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Influence of subsurface heterogeneity on observed borehole temperatures at a mountain permafrost site in the Upper Engadine, Swiss Alps

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Permafrost in high mountain areas occurs in a large variety of surface and subsurface material within short distances. This work presents a nine-year (2002 - 2011) data set of borehole temperatures for five different (sub-) surface materials from the high alpine permafrost area, Murtèl-Corvatsch, Switzerland (Haeberli et al. (1988) and Hanson & Hoelzle (2005)). The influence of the material on the thermal regime was investigated by borehole temperature data, the temperature at the top of the permafrost (TTOP-concept) and the apparent thermal diffusivity (ATD).

The results show no consistent subsurface temperature trends since 2002 within the uppermost 6 meters. Rather, the thermal regime is predominantly influenced by the composition of the subsurface material and the thickness and duration of the snow cover. At all sites the subsurface temperatures were the lowest when the snow thickness was less than 1m. As pointed out in Luetschg et al. (2008), it could be confirmed, that the longer the non-insulating snow cover lasts in autumn, the colder is the ground surface temperature (GST) through the entire year. At all sites the cooling during autumn/ winter and the duration of the zero curtain in spring had a stronger influence on the interannual variability of the thermal regime than the temperature increase during summer.

At coarse blocky, ice-rich sites no changes in active layer depth were observed. Rather, the ATD values of the active layer and the high temperature transport rate of 5.6 K m-1 d-1 confirm a high thermal response of the active layer. Within coarse blocky material, the air ventilation (as described in Wakonigg (1996)) and the seasonal production of ice seem to be the main factors for permafrost occurrence in high alpine regions. While temperatures within the talus slope are close to 0 °C and a stable permafrost regime is observed, the subsurface of the fine-grained site (where convective and advective airflow can be neglected) showed positive temperatures throughout the uppermost 6 meters in 2008/2009 for the first time.

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