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Thermal processes within the active layer of the rock glacier Murtèl-Corvatsch, Upper Engadin, Switzerland

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Coarse debris is a characteristic ground material in high alpine environments. The special thermal properties of this ground material favour the existence of permafrost. However, the most important processes explaining the common thermal anomaly found within these materials are still not yet fully understood. Many different approaches try to explain these processes. The most common explanation is the heat transfer between atmosphere and ground, driven by heat convection in autumn and winter and stable stratification of the interstitial air in summer. These processes could be shown at the investigated site in an earlier study (Hanson and Hoelzle 2005). On the contrary, Gruber and Hoelzle (2008) tried to explain the observed measurements independent of convective processes, only based on model calculations, which were based on the interaction between winter snow cover and the very low thermal conductivity of the coarse debris layer.

In the present study, we took the ground surface temperature data from the uppermost 90 cm of the active layer of the rock glacier Murtèl-Corvatsch in combination with meteorological data, such as air temperature, snow depth and radiation to analyze the dominant heat transfer mechanisms during the different seasons. The main focus was to assess the contribution of convective processes. The potential for free convection was estimated using the Rayleigh number. In addition, the air circulation within the uppermost active layer measured by three wind sensors was taken into consideration. These data were compared with the other climate variables of the nearby meteorological station.

After analyzing the data, it can be concluded that the potential for free convection in the cavities of the upper blocky layer is high as soon as the stable thermal stratification during the summer month gets instable due to a cooling of the surface. Especially in the autumn and early winter months a strong ground cooling could be observed caused by the low air temperatures and the related vertical convective heat exchange. These processes are limited by the formation of a continuous snowpack. A thick snow cover limits to a large extent the exchange with the atmosphere. Within the blocky layer, however, the potential for convection is still high. During snowmelt in spring, the latent heat transfer is the dominant process. During the summer month, the snow-free period, air circulation in the blocky layer is mainly caused by forced convection. However, this effect decreases with increasing depth of the blocky layer. The analysis of the wind sensor data shows that the ventilation system in the blocky layer is very variable and complex. However, some interpretations could be done. A) it can be shown that the airflow velocities within the blocky layer in the snow-free season are influenced by the atmospheric wind speed. B) in summer and autumn the effect of free convection could be identified with help of the measured air flow velocities and a comparison with the temperature data. C) the formation of a continuous snow cover reduces the airflow velocities, and the influence of forced convection. This effect is intensified during spring by the formation of ground ice caused by percolating melt water. Through the comparison of air and ground temperatures with the airflow velocities convective processes could be detected during a prolonged period in autumn, winter and sometimes even in spring. This indicates that convective processes in the microclimate of the active layer at the rock glacier Murtèl-Corvatsch site play probably a larger role than previously expected.