Name of research institute or organization:

WSL Institute for Snow and Avalanche Research SLF

Title of project:

1. Influences of the snowcover on thermal processes in steep permafrost rockwalls
2. Long-term permafrost monitoring

Part of this programme:

PERMOS; Permasense

Project leader and team:

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Marco Collet

Project description:

1. In the project entitled 'Influences of snow on permafrost rock walls' (SNF project no. 200021E-135531**)** we continued to investigate the role of snow on the thermal regime and mechanical stability of steep rock walls. The research sites included the Sphinx north and south rock walls, which were equipped with temperature logging devices by ETH and the University of Zurich in the context of the PermaSense project (www.permasense.ch). The data is online and complements our data on snowpack characteristics, which was obtained manually in snow pits. Snow covers in rock walls were shown to have distinctive properties. There are strong contrasts between N and S aspects due to lack of / enhanced solar insolation and we observed strong inter-site similarities. The formation of basal ice layers (Fig. 1a) under the snow on the frozen rock can prevent melt water infiltration, contributing to rock wall stability (Phillips et al. 2016). Regardless of aspect, windward rock walls are covered in rime or glaze during storms (Fig. 1b), which does not occur in flatter terrain. These snowpacks are difficult to simulate using 1D snow cover models due to the complex fluxes of vapour, water and heat in different directions, but their characteristics are easy to anticipate in the field (Phillips et al. submitted). The properties and distribution of the snow cover in rock walls with contrasting orientations were investigated at Sphinx and compared with those in other permafrost rock walls in the Swiss Alps and their distribution and duration were modelled using Alpine3D (Haberkorn et al. 2016).

Figure 1a (left). Basal ice layer in the N face of the Sphinx caused by snow melt and refreezing of melt water on the cold rock surface lower downslope. This phenomenon occurs yearly from mid-April onwards. Figure 1b (right). Rime in the S face of the Sphinx after a storm.

2. The sub-horizontal Jungfrau Ostgrat borehole is located at 3590 m in the north facing wall of the Jungfrau Ostgrat (E ridge). It is 20 m long and equipped with 9 thermistors and a data logger. Rock temperatures vary on a seasonal basis between -4 and -8°C. Due to the time lag with depth, the warmest temperatures are registered in December and the coldest ones in May. The high elevation of the borehole and the fact that it is located in a steep, exposed rocky ridge make the data particularly valuable for long-term monitoring. Borehole temperature data now clearly indicate a warming trend (Fig. 2). In June 2016 lightning destroyed the outermost 3 thermistors. The borehole is part of the Swiss PERMOS network (www.permos.ch, PERMOS 2016) and current borehole temperature data can be obtained and visualized online using: http://shinypermos.geo.uzh.ch/app/BoreholeDataBrowser/.

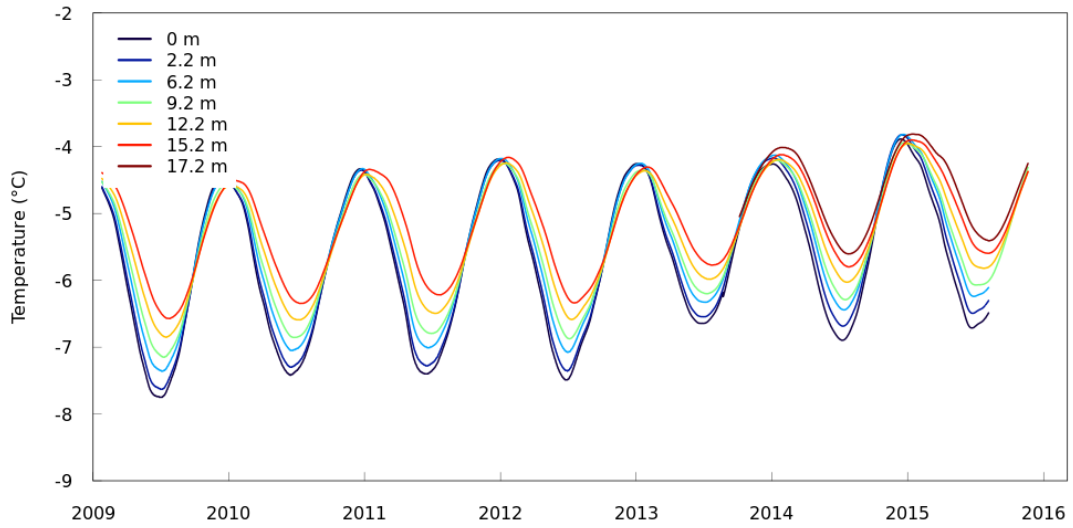

Figure 2. Borehole temperatures (2009-2016) in the Jungfrau Ostgrat N borehole (Legend: 0m is located 6m from the outer surface of the rockwall). The 3 outermost thermistors were damaged by lightning in June 2016.

Both projects are valuable sources of data for the investigation of the role of permafrost regarding rock slope stability in high mountain regions. Our measurements at Sphinx and Jungfrau Ostgrat allow to discern the evolution of rock temperatures and active layer thickness, as well as the role of the snow cover and of snowmelt on rock temperature and rock slope stability.

Key words:

Mountain permafrost, frozen rockwalls, thermal regime, long-term monitoring, snow characteristics

Internet data bases:

www.permos.ch
http://shinypermos.geo.uzh.ch/app/BoreholeDataBrowser/
www.permasense.ch

Collaborating partners/networks:

Universities of Munich, Fribourg and Zurich, ETH Zurich
PermaSense
PERMOS

Scientific publications and public outreach 2016:

Refereed journal articles and their internet access

Haberkorn, A., N. Wever, M. Hoelzle, M. Phillips, R. Kenner, M. Bavay, M. Lehning, Distributed snow and rock temperature modelling in steep rock walls using Alpine3D, The Cryosphere, doi: 10.5194/tc-2016-73, 2016. http://www.the-cryosphere-discuss.net/tc-2016-73/

Phillips, M., A. Haberkorn, D. Draebing, M. Krautblatter, H. Rhyner, R. Kenner, Seasonally intermittent water flow through deep fractures in an Alpine Rock Ridge: Gemsstock, Central Swiss Alps, Cold Regions Science and Technology, **125**, 117-127, doi: 10.1016/j.coldregions.2016.02.010, 2016a. http://dx.doi.org/10.1016/j.coldregions.2016.02.010

Theses

Haberkorn A., The influence of the snow cover on the temperature regime of steep rock walls, Doctoral thesis, Faculty of Sciences, University of Fribourg, Switzerland, Thesis no. 1971, 195 pp., 2016.

Data books and reports

PERMOS 2016. Permafrost in Switzerland, 2010/2011 to 2013/2014, Noetzli J., R. Lüthi and B. Staub (eds.), Glaciological Report Permafrost No. 12-15, University of Fribourg, Cryospheric Commission of the Swiss Academy of Sciences, 85p., 2016. http://www.permos.ch

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