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Quantification of air driven heat transfer within the active layer of rock glacier Murtèl-Corvatsch

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Coarse debris is a common ground material in high alpine environments. The thermal properties of these blocky surfaces may lead to the existence of permafrost at sites, where without such ground characteristics permafrost would not develop. The processes behind this common thermal anomaly within these materials are still not entirely understood. The most common explanation is that the heat transfer between atmosphere and ground is driven by convective and advective heat fluxes within the blocky active layer in autumn and winter and stable stratification of the interstitial air in summer. Such processes have been observed by measurements at many different sites by several studies. In model studies these processes are often parameterised by applying very low effective thermal conductivities for the coarse blocky material. With such approaches, the observed measurements can be modeled quite accurately, independent of the convective processes.

The site of this study is the Murtèl rock glacier in the Murtèl-Corvatsch area in the Upper Engadin Switzerland. The site is characterized by a coarse surface with large blocks over a massive ice core. Energy balance studies at this site showed an annual deviation between a zero energy balance and the calculated sum of the energy balance components of around 20 W/m^2.

The model used in this study is a one dimensional coupled heat and mass transfer model of the soil-snow-atmosphere boundary layer (COUP Model). A complete energy balance is calculated for the snow or soil surface, yielding a surface temperature representing the upper thermal boundary condition of the soil profile. A constant geothermal heat flux determines the lower thermal boundary. The model includes the accumulation and melt of a seasonal snow cover, as well as freezing and thawing of the ground. The model is driven by the following meteorological parameters measured at the site: air temperature, relative humidity, incoming short-wave radiation, incoming long-wave radiation, wind speed, and precipitation.

In the model permafrost does not develop under present climatic conditions.

To account for insulation effect of the stable stratification in summer and convective as well as advective heat loss in the blocky layer in autumn and winter, a heat pump is placed in the model close to the surface layer.

An iterative method was chosen to evaluate the required heat pump power to obtain present day permafrost conditions in the rock glacier Murtèl. The heat pump power was calibrated using the measured borehole temperatures at 5m and 11m depth. The so determined value is about 17 W/m^2 which is close to the annual surplus of 20 W/m^2 found in the measurements.