Geophysical Research Abstracts,
Vol. 11, EGU2009-8943, 2009
EGU General Assembly 2009

VALIDATION OF GEOtop MODEL FOR PERMAFOST RESEARCH ON STEEP HIGH-MOUNTAIN BEDROCK

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Permafrost distribution in high-mountain environments is influenced in a complex way by topography (micro-climate) and high variability of ground covers conditions (debris, snow, etc.). Also, its direct monitoring is very difficult due to logistical problems like accessibility, costs, weather conditions and reliability of instrumentation. In such conditions physically-based modelling of surface rock/ground temperatures is fundamental for the understanding of mountain permafrost dynamics. With this awareness, a 1D version of GEOtop model has been tested in several high-mountain sites and its accuracy to reproduce near-surface bedrock temperature, solar radiation and snow cover depth, has been evaluated using independent field measurements.
GEOtop is a distributed hydrological model with coupled water and energy budgets and is currently under development to suit permafrost research in such complex morphologies. Most of the validation runs have been performed using dataset coming from Corvatsch (3315 m a.s.l., Swiss Alps) since long time-series of meteorological observation are available and many monitoring sites of surface rock temperatures have been equipped during the last years by the University of Zurich. For the validation of modelled snow cover and solar radiation two different dataset coming from Valtournenche (Italian Alps) have been used: Cime Bianche Pass (3100 m a.s.l) and Matterhorn SW ridge (3830 m s.l.m.) equipped by A.R.P.A. Valle d'Aosta.
On each site, a 1D GEOtop simulation of temporal duration equal to the full set of meteorological observations (1982-2008) was performed. The first 4 years are used to define the initial conditions by an iterative initialization procedure, in order to obtain an equilibrium between the deep temperature profile and atmospheric conditions. In order to highlight or structural model's deficiencies, ground properties such as albedo, emissivity, thermal conductivity and roughness length are kept fixed over all sites. For each variable which want to validate, the proposed procedure compares the measured and modelled values on each site using a set of 9 performance measures over the full set of field observation. These measures are evaluated at 3 different levels of temporal aggregation: hourly, monthly and annual. The effects of terrain morphology on model performance are evaluated by means of linear regression between the independent morphological variables (elevation, slope, aspect, sky view factor) and cumulative residuals, calculated on each site and over an arbitrary common time-window.
In detail, sub-surface rock temperature (10 cm depth), incoming short wave solar radiation and snow depth have been validated over some near-vertical and near-flat monitoring sites, characterized by debris-free bedrock conditions. Such choices are driven by the desire of maximize the influence of topography and minimize those of all others factors. The general results show a good behaviour of the model both on flat and steep sites. In some sites the main problems can rise from difficulties in modelling solar radition and snow depth mainly due to micro-morphology and wind effect. The object of this contribution is to describe the details on model evaluation procedure and discuss main outcomes about 1D GEOtop behaviour.