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# Determining the ice volume distribution of glaciers using helicopter-borne GPR and glaciological modeling

Melchior Grab (1,2), Lisbeth Langhammer (1), Andreas Bauder (2), Lasse Rabenstein (3), Lino Schmid (1,2), and Hansruedi Maurer (1)

(1) ETH Zürich, Institute of Geophysics, Earth Science, Zürich, Switzerland (melchior.grab@erdw.ethz.ch), (2) ETH Zürich, Laboratory of Hydraulics, Hydrology and Glaciology (VAW), Switzerland, (3) Drift & Noise Polar Services GmbH, 28209 Bremen

In the near future, the ongoing melting of glaciers in Alpine regions will cause a large loss of water resources and a changning behaviour of the annual river runoff in the forelands. This will have an impact on many fields, with the electricity production from hydropower or the changing characteristics of natural hazards being some of the most prominent ones. For developing strategies to mitigate the ongoing melting of glaciers, an accurate prediction of the future river discharge and the topography of deglaciating regions is needed. A good knowledge of the current ice thickness distribution builds the basis for such predictions.

To obtain this information for the glaciers in Switzerland, we have developed a dual-polarization helicopter-borne ground penetrating radar (GPR) instrument from commercially available components and an associated data processing software package. The GPR data provide ice thickness and the topography of the bedrock on a sparse grid across the glaciers. We combine these data with glaciological modeling techniques, in order to estimate the total ice volume and to provide continuous ice thickness and bedrock topography maps. For this purpose, an algorithm has been developed, which uses inverse theory to constrain a glacier model, obtained from an existing glaciological modeling technique, to the ice thickness from the GPR profiles. By using an inversion scheme, further constraints in addition to the GPR data can be added, such as the glacier outline or smoothing constraints, which can be weighted individually depending on the confidence we have into each of these contributions.

During the past years, we used our GPR-instrument for recording data from most glaciers in the Swiss Alps. Combining these data with our new glaciological modeling scheme, we currently derive the three-dimensional ice thickness distribution of each glacier. Finally, we aim at an improved estimate of the total amount of ice mass in the Swiss Alps.