MODIS does not Capture the Spatial Heterogeneity of Snow Cover Induced by Solar Radiation

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ABSTRACT

Estimating snowmelt in semi-arid mountain ranges is an important but challenging task, due to the large spatial variability of the snow cover and scarcity of field observations. Adding solar radiation as a snowmelt predictor within empirical snow models is often done to account for topographically-induced variations in melt rates. Here we examine the added value of including different treatments of solar radiation within empirical snowmelt models and benchmarks their performance against MODIS snow cover area (SCA) maps over a 14-year (2003-2016) period. Three spatially distributed, enhanced temperature index models, which respectively include the potential clear-sky direct radiation, the incoming solar radiation, and net solar radiation, were compared with a classical temperature-index (TI) model to simulate snowmelt, SWE, and SCA within the Rheraya basin in the Moroccan High Atlas Range. The enhanced models, particularly the one including net solar radiation, were found to better explain the observed SCA variability compared to the TI model. However, differences in model performance in simulating basin wide SWE and SCA were small. This occurs because topographically-induced variations in melt rates simulated by the enhanced models tend to average out, a situation favored by the rather uniform distribution of slope aspects in the basin. While the enhanced models simulated more heterogeneous snow cover conditions, aggregating the simulated SCA from the 100 m model resolution towards the MODIS resolution (500 m) suppresses key spatial variability related to solar radiation, which attenuates the differences between the TI and the radiative models. Our findings call for caution when using MODIS for calibration and validation of spatially distributed snow models.

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