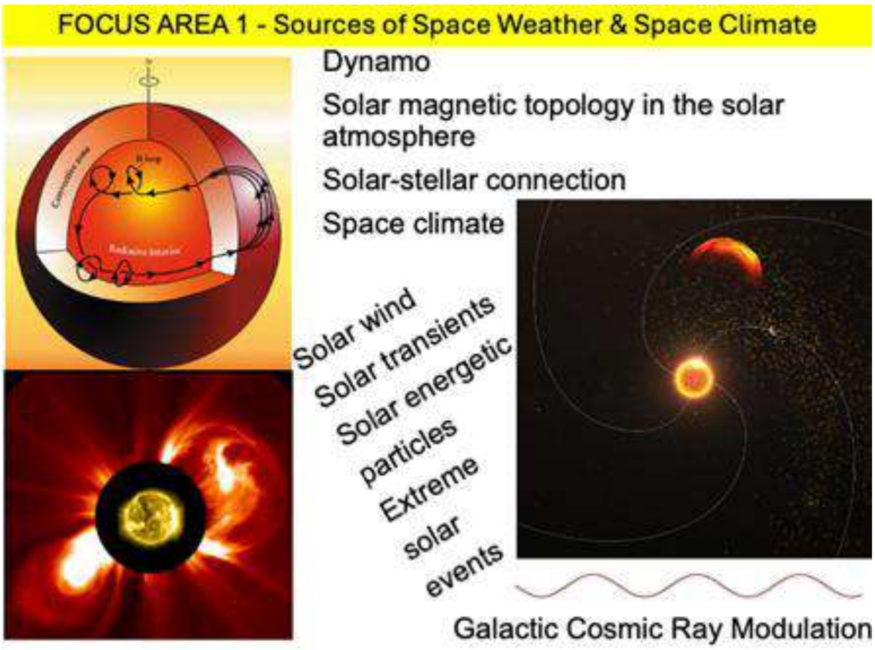

Figure 1. Schematics of Focus Area 1 main topics.

and Ionosphere coupling; 3) External impacts and internal dynamics of the Earth atmosphere. For each Focus Area the NSP committee has identified: 1) long-standing goals, i.e., key questions persistent through SCOSTEP scientific programs; and 2) objectives, i.e., precise outcomes that can be addressed over the 5-year program duration, which contribute to achieving the goals over the long term. Moreover, the committee envisions the implementation of the program through: identified novel methods, including machine learning (ML) and Artificial Intelligence (AI) techniques; integrated models; new missions; the combination of multipoint in-situ data with ground observations; improved metadata; and adoption of Findable, Accessible, Interoperable, and Reusable (FAIR) principles. This short article describes a brief overview of the COURSE program. More detailed descriptions will be published later in a refereed journal.

The COURSE program

The Sun is the primary driver of space weather and space climate, affecting the whole Heliosphere. Solar activity is variable over a wide range of spatial and temporal scales and many processes in the solar terrestrial system are coupled across different spatial, temporal, and energy scales, including: the generation of the solar magnetic fields through the solar dynamo; the coupling of the solar interior with the surface where magnetic flux emerges; the plasma and magnetic field motion and re-configuration in the solar atmosphere, involving different coupled scales, leading to transient eruptive events, such as coronal mass ejections (CMEs), flares, solar energetic particles (SEPs); the cross-scale coupling between the solar wind and its transient and corotating perturbations (interplanetary CME, stream interaction regions- SIRs, corotating interaction regions-CIRs) with the magnetosphere and the ionosphere; cross -coupling across the geospace – atmosphere system.

Cosmic rays are another important source of Space Weather and Space Climate and a proxy of interplanetary perturbations as well. The propagation in the Heliosphere down to the magnetosphere and interaction with the atmosphere also involve several cross-scale coupled processes, such as small-scale diffusion and large-scale drifts.

Understanding the basic mechanisms of the cross-scale coupled processes from the Sun to the Earth and those underlying the cosmic ray propagation is of primary importance both for:

- making significant advances in solar-terrestrial Physics;
- realising a quality leap in our capabilities to predict Space Weather (SWE), address Space Climate effects, and ensure effective mitigation;
- preparing for human exploration.

The SCOSTEP Next Scientific Program, called COURSE, (Cross-scale cOUpling pRocesses in the Solar-tErrestrial system) aims at facilitating a comprehensive and interdisciplinary approach through focused, internationally coordinated efforts addressing the cross-scale coupling processes in the Sun-Earth system, i.e., in and between different regions, plasma regimes, and particle populations, ranging across short term (seconds to days) space weather to long-term (decades to centuries) climate timescales, a great variety of spatial scales from plasma kinetic scales to many AUs, and a wide range of energies (1 eV to GeVs).

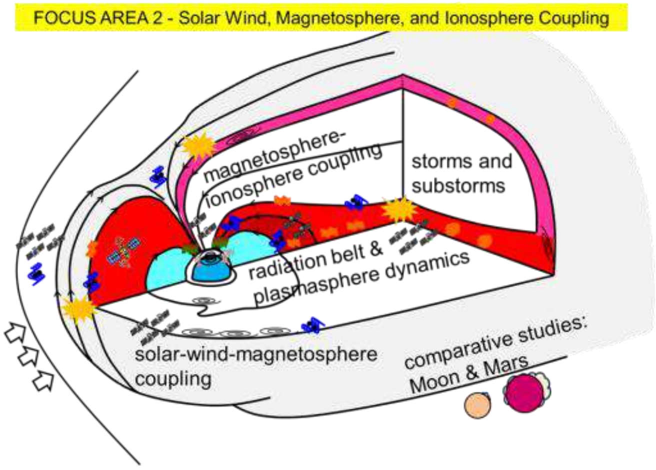

Figure 2. Schematics of Focus Area 2 main topics.

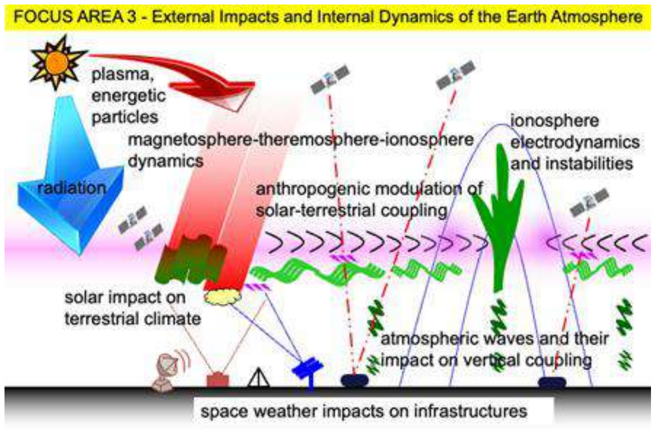

Figure 3. Schematics of Focus Area 3 main topics.

The program is organised in three Focus Areas namely: 1) Sources of Space Weather and Space Climate: 2) Solar wind, Magnetosphere, and Ionosphere coupling; 3) External impacts and Internal dynamics of the Earth atmosphere.

For each Focus Area, the program contains identified scientific goals outlining the ultimate aim or desired outcome of the research that are persistent through scientific programs, to set the direction and provide the overarching context for studying solar terrestrial relationships. Moreover, it specifies objectives, i.e. specific, measurable statements detailing what the research aims to achieve. Objectives are narrower than goals and define precise outcomes that contribute to achieving the goal. Objectives should be reached over the next scientific program. The main topics addressed in Focus Areas 1, 2, and 3 are highlighted in Figures 1, 2, and 3, respectively.

The three Focus Areas are naturally interconnected through cross-scale coupled physical processes, e.g., reconnection, turbulence, waves, wave-particle interaction, shocks, instabilities, common to the different regions of the solar terrestrial system and several other overarching themes, such as societal impacts, extreme events, human and robotic exploration, improving predictions.

Methodology and implementation

The NSP includes the suggested methodology, i.e., the approach or procedures used to conduct the research and help answer the scientific questions. Recommendations are provided to the community to achieve the proposed objectives. In particular, the program highlights the promising techniques, tools, and processes, also including Machine Learning (ML), employed to collect, analyze, and interpret data, but also the necessity of developing integrated models and the need of their validation, as well as the importance of new observations from next generation missions, multipoint data, combination of space and ground-based observations.

The program encourages the scientific community to support and extend ground-based networks, to continue practice of observing campaigns and preserving data, to perform cross-calibration of data, to use data standards, metadata systems, give credit for data, and to adopt FAIR principles.

To implement the program to address any one of the proposed questions, it is recommended to form a core team comprising of international experts to attack the question of interest consistently and persistently for a period between 3 and 5 years. Focus area leaders have the flexibility of forming new teams or dismantling old teams as the program evolves. While "SCOSTEP/COURSE" provides the seed funding, the teamwork shall help the participants apply for research support (grants etc) from their home countries. In addition to in-person meetings, the virtual meetings shall facilitate the continuing collaborative efforts of the team members.

The members of the Next Scientific Committee are: Carine Briand, Maria Graciela Molina, John Bosco Habarulema, Natalie Krivova, Kanya Kusano, Hanli Liu, Monica Laurenza (chair), Hilde Nesse, Jana Šafránková, Jie Zhang, Qiugang Zong. The SCOSTEP Representatives, Kazuo Shiokawa (President), Bernd Funke (Vice President), and Nat Gopalswamy (Past President) also joined the committee. The NSP committee meetings were held in 1) Nagoya, Japan, on 18-21 June 2024 and in 2) Rome, Italy in 14-17 October 2024. We are grateful to all the invited experts who joined the meetings i: 1) Prayitno Abadi, Hisashi Hayakawa, Lan Jian, Masayoshi Kozai, Young-Sil Kwak, Fusa Miyake, Yoshizumi Miyoshi , Kazuoki Munakata , Yuichi Otsuka, Kaoru Sato, Matthew J. West; 2) Tommaso Alberti, Dalia Buresova, Jorge Chau, Odele Coddington, Sergio Dasso, Shin Fung, Keith Groves, Federica Marcucci, Rumi Nakamura, Claudia Stolle, Manuela Temmer , Ilya Usoskin.

Article 2:

Updating the International GLE Database to Include Non-Standard Detector Records


Koldobskiy Sergey


Aksar Ibragimov

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The study of high-intensity fluxes of solar energetic particles is fundamental to understanding the processes of particle transport and acceleration on the Sun and in interplanetary space. Additionally, it plays a critical role in assessing radiation hazards in space and even for regular flights in polar regions. While space-borne experiments have limited capabilities for registering high-energy solar energetic particle (SEP) fluxes, these fluxes can be effectively measured using ground-based detectors. Such SEP events are referred to as Ground Level Enhancements (GLEs) [1]. Since the mid-1950s, a global network of standardized neutron monitors has been established. These monitors, which primarily detect the nucleonic component of secondary particle showers, have recorded GLEs starting from GLE #5 (23-Feb-1956) [2], [3] to the most recent events observed in 2024.

Around the start of observations, international collaboration on NM data exchange was initiated, initially through mail correspondence, but by the end of the 1960s, it became evident that the creation of an archive of all GLE records was necessary. Over time, and with the advent of the Internet, this archive was made accessible online. Currently, the University of Oulu hosts the International GLE database (IGLED, gle.oulu.fi, [4]), which collects NM records for all GLE events starting from GLE #5. These records are displayed through a web interface and made available for download. We also add information about new GLEs shortly after their registration.

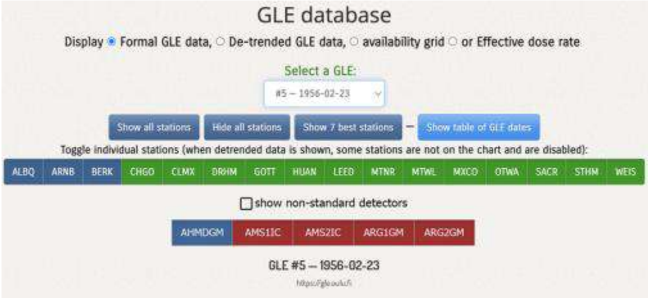

Figure 1. Prototype of updated interface of IGLED with the option to show non-standard detector records.

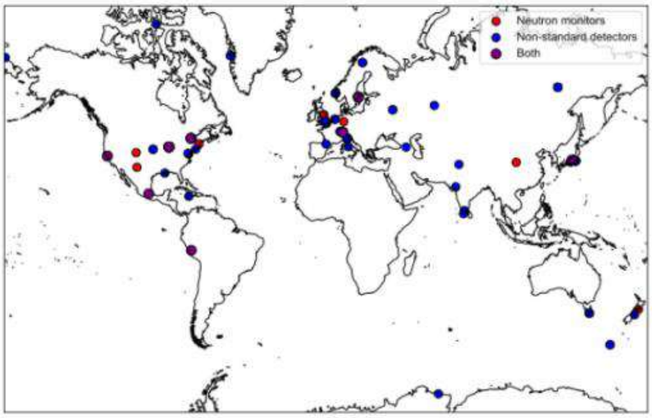

Figure 2. Locations of GLE #5 measurements by neutron monitors (red), non-standard devices (blue), and locations where both types of detectors were installed (purple).

However, the registration of the earliest known GLEs (#1–4), as well as some early events registered with NMs (notably, #5, the strongest one, and #8), was also performed using detectors other than NMs, such as ionization chambers and Geiger-Müller counters. These detectors were non-standardized; even the design of ionization chambers could differ from site to site, affecting the detectors' response to SEP particles. Nonetheless, these early GLE records represent a priceless dataset, extending the statistics of the high-energy SEP events back to solar cycles 17 and 18.

With this aim, we plan to modify the web interface of IGLED for the inclusion of non-standard records. The work on the modification of the web interface was supported by SCOSTEP. Here, we present the prototype of the updated interface that incorporates non-standard records. The new version of the interface contains a checkbox labelled "Show non-standard data," which is disabled by default for all GLE events and hidden if the given GLE does not have non-standard data. When there is non-standard data for a given GLE and the checkbox is selected, the option to display the signal from these detectors becomes available interactively and can be downloaded in the standard IGLED format. For non-standard GLE records, we have introduced a new color scheme in addition to green (used for selected GLE records) and blue (for unselected records). Non-standard detector records are displayed with dark red shades (for selected records, unselected ones remain blue).

The update is expected to become operational around the summer of 2025.

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Article 3:

An Active Region Database for Solar Cycle Variability and Prediction

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Ruihui Wang   Jie Jiang   Yukun Luo

Solar active regions (ARs) are areas where strong magnetic fields are distributed. Within the framework of the Babcock–Leighton (BL) dynamo, the emergence of ARs and the subsequent transport of erupted AR flux on the surface reverse the polar field, and build a polar field with the opposite polarity. The polar field in solar minimum determines the subsequent cycle strength [1, 2]. The contribution of an AR to the polar field is measured by its axial dipole field (or axial dipole moment), which results from flux emergence and subsequent flux transport over the solar surface [3]. If the dipole fields of all ARs in a cycle are known, we can predict the polar field in solar minimum, and the strength of the following cycle.

Recent studies have emphasized the importance of considering the actual configuration of active regions (ARs) to obtain their dipole fields, rather than relying on the commonly used bipolar magnetic region (BMR) approximation [4]. Therefore, we developed a method to automatically detect ARs from SOHO/MDI and SDO/HMI synoptic magnetograms [5]. Our method is based on morphological operations and region growing. An example of detection results is shown in Figure 1. We then calibrate the detections from MDI and HMI synoptic magnetograms to ensure consistency. Based on these detection results, we provide the fundamental AR parameters, such as number, area, and flux. Figure 2 demonstrates that our results are consistent with other databases, which shows the homogeneity and reliability of our database.

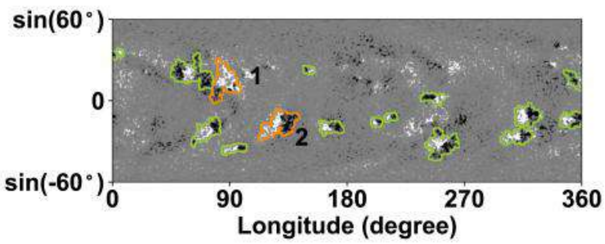

Figure 1. An example of the AR detection and repeat-AR-removal. The two ARs labeled with orange lines are repeat ARs, and the other ARs labeled with green lines are new ARs. The map is the MDI synoptic magnetogram of CR 1968.

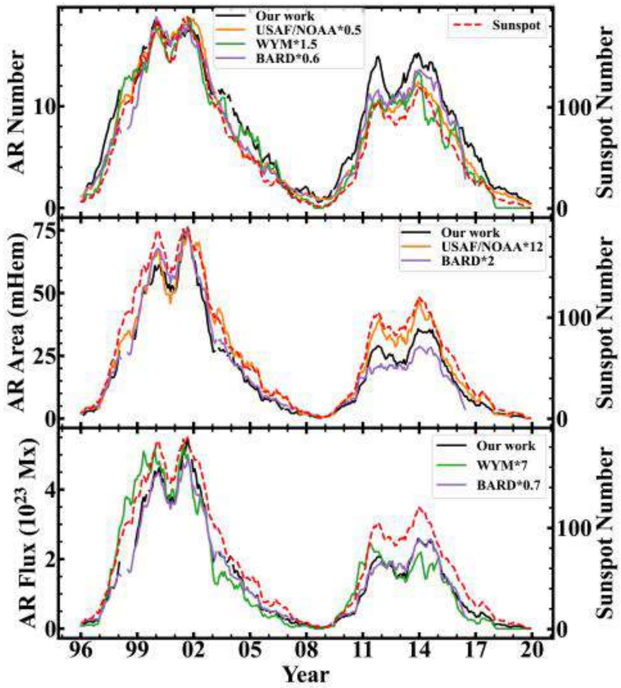

Figure 2. Comparison of our results (black) with those of other databases in terms of number (top), area (middle), and flux (bottom).

Furthermore, we calculate the AR dipole fields and their corresponding results with BMR approximation. The calculation method and additional details are provided in our paper [6]. Since some ARs can live for many CRs and significantly impact the end-of-cycle polar field, we identify and remove the repeat detections from our database. The detection results of repeat ARs are also shown in Figure 1.

The database and associated codes are freely available to everyone on GitHub (https://github.com/Wang-Ruihui/A-live-homogeneous-database-of-solar-active-regions). It currently comprises 3248 ARs (with 243 repeat ARs) spanning from CR 1909 to CR 2290 (1996.5–2024.11). We offer two versions of the database: one includes all detected ARs, and the other excludes repeat ARs. Both versions contain the same parameters, including the latitude and longitude of the flux -weighted centroid for both polarities and the entire AR, the area, the flux of each polarity, the maximum magnetic field of the entire AR, the dipole fields, and dipole fields with BMR approximations. Additionally, we provide low-resolution (180*360) maps of detected AR on the website.

We plan to continuously extend the time range of the database. The constantly updated database, covering more than two full solar cycles, will be beneficial for understanding and prediction of the solar cycle. It will also serve as an important resource for applying the surface flux transport model to study the evolution of the solar surface magnetic field and provide boundary conditions for global coronal magnetic field simulations.

Acknowledgements

The database is supported by SCOSTEP/PRESTO 2024 database grant, the National Key R&D Program of China No. 2022YFF0503800, the National Natural Science Foundation of China Nos. 12173005 and 12350004.

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Article 4:

Creation of an open database of original and annotated sunspot drawings of the seventeenth and eighteenth centuries, accompanied by a catalog of sunspot data extracted from these historical observations

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Satellite measurements of the solar magnetic field cover less than five decades. Over longer timescales, the evolution of the magnetic field is characterized by solar activity, which is mainly traced by sunspot observations. Long-term solar activity indices (e.g., sunspot numbers, sunspot group numbers, and sunspot areas) are constructed by combining individual observations made by different astronomers and observatories over the past 400 years into a single unified dataset. This process relies on overlapping observational records, which enable the application of various scaling techniques, such as the backbone method, active-day fraction, synthetic reference, linear and nonlinear scaling, tied ranking, calibration matrix of probability distribution function, scaling by means of external indices like solar radio emission F10.7, CAIIK plage areas, isotopes, and geomagnetic proxies like IDV index and the By-component, etc. [1].

Until the nineteenth century, sunspots were regarded as a sporadic phenomenon, leading to their irregular observation. The occasional reports that have nevertheless been made by various astronomers are invaluable [2]. These archival series of observations often lack temporal overlap. Furthermore, the purposes and

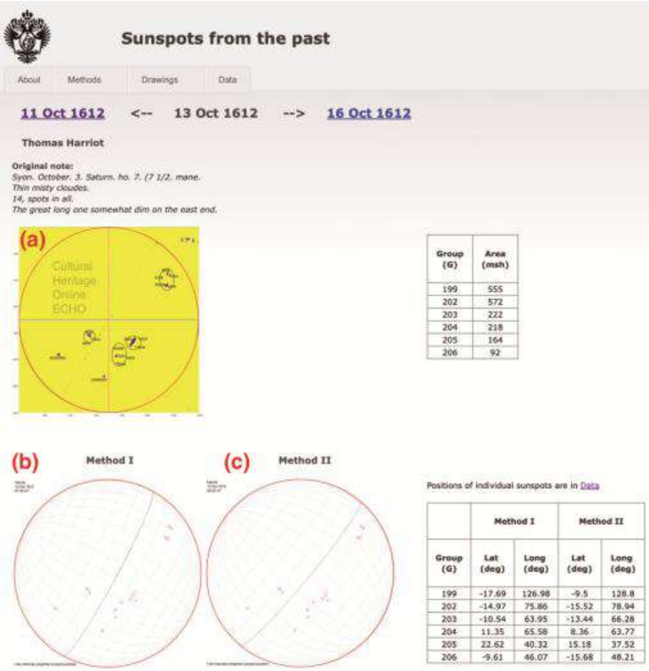

Figure 1. Example of the web-page providing the sunspot report by Thomas Harriot on 13 October 1612: (a) annotated drawing which shows sunspots sorted into groups with assigned numbers; (b) sunspot drawing reproduction with an imposed heliographic grid whose orientation corresponds to the time of the observation (Method I); (c) the same, but the orientation of the heliographic grid is chosen to minimize uncertainties in sunspot mapping.

methods of the observations significantly influenced the resulting measurements and solar drawings. For instance, astronomical records that document solar altitude or diameter measurements without mentioning sunspots can be interpreted as spotless reports [3] or misinterpretation of solar reports [4–7]. Thus, discussions on methods for reconstructing solar indices must always consider the type and quality of the original data used.

Our project aims to create an open-access database showcasing the detailed processing of original sunspot observations dating back to 1610 (https://geo.phys.spbu.ru/~ned/History.html), which we have analyzed in our publications [8-12]. Figure 1 provides an example: Thomas Harriot's report on 13 October 1612. We include the original record, an annotated solar disk with sunspot numbering and clustering into groups, and two reproductions of his drawing overlaid with heliographic grid. Given the uncertainties in sunspot mapping, various methods can be applied to reconstruct the actual heliographic grid. Figure 1 illustrates two approaches: Method I uses the recorded observation time, while Method II minimizes the day-to-day variability of sunspot latitudes.

The website is continually updated with new data, offering information about historical astronomers, their observational techniques, methodologies for deducing the solar rotation axis's orientation, and additional updates. The calendar highlights days with sunspot observations. Data includes extracted sunspot parameters. For each sunspot, we provide the reconstructed data along with solar ephemerides. Our goal is to make historical solar drawings accessible to the public, akin to modern routine solar observations conducted at observatories.

Acknowledgements:

The project has been supported with a SCOSTEP/PRESTO grant for database development.

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Highlight on Young Scientists 1:

Including a new aspect in Space weather studies

Manu Varghese

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Space weather is modulated by the Sun mainly through coronal mass ejections (CMEs) (e.g., Gopalswamy et al., 2005), which impacts Earth's environment through magnetic reconnection (e.g., Dungey, 1961). My research focuses on severe space weather (SvSW) events that can lead to power outages, their prediction and their effects on the ionosphere-thermosphere system (Manu et al., 2022; Manu et al., 2023).

Manu et al., 2024 has highlighted a previously overlooked aspect of geomagnetic storms: the early positive part of the main phase (MP) between the onset and the 0-level of SYM-H. By shifting the baseline from 0 to the main phase onset level, we have revised the storm intensity (SYM-HMin^r) and impulsive strength (IpsSYM-H^r) of magnetic storms (Fig. 1).

IpsSYM-H^r clearly identifies all three known SvSW events causing power outages (Medford et al., 1989; Pulkkinen et al., 2005; Marshall et al., 2013) and eight minor-system-damage events (MSW) (Kappenman, 2003) from over 1300 normal events. However, the traditional storm intensity only identifies one SvSW and one MSW event (Fig. 2).

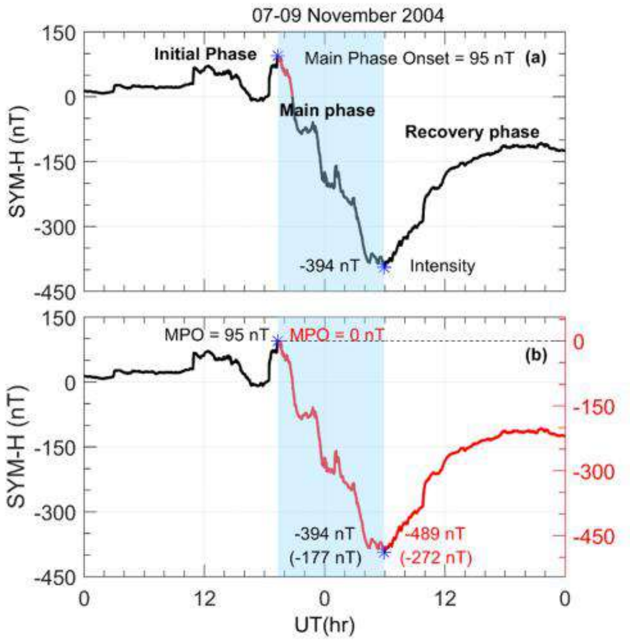

Figure 1. The geomagnetic storm on 07-09 November 2004 has SYM-H minimum (intensity) -394 nT and the red is the missed part in the early main phase (a). (b) The original values (LHS scale) and corrected values (RHS scale) of MPO, intensity and impulsive strength (in brackets) are noted. Main phase highlighted in blue.

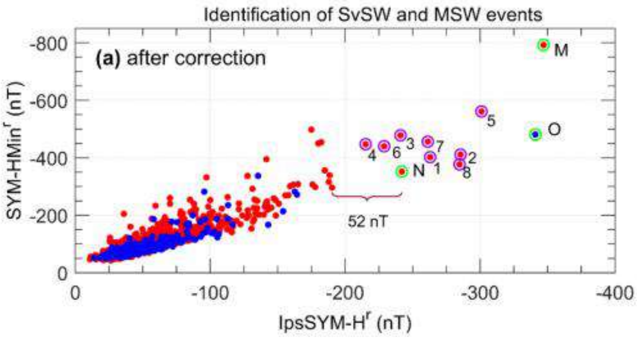

Figure 2. IpsSYMH^r (X-axis) identifies all 3 SvSW events (green circles) and all 8 MSW events (purple circles) with large separations of 52 nT and 25 nT from over 1300 NSW events (red and blue dots alone) in 1981-2019. SYM-HMinr (Y-axis) identifies only 1 SvSW and 1 MSW events each.

Further analysis showed that for 74% of storms, the positive main phase part is mainly due to the increase in interplanetary electric field (IEFy) or ring current (Jijin K. Raj et al., 2024, under review). We are now studying how this revision affects low latitude aurora observations and ionospheric storms, which started when I visited ISEE (Nagoya University) as a SCOSTEP visiting scholar during October-December 2023 with Prof. Kazuo Shiokawa. We are using ISEE All sky imagers (e.g., Shiokawa et al., 2005) and GNSS TEC (e.g., Otsuka et al., 2002) data for the investigations.

I thank my colleague Jijin K. Raj, Shandong University for sharing his work and expertise in theoretical modeling.

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Highlight on Young Scientists 2:

Polarization Jet and STEVE: Multi-instrument approach

Aleksandr Sinevich

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Among the phenomena of the subauroral ionosphere, one of the most interesting for study is the polarization jet (PJ) [1], which is also called SubAuroral Ion Drift (SAID) [2]. It is a narrow (1°-2°) band of fast (more than 1 km/s) ion drifts to the west. In order to fully understand the structure of the PJ/SAID and its impact on the propagation of radio waves in the ionosphere, a study was conducted using simultaneous measurements of various instruments, including ground-based and satellite (Figure 1) [3].

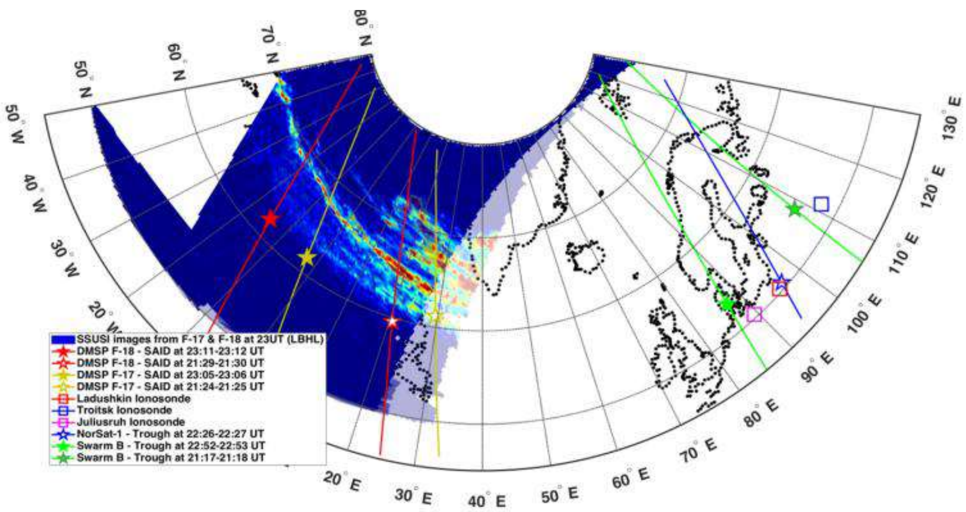

Figure 1. Satellite passages, PJ/SAIDs and ionosonde station locations, and UV snapshots of auroral emissions at AACGM coordinates at 21-23 UT on March 18, 2018.

A rich and diverse set of instruments made it possible to study in detail the effects at subauroral latitudes during the presence of PJ/SAID and its influence on ionograms and the operation of ionosondes and on local TEC maps (Figure 2).

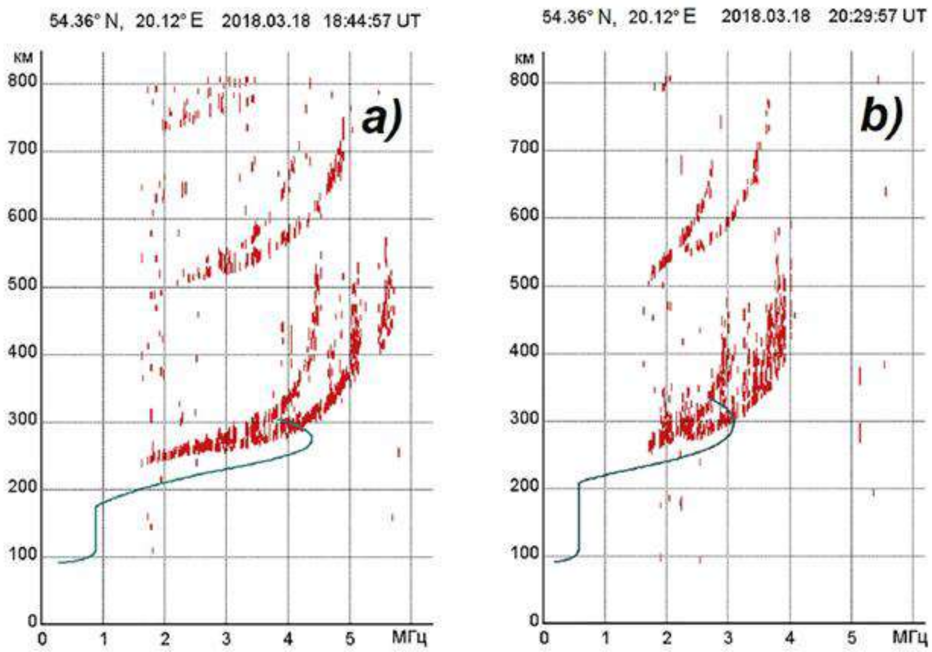

Figure 2. Ionograms from Ladushkin ionosonde station illustrating the characteristic features associated with Polarization Jet/SAID.

In addition, the relationship of the PJ/SAID with such an optical ionospheric phenomenon as STEVE [4] was considered. On 18 March 2018, civilian photographers recorded STEVE's presence in Northern Germany at the locations where STEVE was observed are at the latitudes of ionosonde stations and at latitudes where the strong PJ/SAID is discovered.

The following results were obtained:

- During the storm in question, SSAID (Stratified Subauroral Ion Drift) [5] was detected and its connection with such a phenomenon as STEVE was confirmed.

- It was found that at a consistently high level of geomagnetic activity, the geomagnetic latitude of the PJ/SAID decreases by 1.5°-2° per hour in the 00 MLT sector and by 0.5°-1° per hour in the 18 MLT sector. In addition, with an increase in MLT, the geomagnetic latitude of the PJ/SAID drops by 0.8°-1.5° per hour MLT.

- The drift velocity of ions in the PJ/SAID band at altitudes of the lower part of the F-layer (180-200 km) is 5-8 times lower than the drift velocity of ions at the altitude of satellite measurements (830 km).

- Polarization jet strata (PJS) [5] and small-scale irregularities of plasma parameters inside them can cause multiple reflections of the radio signal, which manifests itself on the ionograms of ground-based ionosondes as F-spread.

Acknowledgements:

I would like to express my gratitude to my co-authors of this work: Chernyshov A.A., Chugunin D.V., Klimenko M.V., Panchenko V.A., Yakimova G.A., Timchenko A.V., Miloch W.J. and Mogilevsky M.M.

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Highlight on Young Scientists 3:

Ionospheric Electron Formation Due To A Solar Flare

Dmitry Grankin

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Solar flares are sporadic emissions of solar radiation. Emitted photons of solar origin can reach Earth's atmosphere. Compared to energetic particles, photons carry less energy. Still, they can bring extra energy into Earth's atmosphere and therefore induce ionization and then drive chemical reactions. In this work we investigated an electron density formation due to a large X-class flare observed 10 of September 2017. Electron density was studied for the region of São Paulo, 23.2S.

We use GEANT4 code [1] to simulate the formation of electron-ion pairs in the ionosphere by primary photons impact at different altitudes and local zenith angles [1-3]. Then we multiply these ionization rate matrices by the background-subtracted X-ray energy spectrum of the flare at peak time, obtaining distributions of electron-ion production rate in altitude for each of the local zenith angles considered. And finally, we use a background subtracted high-cadence GOES X-ray light curve of the flare (time resolution of 2 seconds), obtained by summing up the photon fluxes in the short and long wavelength channels and normalized with respect to the photon flux at peak time, to compute the altitude dependent ionization rates over the whole time interval of the flare [3]. Obtained ionization rate profile for solar flare event 10 of September 2017 is shown in Figure 1.

We use a one dimensional radiative-convective transient model with photochemistry for neutral and charged species to estimate the electron formation in the lower ionosphere [4-5]. Spatial and time resolutions for this model are 21-110 km and 2 hours respectively. We have chosen the exact flare, the impact of which lasted for a few hours in the evening sector. The

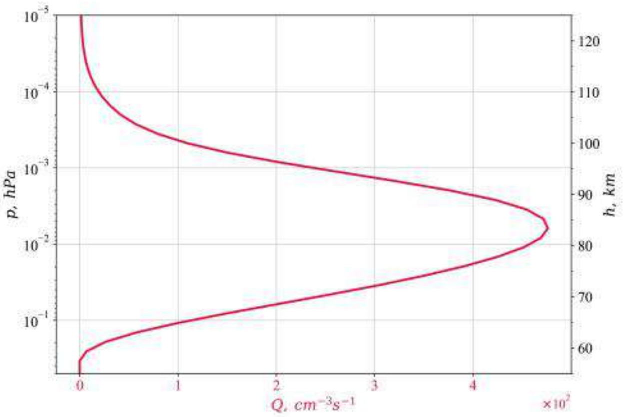

Figure 1. The ionization rate profiles induced by a flare 10 of September 2017, at latitude of São Paulo (23.2S).

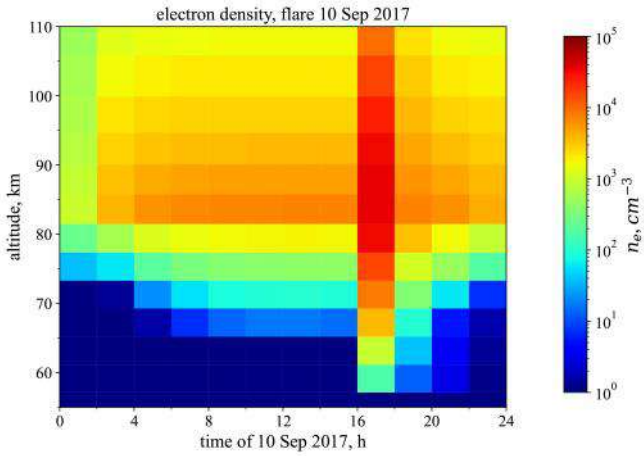

Figure 2. Electron density for 10 of September 2017. Ionization was applied in 16-18 h UT.

model includes calculations for reactions involving more than 100 chemical neutral and charged species [4, 6]. In our case the solar flare event 10 of September 2017 lasted for a few hours in the evening sector.

Electron density changes are shown in Figure 2. We can see that increased electron content due to X-ray solar flare radiation can reach values of 1E4 electrons per volume unit in the lower ionosphere. The increased amount of electrons may be observed for up to 4 hours after the ionizing effect.

The results obtained show that solar flares produce ionization amount needed for extra electron formation. Since that, the lower border of the ionosphere at latitudes of São Paulo (23.2 S) can expand lower, affecting very low frequency radio waves propagation [2, 3, 6].

Acknowledgements

The presented results were obtained with the support of the Visiting Scholar Program (SVS) program. I am thankful to the Center for Radio Astronomy and Astrophysics at Mackenzie (CRAAM) in São Paulo, Brazil, for the unique opportunity to conduct research during the SCOSTEP Visiting Scholar (SVS) program. I am grateful to the observatory staff for their assistance and guidance during the research. I am also grateful to São Paulo School of Advanced Science on Solar Activity and Space Weather (ESPCA) and PRESTO/SCOSTEP Workshop and all the participants and organizers of the conference and workshop for interesting and useful reports, discussions and lectures.

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Highlight on Young Scientists 4:

Response of the Low-Latitude Ionosphere to Atmospheric Disturbances during 2020-2021 North Atlantic Hurricanes

Oluwaseun Victoria Fatoye

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[1]South African National Space Agency (SANSA), Hermanus, South Africa

This research focused on the sensitivity of the ionosphere at low latitudes to severe meteorological phenomena to analyse the interaction that occurs between the solar-terrestrial layers and how this interaction affects the propagation of VLF at the ionosphere, thereby affecting the earth systems that rely on VLF propagation to function. The tropical cyclones under consideration are Ida, Eta, and IoTa, which occurred in 2020-2021, respectively. They were observed for their impact on VLF signals transmitted at NAA and NDK transmitters located at the high latitude to SANAE (South African National Antarctic Expedition IV station) and MAR (Marion Island) receivers at the low latitudes. The calculated analysis, using +/- 1.5 standard deviations of VLF amplitude received at SANAE from the NAA transmitter during the days of tropical cyclone

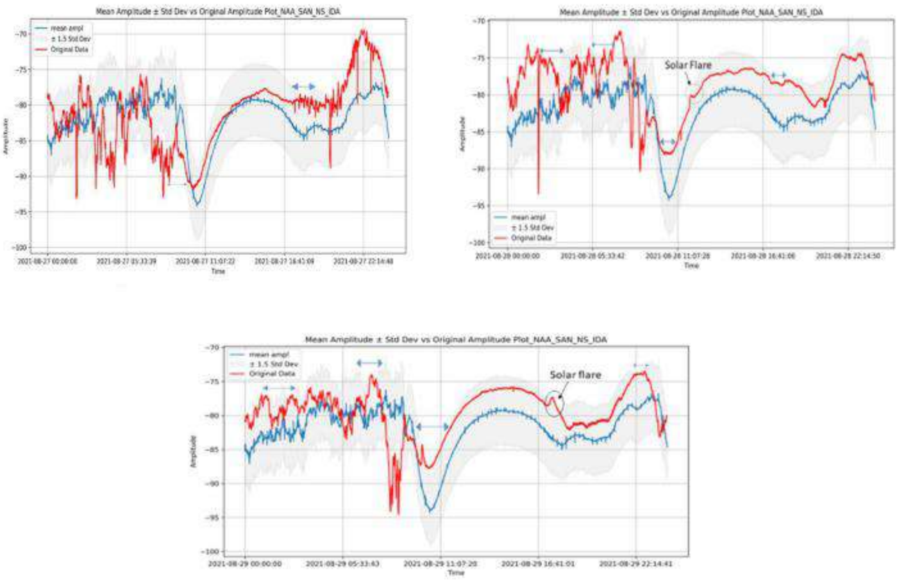

Figure 1. VLF signal amplitude in red, mean amplitude in blue, +/- 1.5σ, amplitude excursion in blue arrow as a function of 00–24 hours UTC for SAN-NAA (Tx-Rx stations).

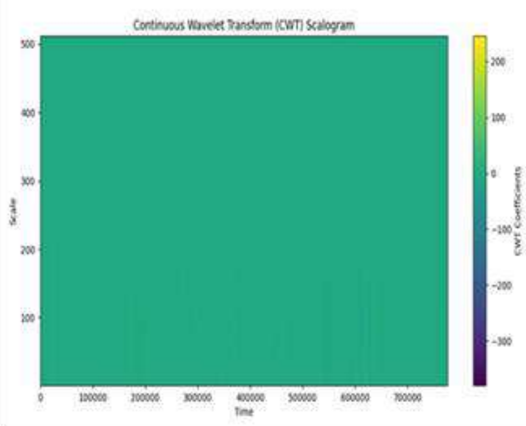

Fig 2a: Continuous Wavelet Transform (CWT) of quiet days before stormy days (Tropical Ida).

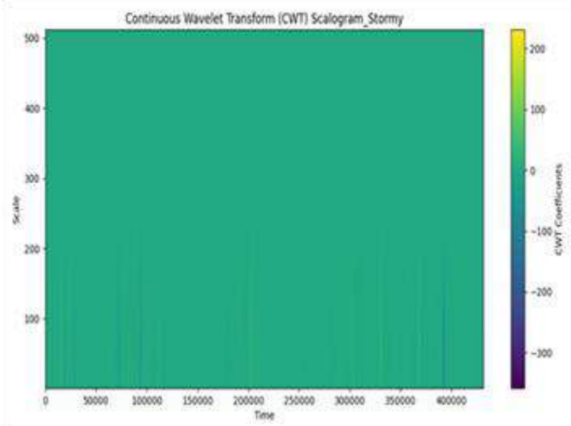

Fig 2b: Continuous Wavelet Transform (CWT) of stormy days (Tropical Ida).

Figure 2. Continuous Wavelet Transform (CWT) of quiet and stormy days.

Ida (Fig.1), which occurred in Northern and Southern America, shows that it is not strong enough to disrupt the HF communication and navigation system. The continuous wavelet analysis (CWT) shows minor disturbances for cyclone Ida (Fig.2), with no significant impact, and no disturbances were observed during cyclone IoTa and Eta. The findings noted that the distance of propagation and the atmospheric conditions in the VLF-travelling regions are important factors in the observed amplitude anomalies across different stations.

Acknowledgement

I express my sincere gratitude to the South Africa National Space Agency for providing the opportunity to conduct this research under the SCOSTEP Visiting Scholar (SVS) program. I am especially thankful to Dr. Stefan Lotz, Dr, Shikwambana Lerato and Dr. V.U.J Nwankwo for their invaluable supervision and support.

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Highlight on Young Scientists 5:

Assessment and Prediction of Coronal Mass Ejections and Their Impacts on Satellite Orbits

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Coronal mass ejections (CMEs) are violent large-scale eruptions from the Sun which make the primary drivers of space weather. Earth-directed CMEs containing flux ropes with favourable magnetic field orientations reconnect with the terrestrial magnetic field, triggering geomagnetic storms.

During geomagnetic storms, energy from the solar wind majorly dissipates as Joule heating in the Earth's magnetosphere-atmosphere system, causing thermospheric expansion and increased atmospheric drag on Low Earth Orbit (LEO) satellites, affecting their orbital lifetimes [1]. This phenomenon resulted in the

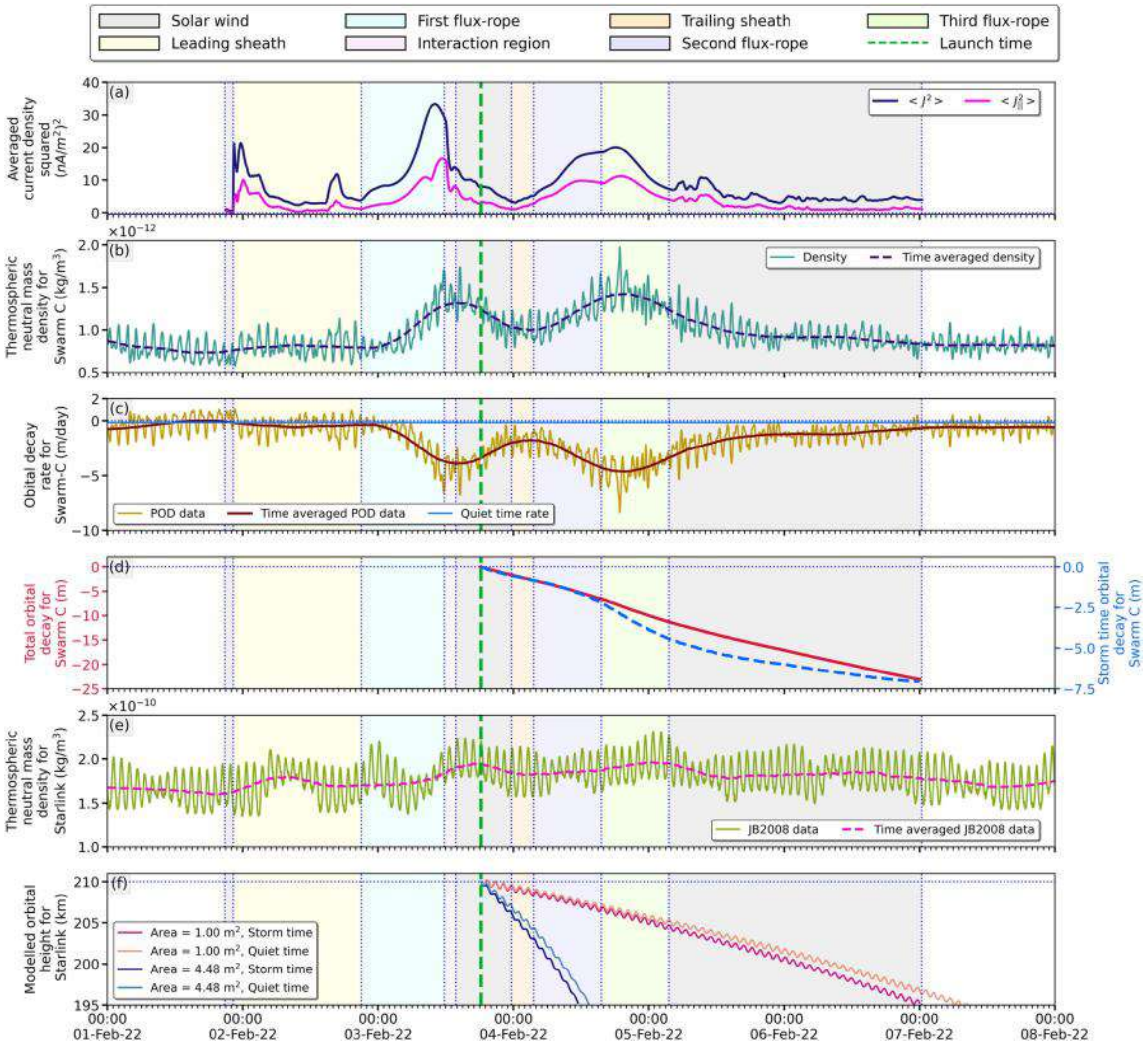

Figure 1. The plots show the atmospheric current density, thermospheric neutral density and orbital decay of Swarm C at 434 km and Starlink satellites at 210 km respectively between 1-7 Feb 2022. The vertical green dashed line denotes the time of launch of the Starlink satellites. This figure shows that the satellites were launched into a perturbed atmosphere when the current density and thermospheric density were elevated relative to quiet time conditions which persisted for a long time, resulting in their enhanced orbital decay.

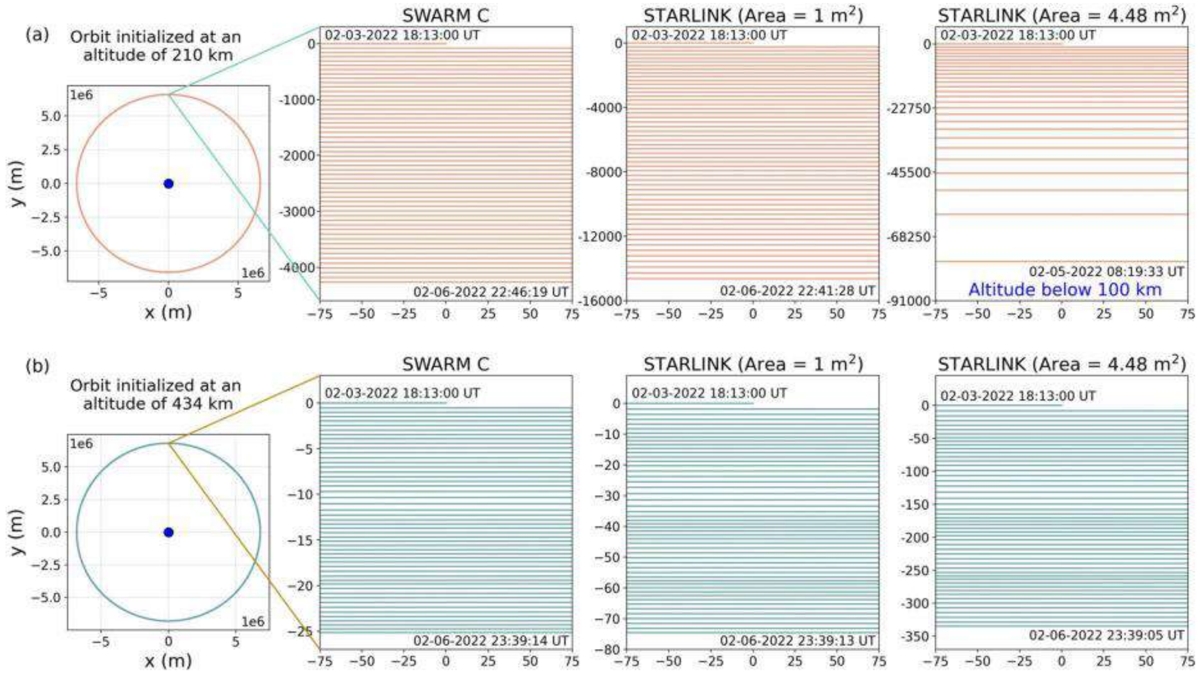

Figure 2. The plot shows simulated orbits for Swarm C and Starlink satellites with different ram areas, initialised at altitudes of 210 and 434 km respectively on 3 February 2022. The figure depicts a higher orbital decay of Starlink satellites than Swarm C under the same geomagnetic conditions.

atmospheric re-entry of 38 Starlink satellites in February 2022 after a geomagnetic storm. In our study [2], we analyzed the 3-4 February 2022 storm, simulated the near-Earth space environment, and estimated the orbital decay of Swarm C and Starlink satellites (shown in Figure 1). The results reveal that low orbit insertion, a perturbed atmosphere, and low mass-to-ram area ratios (as shown in Figure 2) contributed to the Starlink losses. While severe storms cause higher orbital decay, our study shows even moderate storms can lead to significant satellite altitude loss and atmospheric re-entry. This case study emphasises the importance of space weather predictions to protect our technological infrastructure.

The severity of a geomagnetic storm depends on the magnetic and kinetic properties of CMEs, making accurate prediction of these parameters near Earth essential. In an ongoing work, we use EUV solar observations and the CESSI Magnetic Cloud Prediction model [3] to predict CME magnetic field vectors near Earth, and improve these predictions with inner heliospheric in-situ solar wind data. This research work, supervised by Professor Dibyendu Nandy, is conducted in collaboration with Dr. Nat Gopalswamy, Dr. Seiji Yashiro, Dr. Sachiko Akiyama, and Dr. Sanchita Pal at NASA GSFC. I would like to extend my gratitude to SCOSTEP for providing me with the opportunity to visit NASA GSFC under the SCOSTEP Visiting Scholar Program.

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Meeting Report 1:

The 2025 PRESTO Workshop

Ramon E. Lopez

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The 2025 PRESTO workshop was held in São Paulo, Brazil in conjunction with the São Paulo School of Advanced Science on Solar Activity and Space Weather from November 11 - 22. The main venue was Mckenzie University, although one day of the PRESTO workshop was held at INPE, the Brazilian National Space Research Institute. Primary funding, which supported students, came from a grant to Mckenzie University from FAPESP (Fundação de Amparo à Pesquisa do Estado de São Paulo), which provides grants to private and public institutions programs to support research, education and innovation in the state of São Paulo. Additional funding came from PRESTO and INPE. 97 attendees from 22 countries participated in the activity, and there were many excellent talks. PRESTO leadership played a significant role in organizing speakers for school and the workshop, and the Chair and Co-Chairs of PRESTO attended the workshop.

Figure 1. A group photograph of the participants.

Meeting Report 2:

The International Space Weather Initiative (ISWI) School 2024

Nishu Karna

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The International Space Weather Initiative School 2024 was held in Kathmandu, Nepal, from September 16 -20, 2024, hosted by the Nepal Physical Society. The school targeted fifty pre-grad and graduate students: 32 students participated from Nepal and the rest eighteen students from India, Bangladesh, Kenya and Egypt. This program aimed to enhance the understanding of space weather phenomena among students, researchers, and professionals from around the world. The school featured lectures from leading international experts in the field, as well as hands-on workshops and exercises. The instructors were from NASA, CfA, Stanford, MIT, UAH, JAXA, University of Tokyo, University of Calgary, and Tribhuvan University. It is the first time any solar physics and space weather-related program in such a large scale has been held in Nepal. This event not only enhanced the scientific community's understanding of space weather but also to fostered international cooperation in this critical field.

Figure 1. A group photograph of the participants.

Meeting Report 3:

Space Weather and Upper Atmospheric Data Analysis Training Workshop for East African Community held at Maseno University from September 23 - 24, 2024

George Omondi

George Omondi[1]
[1]Maseno University, Maseno, Kenya

On Monday 23rd September, 2024 the local organizer, Dr. George Omondi, welcomed the lecturers and the rest of the participants to the workshop and gave a brief background on the workshop. He appreciated the Scientific Committee on Solar Terrestrial Physics (SCOSTEP) for funding. He also appreciated Maseno University through the vice chancellor, Professor Julius Nyabundi, for accepting to host the workshop. Dr. Omondi proceeded to invite the dean of the School of Physical and Biological Sciences of Maseno University, Prof. Godfrey Netondo, who congratulated Dr. George Omondi for writing the successful proposal that necessitated Maseno University to host the workshop. He appreciated the local organizer for ensuring that research in Space Science is active within the University. Prof. Netondo welcomed all the participants to the University and declared the workshop officially open. The presentations consisted of brief lectures and largely hands on activities on actual data analysis and interpretation. The main topics handled included Space Weather and its Impacts on Technological Systems, Occurrence of geomagnetic storms, Matlab programming, solar wind and IMF data analysis, Radio occultation data analysis and interpretation, Extraction of Ionospheric Parameters from NeQuick and IRI Models.

Figure 1. A Group Photograph for Maseno Space Weather Workshop.

Meeting Report 4:

The International Meridian Circle Program (IMCP) Workshop

Liwen Ren[1]
[1]International Meridian Circle Program Office/National Space Science Center, Chinese Academy of Science, Beijing, China

Liwen Ren

The International Meridian Circle Program (IMCP) Workshop took place in São Paulo, Brazil, from September 23–27, 2024. It was jointly organized by the National Space Science Center of the Chinese Academy of Sciences and Brazil's National Institute for Space Research (INPE).

Bringing together nearly 50 seasoned space scientists and over 20 aspiring young researchers from 10 countries, the workshop had a particularly strong representation from South America. It explored diverse topics such as the effects of solar storms on space weather, interactions between space weather and Earth's lower atmosphere, the South Atlantic Anomaly, and advancements in ground-based space weather observation systems.

For young researchers, the workshop provided an invaluable platform to gain deep insights into space weather science and build professional connections with leading experts. To encourage active engagement, several early-career scientists were hired as session reporters, giving them a direct role in the meeting's proceedings.

Highlighting its commitment to fostering emerging talent, the workshop introduced the IMCP Young Scientist Award, honoring six young researchers for their outstanding contributions to the field.

Figure 1. A group photo of the participants of the workshop.

Meeting Report 5:

Organization of the Ninth International Space Climate Symposium (SC9)

Hisashi Hayakawa[1]
[1]Nagoya University, Nagoya, Japan

Hisashi Hayakawa

With thanks, we wish to report our conference organization of the Space Climate 9 / ISEE Joint Symposium on 1-4 October 2024, under the SCOSTEP/PRESTO Grant co-sponsorship. This conference had a special focus on extremity, long-term variability, and data of solar impacts on Earth. In parallel with the registration on 30 Sep, we have also hosted a splinter meeting of the IAU Inter-Division B-E WG Coordination of Synoptic Observations of the Sun. This conference accommodated 161 registered participants from 25 nationalities and hosted 15 sessions, 103 talks, and 77 posters. We hosted regular sessions for the solar activity, cosmic environments, and terrestrial environments as well as special session clusters for the space climate data, extreme events, and the May 2024 storm. Particularly, we have tried to accommodate wider topics for stellar flares and stellar cycles to contextualise the solar storms and solar cycles. These attempts hopefully open new possible collaborations.

Figure 1. Group Photo of Workshop Participants.

Meeting Report 6:

The The 2024 COSPAR Capacity-Building Workshop

Joseph Ouko Olwendo

Joseph Ouko Olwendo[1]
[1]Pwani University, Kilifi, Kenya

The 2024 COSPAR Capacity-Building Workshop (CCBW) on the International Reference Ionosphere (IRI) was conducted in Kilifi, Kenya during September 2 – 13, 2024. The CCBW was planned in conjunction with the IRI workshop that took place during the second week of the CCBW. The event had 35 participants, 32 of whom came from 8 African countries namely; Kenya, Eqypt, Nigeria, Uganda, Tanzania, Ghana, south Africa and Ethiopia with two students coming from China and one from Poland.

In the first week the students were taught through tutorials and lectures the basics and recent advances in observation techniques and modelling approaches for the Earth's ionosphere. The students were given hands on demonstrations on the access and usage of ionospheric data set and models to enable them continue their research interest at their home institutions. The students were divided into 7 teams and each group received a specific research problem to be studied during the 2 weeks. Each team had one of the lecturers as their main advisor but were free to ask help from other lecturers as well. The students presented their project results at the end of the second week to the full IRI workshop audience.

Figure 1. Group picture of the IRI workshop participants.

Meeting Report 7:

The International Conference on "Solar Cycle Variability: From Understanding to making Prediction"

Bidya Binay Karak

Bidya Binay Karak[1]
[1]Indian Institute of Technology (BHU), Varanasi, India

The international conference on "Solar cycle variability: From understanding to making prediction" was organized for five days, starting on October 14, 2024, at ARIES Nainital, India. About 70+ delegates from around the globe participated in this meeting. The scientific program was specifically focused on topics including observations of solar activity over long time scales, the associated theoretical studies, the heliospheric variability with the solar cycle, and the solar cycle and space weather prediction. Additionally, a visit to the Devasthal observatory was organised on the last day, where a splinter session was arranged to discuss the progress and initial results of Aditya-L1. Overall, 8 invited review talks were delivered by senior researchers in addition to 20 invited talks and 29 contributed presentations by subject experts, young PhD students, postdocs, and early-career researchers. Provisions were made to encourage long discussions during breaks. The support from SCOSTEP/PRESTO was acknowledged on our webpage and via all the material distributed.

Figure 1. A group photograph of the participants.

Meeting Report 8:

VERSIM XI Workshop

Robert A. Marshall

Robert A. Marshall[1]
[1]University of Colorado Boulder, Boulder, CO, USA

The recent VERSIM workshop brought together experts from various fields to discuss the latest advancements in VLF and ELF science and foster collaborative research. There were 55 attendees in total, including 11 students, 11 early-career scientists, and 33 "senior" scientists. This diversity of experience offered an enriching environment, encouraging knowledge exchange between experienced professionals and those early in their scientific journey. Attendees came from 12 countries on four different continents.

With 56 talks presented, the workshop facilitated an intensive exchange of ideas. Talks were sorted into seven categories: i) Simulations, Data assimilation, and machine learning applications; ii) Wave-particle interactions; iii) Active Experiments; iv) Results of Recent Space Missions; v) Wave Propagation in the Ionosphere and Magnetosphere; vi) Wave-induced Particle Precipitation; and vii) Waves in other Magnetospheres. Overall, VERSIM succeeded in its goal to promote international collaboration, advance scientific innovation, and strengthen professional networks across different career stages and regions.

Figure 1. A group photo of the participants.

Meeting Report 9:

iMST Radar and Lidar School

Jorge L. Chau

Jorge L. Chau[1]
[1]Leibniz Institute of Atmospheric Physics at the University of Rostock, Rostock, Germany

The 16th **International Workshop on Technical and Scientific Aspects of iMST Radar and Lidar (MST16/iMST3)** held in person on September 9-13 2024 in Rostock, Germany, was preceded by a three-day school. The school was held at the Leibniz Institute of Atmospheric Physics in Kühlungsborn on September 6-8, 2024.

The school brought together the world's experts in atmospheric soundings by radar and lidar. The school was attended by 35 students from 13 different countries. The lectures were given by 15 experts on their respective topics. The lectures included theoretical session on fundamental concepts of atmospheric waves and coupling processes, as well as basics of lidar and radar technology. These sessions were complemented with hands-on hardware and software sessions on lidar and radar. The final lectures were on "Out-of-the box" uses of atmospheric lidars and radars. Besides the formal lectures, two brainstorming and networking activities were organized in the first and second day.

Figure 1. School group picture in front of the main venue, i.e., the Leibniz Institute of Atmospheric Physics.

Meeting Report 10:

17th European Solar Physics Meeting

Alessandro Bemporad

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In the week 9-13 September 2024 the city of Turin hosted the "17th European Solar Physics Meeting – ESPM17" (https://indico.ict.inaf.it/event/2553/). The event, organized by the INAF-Turin Astrophysical Observatory, was attended by 317 people in person and 18 people remotely coming from 32 different countries, 20 EU and 12 extra-EU, with approximately 40% females and 60% males. The participants were not only Researchers and Professors belonging to different Research Institutes and Universities, but also students (Ph.D. and pre-doc students) for a total number of 110 people. Among them, 30 students received an accommodation support having the possibility to lodge in the nearby University Residence for free or for a discounted price, 20 students were supported with a registration fee waiver, and 57 students were supported with a 49% discount on the registration fee. The meeting was also the occasion for the distribution of various prizes and awards, and in particular three "Best Presentation Awards" sponsored by "Solar Physics – Springer", one "EPS Poster Prize", two "EPS Conference Grants", and one "EPS Invited Speaker Grant" sponsored by the "European Physical Society – EPS" (https://indico.ict.inaf.it/event/2553/page/1309-prizes-and-grants). The scientific program of ESPM17 was distributed over six main sessions during which 1 senior prize lecture, 18 invited talks, 59 contributed talks, and 237 posters were presented. The meeting was also the occasion for social activities, with the organization of 7 different social excursions in Turin and in the surrounding areas, the welcome reception, and the closing dinner. Moreover, different outreach events were organized and in particular 1) an outreach conference titled "The Sun, climate, and nuclear fusion", 2) a series of outreach videos (in Italian language) published on YouTube and titled "Sapore di Sole" (https://youtu.be/FIK2gxqVUFE?si=WnP9JLpCftmqsXGl), and 3) a lunch-break session during ESPM17 to present recent outreach events organized by the community. Overall the event was a great success and (as verified with a survey carried out after the meeting among participants) recognized as excellent or very good by 90% of participants.

The contribution provided by SCOSTEP/PRESTO was very important to maximize the number of supported students mentioned above, making the ESPM17 also a good opportunity to introduce the future generation of scientists to the topics covered by the event.

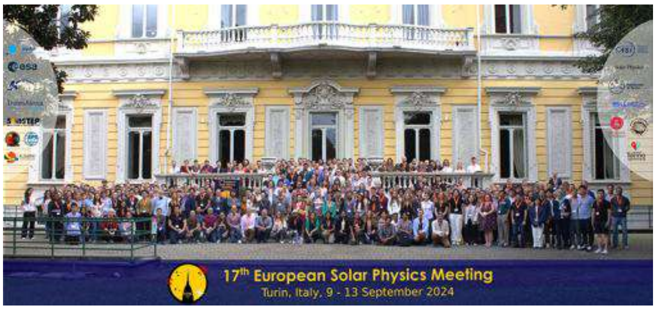

Figure 1. Attendees at the Solar MHD (UKUS 7) conference held in Instituto de Astrofisica de Canarias (IAC), Tenerife, Spain. Credit: Inás Bonet (IAC).

Upcoming meetings related to SCOSTEP

Conference	Date	Location	Contact Information
COSPAR ISWAT 2025 Working Meeting	Feb. 10-14, 2025	Canaveral, FL, USA	https://iswat-cospar.org/wm2025
The 8th ISEE Symposium Frontier of Space-Earth Environmental Research as Predictive Science	Mar. 5-7, 2025	Nagoya, Japan	https://www.isee.nagoya-u.ac.jp/symp2025/
The 2025 Sun-Climate Symposium	Mar. 31-Apr. 4, 2025	Fairbanks, Alaska	https://lasp.colorado.edu/meetings/2025-sun-climate-symposium/
IAGA / IASPEI Joint Scientific Meeting 2025	Aug. 31-Sep. 5, 2025	Lisbon, Portugal	https://iaga-iaspei-2025.org/
6th Symposium of the Committee on Space Research (COSPAR): Space Exploration 2025: A Symposium on Humanity's Challenges and Celestial Solutions	Nov. 3-7, 2025	Nicosia, Cyprus	https://cospar2025.org/
The International Symposium for Equatorial Aeronomy 17 (ISEA-17)	Feb. 9-13, 2026	Costa Rica	https://www.iap-kborn.de/isea17/home
SCOSTEP's 16th Quadrennial Solar-Terrestrial Physics (STP-16) Symposium	Jun. 1-5, 2026	Tessaloniki, Greece	https://scostep.org/events/stp-symposia/
46th Scientific Assembly of the Committee on Space Research (COSPAR) and Associated Events	Aug. 1-9, 2026	Florence, Italy	https://www.cospar2026.org/

Please send the information of upcoming meetings to the newsletter editors.

Announcement 1:

Sustainable Space MOOC course

Emilia Kilpua[1]

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Emilia Kilpua

Space has become vital to us. Our modern society increasingly depends on space-based infrastructure, and space activities and the economy continue their rapid growth. While these actions introduce significant sustainability challenges, they also help to address many sustainability issues on Earth.

This new massive open online course will provide you with a comprehensive introduction on aspects critical for understanding sustainable use of space, its prospects and challenges. The course is free and no prior knowledge on the field is required. It can be taken any time and at your own pace. By registering and completing the exercises (multiple choices), you can receive 2 study credits from the Helsinki Open University. The material can also be accessed without registering.

The course covers diverse and interdisciplinary topics related to sustainable usage of space:

- Sun, heliosphere and solar eruptions
- Basics of satellites, orbits and launchers, astronaut training
- Satellite missions, commercialization of space, and activities advancing sustainability
- Space debris
- Space law and ethics
- Near-Earth space and space weather

Future manned space flights to Moon and Mars, harvesting space, future of low-Earth orbits, and space tourism

Access the course / register here: https://sustainable-space.mooc.fi

The course has been prepared by the University of Helsinki researchers, as part of Academy of Finland's Centre of Excellence for Research in Sustainable Space.

Announcement 1:

SCOSTEP/PRESTO Announcement of Opportunity - Grants for campaigns, meetings, and databases

Ramon E. Lopez (PRESTO chair)[1], Odele Coddington (PRESTO co-chair)[2], Jie Zhang (PRESTO co-chair)[3] and Kazuo Shiokawa (SCOSTEP President)[4]
[1]University of Texas at Arlington, TX, USA
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Although the SCOSTEP's PRESTO program will end in 2024, the next SCOSTEP program can be started only from 2026, because the next program committee is now discussing the new program. Under this circumstance, the SCOSTEP Bureau has decided to continue the PRESTO grant in 2025, to support the scientific activities on solar-terrestrial physics, particularly to those related to PRESTO in 2025. Considering the meetings in early 2026, this time we take proposals for activities up to March 31, 2026.

The details of the announcement of opportunities for the campaigns, meetings, and development of databases relevant to the PRESTO topics can be found at https://scostep.org/presto/. Please contact relevant PRESTO Pillar co-leaders on your proposal and explain the relevance of your proposal to the PRESTO activity. Proposals for markedly interdisciplinary activities can be explained directly to PRESTO chair/co-chairs. The deadline proposal submission is December 23, 2024.

The purpose of the SCOSTEP/PRESTO newsletter is to promote communication among scientists related to solar-terrestrial physics and the SCOSTEP's PRESTO program.

The editors would like to ask you to submit the following articles to the SCOSTEP/PRESTO newsletter.

Our newsletter has five categories of the articles:

1. Articles— Each article has a maximum of 500 words length and four figures/photos (at least two figures/photos).
   With the writer's approval, the small face photo will be also added.
   On campaign, ground observations, satellite observations, modeling, etc.
2. Meeting reports—Each meeting report has a maximum of 150 words length and one photo from the meeting.
   With the writer's approval, the small face photo will be also added.
   On workshop/conference/ symposium report related to SCOSTEP/PRESTO
3. Highlights on young scientists— Each highlight has a maximum of 300 words length and two figures.
   With the writer's approval, the small face photo will be also added.
   On the young scientist's own work related to SCOSTEP/PRESTO
4. Announcement— Each announcement has a maximum of 200 words length.
   Announcements of campaign, workshop, etc.
5. Meeting schedule

Category 3 (Highlights on young scientists) helps both young scientists and SCOSTEP/PRESTO members to know each other. Please contact the editors if you know any recommended young scientists who are willing to write an article on this category.

TO SUBMIT AN ARTICLE

Articles/figures/photos can be emailed to the Newsletter Secretary, Ms. Mai Asakura (asakura_at_isee.nagoya-u.ac.jp). If you have any questions or problem, please do not hesitate to ask us.

SUBSCRIPTION - SCOSTEP MAILING LIST

The PDF version of the SCOSTEP/PRESTO Newsletter is distributed through the SCOSTEP-all mailing list. If you want to be included in the mailing list to receive future information of SCOSTEP/PRESTO, please send e-mail to "scostep_at_bc.edu" or "scosteprequest_at_bc.edu" (replace "_at_" by "@") with your name, affiliation, and topic of interest to be included.

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