Geophysical Research Abstracts
Vol. 13, EGU2011-12162, 2011
EGU General Assembly 2011

On the use of water content monitoring to study the evolution of mountain permafrost

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The water content of the subsurface (or soil moisture) plays a major role for the energy and water budget of polar permafrost occurrences. Especially regarding its influence on the thermal and hydraulic conductivity of the soil as well as regarding phase changes during freeze and thaw processes, the importance of soil moisture has been confirmed in many monitoring and model studies.

In high mountain permafrost areas, such as the European Alps, the surface is mostly characterised by coarse-blocky material, bedrock and unconsolidated sediments without organic soils, which leads to small (liquid) water contents within the subsurface. Infiltrating rain water and melt water from the snow cover often drains quickly, due to the the absence of water retaining fines and the absence of flat terrain. Consequently, the water content in the active layer of Alpine permafrost and its spatio-temporal variability is considered small during most of the year. Processes related to infiltration are mostly limited to the snow melt phase, where infiltrating water and refreezing processes may play a larger role for short-term temperature fluctuation, also at larger depths (cf. Rist and Phillips 2005, Scherler et al. 2010).

In model studies of mountain permafrost, however, thermal results show a high sensitivity to the set-up (porosity, hydraulic conductivity) and initialisation of the subsurface water content, due to the non-linear dependence of thermal properties on the liquid water-ice relationship. As direct measurements of water contents and porosities are scarce, these subsurface properties are often adapted in a way that the difference between modelled and measured ground temperatures is minimised.

In this contribution we will present direct measurements of the subsurface water content at two permafrost sites in the Swiss Alps, and compare the absolute values and their spatial and temporal variability with typical model assumptions in mountain permafrost research. In addition, the relative importance of water content variability for freeze and thaw processes will be compared with corresponding data from non-permafrost sites at lower altitudes and permafrost sites at higher latitudes.

Rist, A. & Phillips, M. 2005. First results of investigations on hydrothermal processes within the active layer above alpine permafrost in steep terrain. Norwegian Journal of Geography 59(2): 177-183.

Scherler, M., Hauck, C., Hoelzle, M., Stähli, M. and Völksch, I., 2010. Meltwater infiltration into the frozen active layer at an alpine permafrost site. Permafrost and Periglacial Processes 21: 325–334, DOI: 10.1002/ppp.694.