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Modeling spatial snow-cover distribution using snow-melt models and MODIS images

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Reliable representations of spatial distribution of snow and subsequent snow-melt are critical challenges for hydrological estimations, given their crucial relevance in mountainous regimes especially because of the high sensitivity to climate change. Relatively accurate physically based models are data intensive while in-situ measurements of snow-depth are prone to be non-representative due to local influences. Likewise, lack of snow-depth information and to some extent, cloud cover in the mountains limit the usage of Remote-sensing images in snow estimation. Against this backdrop, this work presents a methodology incorporating available remotely-sensed images (MODIS Snow-cover products) and simple distributed snow-melt models to estimate a time-continuous spatial snow extent in snow dominated regimes.

The methodology employs relatively cloud-free MODIS composite images to calibrate the spatial distribution of snow simulated by different distributed degree-day models. These variants of models are run in a domain of 500m x 500m grids, and incorporate daily precipitation, daily min-, max- and mean temperatures, and daily radiation data interpolated onto the aforementioned grids. Variations in the models include a simple degree model followed by incorporation of different aspects governing snow hydrology such as precipitation induced melt, radiation, topography, and land use. The modeled snow depths in each grid are reclassified to '1' (snow depths above a threshold) and '0' (no snow), and calibrated against MODIS snow-cover for cloud-free days with snow. Snow-melt parameters are then estimated for the region of interest. The result is a spatial snow-cover distribution time-series. This approach is replicated in different regions viz. Baden-Württemberg and Bavaria in Germany, and in Switzerland. Results suggest good agreement with MODIS data and the parameters show relative stability across the time domain at the same sites and are transferrable to other regions. Calibration using readily available images used in this method offers adequate flexibility, albeit the simplicity, to calibrate snow distribution in mountainous areas across a wide geographical extent with reasonably accurate precipitation and temperature data. The final validated spatial snow-distribution data can be, as a stand-alone input, coupled with distributed hydrological models to reliably estimate streamflow in data-scarce mountainous catchments.