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Ground penetrating radar system for measuring deep ice in Antarctica using software-defined radio approach

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This work shows the design of a radar instrument specifically developed for cold ice measurements in polar regions. The instrument is based on a high-performance software-defined radio (SDR) platform, employing sampling frequencies of 800 MHz for digitizing and 1600 MHz for arbitrary signal generation. A flexible multifrequency radar instrument is built on this SDR system, that comprises: 1) a deep ice chirp-pulsed radar working at central frequency of 155 MHz, with 20 MHz of bandwidth, 1 kW of maximum transmitting power and including synthetic aperture radar in post-processing; and 2) a high-resolution shallow-ice frequency-modulated continuous wave radar, which operates from 200-700 MHz and with 100 mW of output power. We used this instrument in December 2017 during a ~460 km over-snow campaign conducted to Subglacial Lake CECs (79°15′S 87°34′W), West Antarctica. We measured a maximum ice thickness of ~2700 m using the deep ice radar and ~150 m of snow/firn thickness obtained in high detail by the shallow ice radar. A detailed description of the radar instrument will be presented, together with some results and their comparisons with data previously obtained in the same area with different radar systems. The instrument presented here shows an improvement in signal-to-noise ratio and along-track resolution of bedrock and englacial structures over previous radar measurements, and also the system provides better adaptability for future parameter changes or upgrades.

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Review of 55 years of Russian radio-echo sounding investigations in Antarctica

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Russian (former Soviet) investigations in Antarctica began on 13 February 1956 when Mirny Station was founded. The first radio-echo sounding (RES) tests in Antarctica were carried out in January 1964. The first airborne RES survey on the regular net was carried out in February 1968 in Enderby Land. After that positive experience, the same work was repeated on the wide coastal area between 50°E and 100°E in the framework of Operation Amery (1971-74). This was the first large Russian multidisciplinary long-term scientific project, which included many different geophysical methods. After an interruption, regular airborne surveys including RES were recommenced in this area in 1985 and continue until the present day. The same investigations were also carried out in the Pensacola Mountains area (West Antarctica), on the Filchner-Ronne Ice Shelf in 1980-82, and in Coats Land, Dronning Maud Land and Enderby Land in 1985-91. In the same period (1987-90) a wide regional survey of inland East Antarctica was also carried out. Ground-based RES investigations were started on the band of Mirny-Vostok scientific and logistic traverses, mostly in the 1970s and 1980s. They were continued after the discovery of Lake Vostok in 1993. RES investigations were carried out in 1998-2008 to study this unique feature. They resulted in the discovery of a number of lakes. Since 2008, ground-based RES investigations have been carried out in the track of the new logistic traverse route Progress-Vostok. These were completed in 2013. All these ground-based studies were followed by glaciological measurements (AARI) and geodetic observations (TUD, Dresden, Germany). Special Russian GPR investigations were begun in 2012 in collaboration with INGV (Rome, Italy). They were carried out in conjunction with ground-based RES along the logistic traverse Progress-Vostok to study the internal structure of the snow-firn layer. These have been continued until the present time to acquire scientific results and solve the applied tasks. Mostly they are related to investigations of crevasses and sea ice. One of the main results has been the resumption of the snow-runway at Mirny Station. The other is the study of the vast depression in Dålk Glacier (Progress Station area, East Antarctica) and finding a new path to connect the station and airfield broken by the depression. This study was funded by RFBR according to the research project No. 17-55-12003 NNIO_a.

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Overview of the low-frequency ice penetrating radar system survey conducted to Subglacial Lake CECs, West Antarctica

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In December 2017, Centro de Estudios Científicos (CECs), conducted a survey at the Subglacial Lake CECs area, West Antarctica (79°15′S 87°34′W). The over snow survey used a deep-penetrating low-frequency radar system developed by CECs that was mounted on sledges pulled by snowmobiles allowing measuring near 260 km of the central West Antarctic plateau. The system is an impulse radar working at a central transmission frequency of 2 MHz having three main components: a 4 kV power transmitter that works at 1 kHz pulse repetition frequency (PRF); a digital acquisition system ADQ214, with an analog to digital converter working at 400 MHz of sample rate, with a resolution of 14 bits and 256 traces on average; and a dual-frequency GPS receiver used for georeferencing the whole system. Transmitter and receiver antennae were resistively loaded wire dipoles. The components were installed inside peli-cases, each one having its own power and solar-panel charging system, including batteries allowing 8 hours of a continuous survey. Each component was installed on sledges tied together forming a 140 m long convoy. The convoy was pulled by snowmobiles moving at 8-10 km h^{-1} surface velocity. Ice thickness up to ~2700 m was reached. The