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Geophysical and remote sensing survey of the Russel glacier, Southwest Greenland

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In this study, ground penetrating radar (GPR), GPS system and aerial unmanned vehicle were used to create three dimensional models of the marginal zone of the Russell glacier.
Research area is located in the south-western Greenland, where the Greenland Ice Sheet is drained by the Russell glacier. Surface topography of the Russell glacier is articulated, as a result GPR data gathering and creation of precise surface elevation map is difficult.
GPR measurements were performed by GPR Zond 12-e and low frequency 38 MHz antenna. During data acquisition, the time window of 2000 ns was used. Assuming that the average dielectric permittivity of ice is equal to 3.5, it allowed detecting the reflections of depth up to 160 m beneath the ice surface. Acquired GPR data were processed and analysed with Prism 2.5 software. The coordinates of start and end points of each GPR profiles were determined by GPS system Magellan Promark 3 that is composed of two GPS receivers. Working with this particular GPS allowed us to take measurements and post-process results with geodetic accuracy, without GSM or radio support.
Approximately 2.8 km of GPR profile lines were recorded perpendicular to the glacier margin covering an area of 17 ha. Additionally, surface elevation map of the surveyed part of the Russell glacier was created using 579 aerial photographs captured with drone DJI Phantom 3 advanced. Digital elevation model and orthophoto map of the research area with precision of 5 cm was created with Pix4D Mapper software. A model of the subglacial topography and ice surface was created by SAGA GIS software and Thin Plate Spline (Global) interpolation method.
Altogether, obtained B-scans were of high quality and it was possible to trace not only reflections from the glacier bed but also scattered reflections indicating warm ice. Reflections visible as parabolas were mostly interpreted as englacial channels. In some cases, B-scans were more blurred and tracing of bed reflection was challenging. We assume that radar signal was altered by complicated ice structure formed due to internal ice deformation and highly compressional ice flow close to ice margin.
The linear bedrock depression close to the ice margin was discovered suggesting favourable path to subglacial meltwater that flows periodically from the ice-dammed lake due to jökulhlaups (Russell 2007); the last ones have been documented in 2007 and 2008 (Russell et al. 2011). Obtained results show that it is possible to collect high quality GPR data on glaciers even if the ice surface is uneven. Combination of surface topography map obtained with drone and glacier bed topography map constructed with GPR data allowed to create high precision three dimensional model. We show that such application can be used, if the ice surface is complex.

Literature

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