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Permafrost investigation in the Mont Blanc massif steep rock walls: a combined measurement, modelling and geophysical approach

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The steep rockwalls of the Mont Blanc massif have been affected by an increase in rockfall activity in the last decades. Permafrost degradation is suggested as the most likely triggering factor. To better understand geomorphic processes we investigate permafrost distribution and address questions on its pattern in steep alpine bedrock.

We use GIS-modeling to simulate Mean Annual Rock Surface Temperature (MARST) distribution. Rock temperature measurements including three 10-m-deep borehole monitoring at the Aiguille du Midi (AdM, 3842 m a.s.l) serve to estimate the temperature offset (i.e. temperature difference between rock surface and depth of negligible inter-annual temperature varibility). The estimation of the lower extent of permafrost distribution is derived from a combination of both approaches and hypotheses on permafrost occurrence are evaluated with Electrical Resistivity Tomography (ERT) measurements.

The MARST model indicates that the 0°C isotherm extends down to 2600 m a.s.l in the most shaded faces and rises up to 3800 m in the most sun-exposed areas. According to recent literature and the AdM borehole thermal profiles, we postulate that permafrost could extends down below MARST reaching up to 3°C due to temperature offset processes. ERT measurements performed along 160-m-long profiles at six different sites which the top are located from 3360 m a.s.l to 2760 m a.s.l and the MARST range from <-1°C to > 3°C are the first of this kind. Five of sites are located in the granite area making them directly comparable. They all show high resistivity values at depth (>200 kΩ) interpreted as permafrost bodies. Lower resistivity values (< 90 kΩ) are found either above the high resistivity bodies and interpreted as thawed active layer, or below MARST warmer than 2-3°C and interpreted as non-perenially frozen rock. Two sites were measured in autumn 2012 and autumn 2013 allowing for time-lapse investigation which demonstrates the change in resistivity in repeated measurements.

These preliminary results could confirm that steep alpine bedrock permafrost exists below surface temperature reaching up to 3°C. A temperature-resistivity calibration will be performed in a freezing laboratory at the Technical University of Munich to better assess ERT results and their interpretation in terms of permafrost occurrence and interannual changes.