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A study of the transferability and robustness of an enhanced temperature-index model

M. Carenzo, F. Pellicciotti, S. Rimkus and P. Burlando

Institute of Environmental Engineering, ETH Zurich (marco.carenzo@virgilio.it / Phone: +41-44-6332775)

A criticism that is normally moved to temperature-index models is that such an approach depends on empirical parameters that are calibrated for the single glacier and are therefore not transferable. In this paper, we investigate the parameters' transferability and model generalisation of an enhanced temperature-index (ETI) model that was developed and tested on Haut Glacier d'Arolla, Switzerland, during the 2001 ablation season. In a first step, the model parameters (temperature factor TF and shortwave radiation factor SRF) are optimised at five sites on Haut Glacier d'Arolla against simulations of an energy-balance model. The results are compared with those obtained with the original parameters values calibrated at one station and transferred to the other four stations. The model results robust in space during the 2001 ablation season, with small differences in the parameters values between the ablation and accumulation area. In a second step, the model transferability in time and space is tested. First, the model parameters are computed for the 2005 and 2006 melt seasons. Second, the model is applied to two other glaciers in the region: Gornergletcher, a much bigger and not entirely temperate glacier in the Valais Alps, and the Tsa de la Tsa glacier in the Italian Alps.

The model results to be sensitive to the shortwave radiation factor and much less so to the temperature factor, which multiplies the temperature-dependent term in the melt equation. Analysis of the model performance has also shown that this differs substantially between sunny and cloudy days, and that the highest discrepancy with the reference melt is found on overcast days, when the contribution to total melt of the longwave radiation and turbulent fluxes is higher. We therefore developed an algorithm for the separation of cloudy and sunny days, and conducted a separate calibration of the model empirical parameters for these two types of meteorological conditions. By

applying different empirical parameters to cloudy and sunny days we obtain a small increment in the model performance, which suggests that a different model approach might be used for overcast conditions. Finally, the optimisation procedure has pointed out to a problem of equifinality of the parameters: while it is possible to identify a couple of parameters corresponding to the maximum model performance, there is a large region in the parameters space that corresponds to values of the model efficiency very close to the maximum.