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Quantifying Permafrost Thaw on Schilthorn, Swiss Alps, based on a 5-year Geophysical Data Set

C. Hauck (1), M. Hoelzle (2), I. Völksch (3), M. Scherler (2), L. Schudel (2), C. Kottmeier (1), W. Haeberli (2)

(1) Institute for Meteorology and Climate Research, Forschungszentrum Karlsruhe/University of Karlsruhe, Germany, (2) Physical Geography Division, Dept. of Geography, University of Zurich, Switzerland, (3) Swiss Federal Institute for Forest, Snow and Landscape Research (WSL), Switzerland; (hauck@imk.fzk.de)

Monitoring the amount of permafrost degradation in mountain regions is one of the foremost tasks in current permafrost research, especially in the context of climate change and the increased rockfall activity in the European Alps during the anomalously warm summer in 2003. Apart from direct, but singular and costly temperature measurements in boreholes no operational monitoring system exists to date.

A surface-based geophysical monitoring system using electrical resistivity tomography has been initiated in 1999 to monitor the long-term change in electrical resistivity of the subsurface at the PACE21 (Permafrost and Climate in the 21st Century) permafrost monitoring station Schilthorn, Swiss Alps. The electrical monitoring system was installed to determine the amount of freezing and thawing over a 60m long and 10m deep profile line on a regular basis. Two boreholes (13m and 100m deep) with thermistor strings are situated along the profile line. In addition, an energy balance station provides meteorological parameters like radiation, air temperature and snow cover thickness.

Results from the resistivity monitoring system showed the applicability of the method for the detection of freezing and thawing processes in the subsurface in the absence of additional water sources like snowmelt and rain. Seasonal freezing and thawing as well as processes on time scales of a few days could be detected and visualised. In combination with borehole temperature data and for initially saturated and unfrozen material the amount of thawing could be quantified, however, a quantitative assessment of the amount of subsurface freezing and thawing is difficult by resistivity data

alone.

In this contribution we present an improved monitoring approach using additional seismic data to calculate the evolution of the ice content at Schilthorn during 1999-2004. Ice-, water- and air content are calculated using a new model approach based on a combination of two well known geophysical mixing formulas for electrical resistivity and seismic P-wave velocity. Results from the 5-year resistivity data set in combination with additional seismic measurements show a decrease in ice content between 1999 and 2004 corresponding to an increase in active layer depth from 5m up to 7m as determined from the borehole measurements. The results suggest that geophysical monitoring systems may indeed be used to quantify the amount of permafrost degradation over larger areas as well as its spatial and temporal variability.