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Modelling the spatial variability of the snow water equivalent and snow cover by using a topography-based distribution function snowmelt model: comparison with a fully distributed model

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Fully distributed enhanced temperature-index models for snowmelt modelling, incorporating air temperature and clear sky solar radiation, are increasingly used to simulate the spatial variability of the snow water equivalent (SWE). Compared to temperature-index lumped or semi-distributed models, fully distributed enhanced models better account for the spatial variability of the SWE, but are computationally more demanding. This may limit application to large basins and to investigations which require Monte Carlo-based uncertainty analyses, which require large number of model runs.

This work aims to test the capability of a topography-based distribution function snowmelt model (termed TOPMELT) to represent the spatial variability of SWE and snow cover. TOPMELT integrates an enhanced temperature index model into a lumped basin-scale hydrological model, by exploiting a statistical representation of the spatial distribution of clear sky solar radiation. This is obtained by discretising the full spatial distribution of clear sky solar radiation into a number of radiation classes. The computation required to generate a spatially distributed water equivalent reduces to a single calculation for each radiation class. The model includes a routine, which accounts for the variability of clear sky radiation distributions with time, ensuring a consistent temporal simulation of the snow mass balance.

TOPMELT is compared against an enhanced temperature-index fully distributed model, termed EISMODEL (Cazorzi and Dalla Fontana, 1996) by using data from the upper Cordevole river at La Vizza (7.1 km^2, altitude ranging from 1815 to 3150 m a.s.l.), in the Dolomites (Italy), where a detailed data set concerning snow depth, SWE, snow cover and runoff is available. The two models use the same algorithms to describe snow accumulation and melt, with the method used to spatialize solar radiation being the only difference. The two models are compared with the available snow data and are used to feed a lumped hydrological model to simulate the observed runoff. The results illustrate how decreasing the number of radiation classes influences the ability of TOPMELT to describe the observed snow properties in comparison with EISMODEL, and how this influences the quality of the runoff simulation during snowmelt.

References:

[1] F. Cazorzi and G. Dalla Fontana, “Snowmelt modelling by combining air temperature and a distributed radiation index”, J. Hydrol., vol. 181, no. 1–4, pp. 169–187, 1996.