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Idealised Modelling of the Impact of Atmospheric Forcing Variables on Mountain Permafrost Degradation

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To evaluate the sensitivity of mountain permafrost to climate change at two field sites in the Swiss Alps the dominant meteorological forcing variables such as temperature, precipitation, time and duration of snow cover and radiation have to be considered. These variables determine the short-term permafrost responses, such as interannual variability in active layer thickness, but also its future evolution on time scales of decades. In order to analyze whether future climate change may lead to significant changes in the permafrost characteristics, model studies linking the projections from Regional Climate Models (RCM) and high-resolution subsurface models have to be conducted.

We use a 1-dimensional coupled heat and transfer model (COUP model) to investigate the interactions between the atmosphere and the ground focusing on ground temperature evolution and the temporal variability of the active layer depth. Idealized and observed atmospheric forcing data sets are used to determine the meteorological conditions, which have the largest impact on the permafrost regime. In addition, various RCM data sets are used to determine the possible range of projected changes within the subsurface in future.

Borehole temperature and energy balance data from two permafrost stations within the Swiss permafrost network PERMOS (Schilthorn, 2900 m asl and Murtel-Corvatsch, 2500 m asl) are used for verification purposes.

First results for the Schilthorn site show the largest impact due to increased/decreased summer temperatures during the snow free period and to a lesser extent winter precipitation which influence the period of snow cover. Similarly important, but more difficult to simulate, is the timing of the first snow event in autumn which leads to a sufficiently large snow cover to isolate the ground from atmospheric forcing. Changes in short-wave radiation and other variables have minor effects on active layer thickness.

Simulations with different RCM data sets derived from an ensemble of models and scenarios for the time slice 2071-2100 show that inter-model variability results in differences in changes of active layer depth on the same order than between different scenarios.