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Investigating the nature of the GPR antenna orientation effect on temperate glaciers

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In the recent years the bedrock topography of the Swiss Alpine Glaciers has been mapped by ground-based and helicopter-borne GPR (Ground Penetrating Radar) as part of an ongoing comprehensive inventory initiated by the ETH Zürich, the Swiss Competence Center for Energy Research (SCCER) and the Swiss Geophysical Commission (SGPK).
Our recorded GPR data of glacier bedrock topography highlights the need of a better understanding of the interaction between GPR systems and the glacierized subsurface in high mountain terrain.
The Otemma glacier in the Pennine Alps, Valais, has been subject to repeated profiling with commercial GPR ground units (pulseEKKO and GSSI) operating at frequencies ranging from 15-67 MHz deployed at the surface and mounted on a helicopter. Our data shows significant quality differences between similar GPR profiles, which could not be explained by system failure or technical discrepancies. To investigate the issue, we conducted antenna rotation experiments at several locations on the glacier surface. The results indicate a strong relationship between the orientation of the bistatic antennas and the flow direction of the glacier.
Possible explanation for our observations range from anisotropy effects in glacier ice, the influence of directional characteristics of the GPR antennas or distinctive features of the bedrock topography. To explain our results, we perform 3D GPR modeling of the glacier body with the FDTD electromagnetic simulator gprMax. A basic homogenous three-dimensional model of the glacier will be replaced by varying bedrock topography along a transect. Internal structures such as water layers and inclusion will be imbedded in the simulations.
Currently ground based GPR surveys produce higher quality data with respect to the visibility of glacier bed reflections. We intent to enhance our operating system and antenna installation on the helicopter based on the results of the simulations to achieve similar quality standards. The objective is to successfully map the bedrock topography of the Swiss glaciers in the next three years.