Quantifizierung des Permafrostrückgangs in alpinen Felswänden aus 14 Jahren quantitativer 3D Geophysik und geomorphologische Auswirkungen (Steintälli, Mattertal, CH)

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Warming of mountain permafrost leads to growth of active layer thickness and reduction of rock wall stability. The subsequent increase of instable rock volumes can have disastrous or even fatal consequences, especially when cascading events are simultaneously triggered. This growth of climate-change-connected hazard, together with the recent increase of exposition of infrastructure and people, poses the alpine environments at a high risk, which needs to be monitored.

Laboratory-calibrated Electrical Resistivity Tomography (ERT) has shown to provide a sensitive record for frozen vs. unfrozen conditions, being the most accurate quantitative permafrost monitoring technique in permafrost areas where boreholes are not available.

The data presented here are obtained at the Steintälli ridge in Switzerland, which is affected by a strongly melting permafrost lens. A consistent 3D field set-up, the robust temperature calibration and the quantitative inversion scheme allow to compare measurements from the longest known time series (2006-2019) of ERT in steep bedrock.

Confirming the long-term observation from air temperatures, results from multiple parallel transects show an average resistivity reduction of 22%, concentrated at deeper layers of the permafrost lens. The permafrost area in the 3D cross sections also decreased from 30 to 10%, with losses mainly localized on the south-east part of the study site, but in some cases also extending to the north face.

Extensometer transects along the ERT array indicate that deformations of the perennially-frozen crest line and of the NE-facing slope are 3 to 4 times higher than in the non-permafrost-affected SW-facing slope. The velocity of rock displacements in late summer is 20 times higher than in all-season measurements and along a permafrost rock slope respond exponentially to mean air temperature during observation period with an R^2 of 0.86.

These findings support the hypothesised strong response to temperature change due to enhanced ice-creep and failure of ice in fractures.

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