Geophysical Research Abstracts
Vol. 12, EGU2010-6553, 2010
EGU General Assembly 2010

Long term modeling of permafrost in the Alps

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Air Temperature, radiation balance, snow cover and infiltration are known key factors in the thermal regime of permafrost. A model approach to investigate and quantify the influence of changes of these factors could lead to a better understanding regarding the sensitivity of permafrost to changes of climatic factors. Numerical models are well suited instruments to analyze thermal and hydrological processes in permafrost. Furthermore these models have the potential to be used for predicting the reaction of permafrost to climate change. For this application, a well calibrated model is crucial.

The model used in this study is a one-dimensional coupled soil water and heat transfer model of the soil-snow-atmosphere boundary layer (COUP Model). It accounts for the accumulation and melt of a seasonal snow cover, as well as for the freezing and thawing of the soil. The model is driven by the following meteorological parameters: air temperature, relative humidity, wind speed, global radiation, and precipitation. 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 has been applied to simulate ground temperatures together with water and ice content evolution of two high-altitude alpine permafrost sites in Switzerland. The sites are Schilthorn in the Bernese Oberland and Murtèl in the Engadin. The aim of the simulations was the long term modelling (9 years for Schilthorn and 6 years for Murtèl) and the calibration of the model for the two study sites. The model is validated with borehole temperature data as well as soil moisture measurements conducted with a newly developed simplified soil moisture probe (SISOMOP).

The simulated temperatures are in good agreement with the temperatures measured in the boreholes for both sites. The model results indicate that infiltration events at the beginning of the snow melt coincide with the onset of the spring zero curtain, and thus have a strong influence on the thermal regime of the active layer.

The applied model has proven to be suitable for long term simulation of permafrost. The calibrated model will be run with data from regional climate models and used to analyze the sensitivity of permafrost to climate change.