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The Aiguille du Midi (Mont Blanc massif): a unique high-Alpine site to study bedrock permafrost

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Permafrost and its change in steep high-Alpine rock walls remain insufficiently understood because of the difficulties of in situ measurements. A large proportion of permafrost studies is mainly based on modelling, with a few existing instrumented sites and a resulting lack of process understanding. Yet, a number of rockfalls that occurred in the last decade in the Alps are likely related to climatically-driven permafrost degradation, as indicated by ice in starting zones, increased air temperature, and modelling studies.

Starting off in the framework of the French-Italian PERMAdataROC project and presently under development within the EU co-funded project PermaNET (Permafrost long-term monitoring network: www.permanet-alpinespace.eu), our investigations at the Aiguille du Midi begin in 2005. The summit (3842 m a.s.l) is accessible from Chamonix by a cable car which was built at the end of the 1950s. Half a million tourists visit the site each year. Because of its elevation, geometry, and year-round accessibility to rock slopes of diverse aspects and to galleries, the site was chosen for:
- Monitoring of the thermal regime in steep rock walls. Thermistors were installed at depths of 2, 10, 30 and 55 cm, at all aspects and with slope angles in the range 60–90° (determining e.g. the presence and influence of snow).
- Measurements of high altitude climatic data (air temperature and humidity, incoming and outgoing solar radiation, wind speed and direction) perpendicular to the rockwall surface, by movable automatic weather stations. Together with the rock temperature measurements, these data (see Morra et al., poster in session CR4.1) can be used for physically-based model validation (see Pogliotti et al., oral presentation in session CR4.1) or statistical models construction of rock temperature distribution and variability in the rock walls.
- Making a 3D-high-resolution DEM by long-range (rock walls) and short-range (galleries) terrestrial laser scanning.
- Surveying the distribution of permafrost in the rock mass and its seasonal evolution during the year using electrical resistivity tomography and laboratory testing of temperature-resistivity behaviour of the local granite (see Krautblatter et al., poster in session CR4.1).

During the next months, the following complementary instrumentation and research will be accomplished:
- Numerical modelling of the 3-D distribution and evolution of temperature fields in the subsurface, based on the combination of a distributed energy balance model and a 3-D heat conduction scheme for the subsurface.
- Installation of thermistor chains in shallow boreholes (up to a depth of 10 m) to monitor temperatures and to parametrize and validate rock temperature models.
- Infrared thermography, using a handheld thermographic camera, to produce diachronic images of the rockwall radiative temperatures.
- Numerical modelling of rock fractures and water flow in unsaturated fractures.
- Monitoring of the morphological activity of the Arête des Cosmiques SE face – SE Pilastre by long-range terrestrial laserscanning.

The combination of process understanding, statistical analyses and/or modelling will help to improve our understanding of where, why and how permafrost degradation in mountains occurs. Secondly, we are interested

in how a reduction in the uncertainty of data, process understanding and models may contribute to our predictive skill of corresponding effects.

As an illustration of this innovative research project, the poster presents some first results of the investigations at the Aiguille du Midi.