Investigation of bistatic scattering properties of snow using Ku-band radar

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1. Project description

The goal of the project is to investigate the potential of Ku-band bistatic radar for monitoring and parameter estimation of snow cover, as well as to gain further insight into the so far relatively unexplored bistatic scattering properties of snow cover at Ku-band radio frequencies.

The experiments at HFSJG are carried out with the Ku-band Advanced Polarimetric Radar Interferometer (KAPRI), a ground-based portable radar instrument based on the GAMMA GPRI-II. The KAPRI instrument allows deployment of the following radar imaging techniques: 1) Polarimetry: By observing the difference between scattering of horizontally and vertically polarized radio waves, information about the scattering processes occurring within the observed scene can be inferred. 2) Interferometry: By analyzing the phase of the scattered radio waves, small movements on the order of millimeters (e.g., glacier motion) can be detected. 3) Bistatic radar: By deploying an additional receiver in a location different from the transmitter's location, we can analyze the scattering of radio waves under a non-zero bistatic angle (i.e., the separation angle between the transmitter and the receiver from the point of view of the target).

As a follow-up to measurements carried out in August 2021, which observed the snow cover properties in late summer, we carried out a second observation campaign at HFSJG in March 2022. We deployed KAPRI for one week to monitor the Jungfraufirn area of the Aletsch glacier in order to acquire a dataset of observations of fresh snow cover. Identically to the 2021 measurements, the primary transmitter-receiver KAPRI device was deployed on the terrace of the Research Station (see Figure 1). The additional secondary receiver was deployed on the terrace of the East Ridge building (see Figure 2). A wireless synchronization link was established between the two devices. Several time series of observations were acquired at different times of day, with repetition times of 2-3 minutes, and total uninterrupted length up to 30 hours. In addition, calibration targets were deployed on the Jungfraufirn for the duration of the measurements and retrieved afterwards.

Figure 1. Primary KAPRI device observing the Jungfraufirn area from the terrace of the research station. Photo credit: Marcel Stefko.

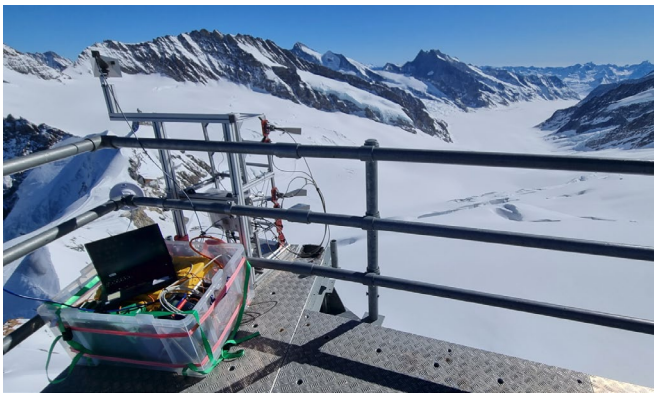

Figure 2. Secondary KAPRI device observing the Jungfraufirn area from the terrace of the East Ridge building. Photo credit: Marcel Stefko.

In-situ snow property data was also collected by digging several snow pits in the Jungfraufirn area, with depth up to 3.5m. This data helped better understand the snow structure and stratigraphy and measure the depth of the fresh snow cover layer. Figure 3 shows the process of acquisition of snow pit data, and the resulting data for one of the snow pits.

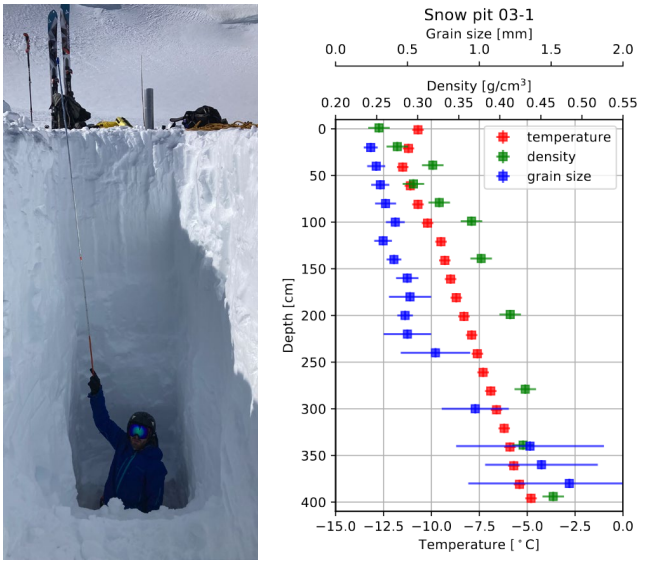

Figure 3. Snow pit measurement in the Jungfraufirn area on 2nd March 2022 and the corresponding acquired data. Six snow pits were dug in total. Photo credit: Michael Arnold, Philipp Bernhard.

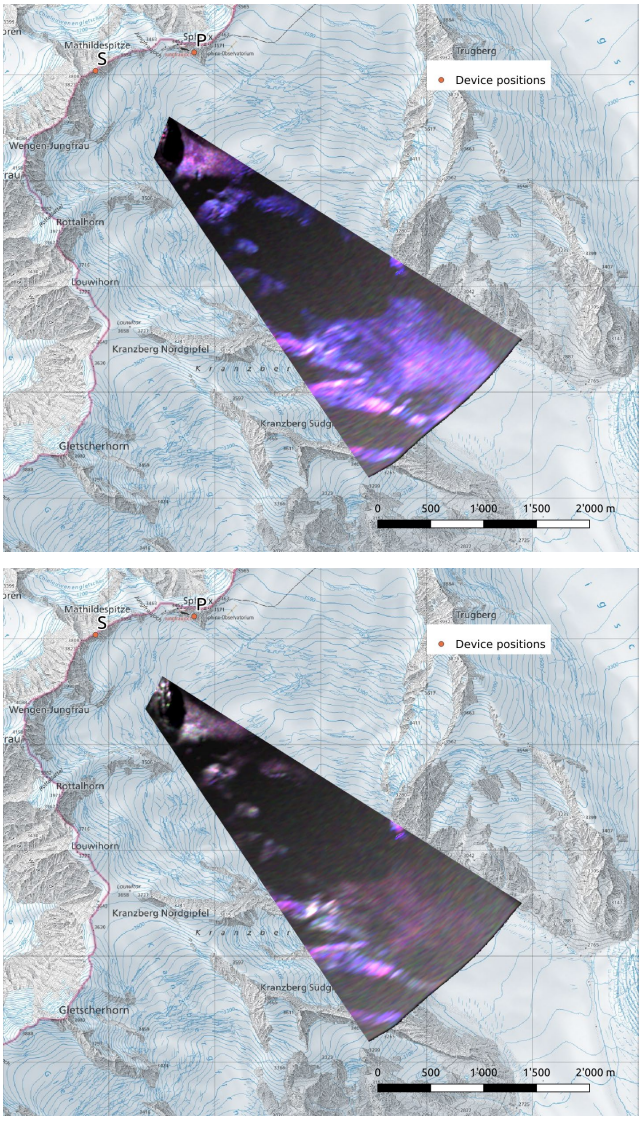

Figure 4. Comparison of polarimetric radar images acquired in the bistatic mode in summer (top) and winter (bottom). The signal was transmitted by the primary device (P) and received by the secondary device (S). The Pauli RGB color representation is used to display the polarimetric data, each primary color roughly corresponds to a different scattering mechanism (blue: surface, red: dihedral, green: volume). A large difference in scattering behaviour is observed between the two seasons, where in summer surface-type scattering is the dominant process, while in winter a larger diversity of scattering processes is present. Map underlay source: Landeskarte 1:25000 by swisstopo.

The polarimetric characteristics of the acquired radar dataset were analyzed. Preliminary results indicate large variability of the scattering characteristics of snow cover between the two seasons, as well as presence of non-reciprocal scattering phenomena which are of interest for bistatic radar observations. Figure 4 shows a visualization of the summer and the winter polarimetric observations performed in the bistatic radar acquisition mode.

The full results are currently being prepared for publication in a peer-reviewed journal in early 2023.

References

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Scientific publications and public outreach 2022

Conference Papers

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