Long-term monitoring of rock temperature in the Jungfrau East ridge permafrost

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1. Project description

The sub-horizontal borehole in the Jungfrau East ridge is located at 3590 m asl (Fig. 1) in the northern flank of the ridge. It is 20 m long and is equipped with 9 thermistors and a data logger. Rock temperatures currently vary between -3.4 and -6.2°C (Fig. 2). Due to the time lag with depth, the highest rock temperatures are registered in winter and the lowest ones in summer. The high elevation of the borehole and its position in a steep rock wall make it valuable for long-term permafrost monitoring, as there are only eight boreholes in high elevation rock walls in the entire Alps.

Figure 1. White arrow: Position of the borehole in the Northern flank of the Jungfrau East ridge (Photograph: M. Phillips).

The Jungfrau borehole temperature data indicate a clear warming at all depths (Figs. 2 and 3), as do other borehole data measured in steep, ice-poor permafrost rock in the Swiss Alps (Haberkorn et al. 2021). Unfortunately, it is not possible to determine whether active layer thickness (ALT) has changed, as the borehole was drilled from a tunnel inside the mountain outwards - and the end of the borehole is 6 m away from the outer surface of the rock wall. At present, ALT has not yet reached 6 m depth.

A number of temperature sensors were destroyed by lightning in 2016 (Fig. 2) and it is planned to replace the entire sensor array in 2022, according to best-practice techniques we have developed based on our long-term borehole temperature monitoring experience in the Alps (Noetzli et al. 2021).

The borehole is part of the Swiss permafrost monitoring network PERMOS and the borehole temperature data can be accessed here: http://newshinypermos.geo.uzh.ch/app/DataBrowser/

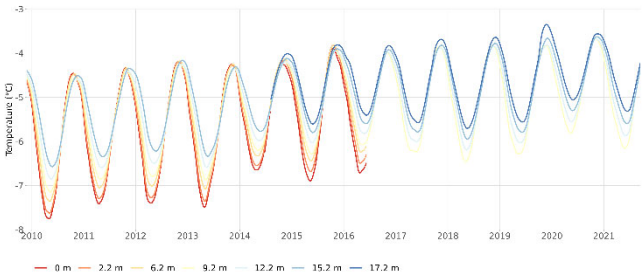

Figure 2. Borehole temperatures (2009-2021) in the Jungfrau borehole. (Legend: 0 is located 6 m from the outer surface of the rock wall). Data: SLF/PERMOS

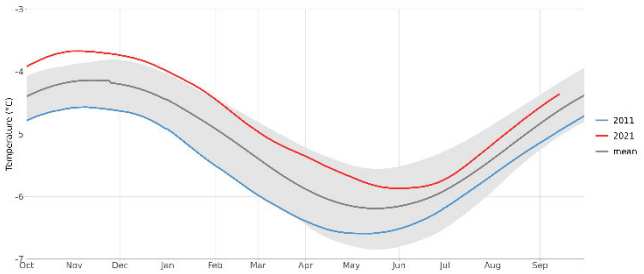

Figure 3. Rock temperature evolution at 12.2 m depth in 2011 (blue line) and in 2021 (red line). Grey line: mean annual temperature at 12.2 m depth. Data: SLF/PERMOS

Internet data bases

www.permos.ch
http://newshinypermos.geo.uzh.ch/app/DataBrowser
https://gtnp.arcticportal.org/data/data-download

Scientific publications and public outreach 2021

Refereed journal articles and their internet access

Haberkorn, A., R. Kenner, J. Noetzli, M. Phillips, Changes in ground temperature and dynamics in mountain permafrost in the Swiss Alps, Frontiers in Earth Science, **9**, 626686 (21 pp.), https://doi.org/10.3389/feart.2021.626686, 2021.

Noetzli, J., L.U. Arenson, A. Bast, J. Beutel, R. Delaloye, D. Farinotti, D., … M. Phillips, Best practice for measuring permafrost temperature in boreholes based on the experience in the Swiss Alps, Frontiers in Earth Science, **9**, 607875 (20 pp.), https://doi.org/10.3389/feart.2021.607875, 2021.

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