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Towards the simulation of a transient 3-dimensional temperature field of the Aiguille du Midi (Mont Blanc massif)

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A large proportion of Alpine permafrost can be found in steep bedrock. Here, ground temperatures react directly, fast and sensitively to changes in atmospheric conditions making the observation of steep bedrock slopes important for monitoring purposes. Further, changes in thermal conditions and cleft ice in rock walls can influence stability conditions for infrastructure or rock fall occurrence. With its easy accessibility, the extreme three-dimensional and steep geometry of a rock pillar with rock faces exposed to all aspects, and the high elevation (3842 m asl) the Aiguille du Midi in the Mont Blanc massif has become an important site to study bedrock permafrost. Research and measurement activities are undertaken by an international group of researchers since 2005 and include near surface temperature measurements, a weather station, ERT profiles, and since October 2009 three shallow boreholes of 11 m depth perpendicular to the surface.

In order to understand the transient three-dimensional thermal processes in the rock pillar and to simulate scenarios of their future development as a result of changing climatic conditions, first steps have been initiated to complement the point measurements by numerical modeling studies. For this we use the modeling approach developed and tested by Noetzli (2008), which combines results from a surface energy balance model (here we newly use the model GEOtop) as the upper boundary condition in a three-dimensional heat conduction scheme for the subsurface (COMSOL Multiphysics). GEOtop is a distributed hydrological model with coupled water and energy budgets. It has been intensively adapted for use in mountain permafrost research.

In this presentation we focus on the preparation and analysis of input data as well as the validation of the GEOtop model for the Aiguille du Midi site, which are fundamental for sound modeling studies. For testing the performance of GEOtop, multiple 1D runs are performed for the measured temperature series (temperature series from the Swiss PERMOS Network may be used to extend the data set for validation). That way, also the sensitivity of the simulation results to e.g. surface characteristics (e.g., albedo, roughness), little known subsurface material properties (e.g., thermo-physical properties, porosity), or levels of temporal aggregation can be evaluated. Detailed climate time series required for driving the model are available from high-elevation sites from MeteoSwiss. However, their relation and correlation to the local climate at the Aiguille du Midi need to be carefully assessed using available measurements of air temperature (since 2007) and the three years of data gained from the weather station on the south side. The objective of this contribution is to present first results on the way to transient three-dimensional modeling studies.