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Assessment of the sensitivity of mountain permafrost to climate change: A comparison between southern Norway and the Swiss Alps

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As part of the SPCC (Sensitivity of Mountain Permafrost to Climate Change) and CRYOLINK (Permafrost and seasonal frost in southern Norway) collaboration two well documented measuring sites, Juvvass (N) and Schilthorn (CH), with very complete data sets over more than 10 years were compared regarding their permafrost response to atmospheric forcing. Both sites have already been part of the PACE project (Permafrost and climate in Europe) and have borehole temperature records since 1999 as well as repeated geophysical surveys between 1999 and 2010. These geophysical surveys include Electrical Resistivity Tomography (ERT) and refraction seismic tomography carried out along several profiles at both sites. Furthermore six shallow boreholes were drilled in 2008 at Juvvass.

Those measurements over comparatively long time periods were used to assess the magnitude of the link between the atmospheric changes (especially the air and ground surface temperature changes) and the response of the permafrost through the change in its physical properties such as active layer thickness, temperature at the top of the permafrost and apparent resistivity by computing sensitivity indices. The measured changes in mean apparent resistivity are hereby used as proxy for ice content changes in the subsurface.

Obvious differences are highlighted by the calculation of the various indices. The permafrost evolution at Juvass is strongly correlated with changes in air temperature whereas at Schilthorn the ground surface temperature (GST) is the fundamental trigger. The GST is a trigger at Juvvass as well, but at least for the PACE borehole site at Juvvasshoe a more or less direct coupling between air temperature and GST was found which is not the case at Schilthorn. The reason is the strong influence of the winter snow cover at Schilthorn, which is very thin or absent at Juvvass. The exceptionally hot summer in Switzerland is also clearly seen as well as its influence on the thermal regime of the following year. By this, clear evidence is presented that ground ice at Schilthorn was degrading in the summer 2003, which was not directly restored in the following year. This presentation will focus on the development and calculation of several sensitivity indices as well as measures to relate this sensitivity to ice content changes within the permafrost based on geophysical measurements and the so-called 4-phase model (4PM).