Investigating the thickness of Hochebenkar rock glacier with ground penetrating radar and a simple rheological model

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Äußeres Hochebenkar (HEK) rock glacier is one of the most intensely monitored rock glaciers in the Austria Alps. Surface flow velocities have been recorded since the 1930s by measuring the displacement of marked blocks. In addition to the long term monitoring campaign, high resolution LiDAR data has been used to determine flow velocities in recent years. In 2002, 2008 and 2013 ground penetrating radar (GPR) measurements were carried out at HEK rock glacier to determine the depth of the bedrock.

The radargrams were analysed using the software ReflexW. To determine the depth of the reflectors, the propagation velocity of the radar pulse must be known. This velocity is likely to vary with density variations. In order to account for this, a range of possible propagation velocities was used in the analysis. Results suggest that the total thickness of the rock glacier ranges from 5 – 10 meters at the lowest parts and increases to up to about 50 meters in upper regions. Based on the GPR results, the main body of the rock glacier is assumed to consist of an ice-rich layer of permafrost covered by a thick layer of ice-free debris.

It is further assumed that the deformation of the ice-rich layer drives the movement of the rock glacier. Using a modified version of Glen's flow law that takes into account the effect of the surface debris, the thickness of the rock glacier is modelled at varying spatial and temporal resolutions. Using flow velocity information gained from LiDAR data, the model is applied to the entire area of the rock glacier. Calculations are also carried out for the transects where block displacement is measured, resulting in a 50 year time series of modelled depth, which shows the considerable effect velocity variations have on the model.

The information gained from the GPR measurements is compared with the model results, allowing a discussion of the possible strengths and limitations of the modelling approach and how these can change over time and due to variations in terrain.