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Monitoring of permafrost temperature and strain in the Eastern Ridge of Mt. Jungfrau

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Progress of the thaw in the mountain permafrost has the correlation with the stability of steep slopes and rock faces. In the aspect of natural hazards, the monitoring of the response of the permafrost to the climate change therefore has the importance in high mountains.

For the alpine permafrost, due to the large effect of topography, the ground surface temperature has the wide range of local variability. Consequently, the distribution of the mountain permafrost should be estimated by the empirical rules or modellings. Yet there are difficulties of the verification for these estimations, because in situ measurements of ground surface temperature are rarely available, which is the essential parameter for the thermal state of permafrost. It is therefore important to perform the actual measurement not only for the verification of the permafrost model, but also for the grasp of the current state of permafrost by the real data.

Since 1995, temperature and deformation have been measured on the East ridge of Mt. Jungfrau. Two boreholes of twenty meters depth are drilled outwards from the inner tunnel, on both of north and south sides of the ridge. Eight thermistors and six-point extensometres are installed for each borehole. The advantage of this measuring site is; 1) having deep borehole in the rock wall of high mountains, 2) measuring the temperature and deformation in the same location, and 3) measuring both of north- and south-wall of the same ridge.

10-years observation shows that the trend of rock wall temperature not necessarily follows that of the air temperature, possible reason of which is the variation of the other factors, such as snow deposit or water content. On the other hand, the entire rock wall temperature doesn't show a strong trend of warming for the last 5 years. It is natural that annual mean temperature does not depend on seasonal variation, but should show some trends when the long-term temperature variation exists. The data imply that air temperature may be not the most important controlling factor of long-term rock wall temperature.

On the south wall, the temperature at 8 meters depth is close to freezing point (i.e. above zero in deeper part), therefore the thickness of the permafrost is estimated less than 10 meters. Generally, permafrost has the long, decade-scale response time to the climate, but such shallow permafrost should be sensible to the climate variation. It can be thawed in relatively short period under the present climate trend. Careful monitoring is needed.

Using temperature data, simple modelling in 1-D and 2-D are performed, in which heat transfer in the mountain is calculated. The results are, however, dependent on the boundary conditions on rock wall surface, and this parameter can vary locally.

The strain data show the contraction from spring to summer and the expansion from fall to winter. The amplitude is different between north- and south- walls, so does the pattern of strain accumulation. It may reflect the temperature and water condition of the rock wall, which requires more detailed analysis.