Geophysical Research Abstracts, Vol. 7, 05605, 2005
SRef-ID: 1607-7962/gra/EGU05-A-05605

Sensitivity of melt rate spatial variations to different modelling approaches

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Melt rate across an Alpine glacier exhibits very high variability, due to the differential distribution of variables such as surface characteristics, snowpack status, topography, insolation, accumulation rates, snow depth etc. In this study, melt rate variations across an alpine glacier simulated using different ablation models are analysed, and the effect of the models characteristics on their ability to reproduce accurately the observed variations is evaluated.

Two ablation models of high spatial and temporal resolutions were used to compute hourly melt rates across Haut Glacier d'Arolla, Switzerland. This is a well-instrumented alpine glacier where meteorological variables and ablation have been monitored for more than four years. A physically-based energy-balance model was applied, which computes the entire energy exchange at the glacier-atmosphere interface, together with an enhanced temperature-index model including the shortwave radiation balance. The energy-balance approach models the energy exchange through the snowpack, which is crucial to be able to reproduce melt when the surface is not at 0 C. In the enhanced temperature index model a solar radiation module is incorporated, which enables to reproduce realistically the main source of melt energy for alpine glaciers.

Sensitivity of computed ablation rates to the depth and the characteristics of the snow layer, and to the albedo and solar radiation models are studied. Observations at 26 ablation stakes uniformly distributed across the glacier are used to validate the model simulations. They show differential ablation rates due to changes in aspect, topography and surface characteristics, which also vary over the course of the ablation season. Terrestrial photos taken from an automatic camera also provide daily images of the glacier surface. Using these data, the ability of the different models to explain the features observed is evaluated, and the importance of taking into account the status of the snowpack through a physically based approach is quantified.