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Snow modelling in a glacierized catchment using scale-dependent calibration data

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Physically-based hydrological models that integrate a large amount of parameters often face the problem of equifinality. Thus, the application of such models to Alpine catchments with high spatial heterogeneity and complex hydrological behaviour is challenging. In this context, the distributed hydrological model GEOtop was employed to simulate snow dynamics in the period 2010 - 2012 at different spatial scales within the Saldur basin (Eastern Italian Alps). In this catchment, hydrometric, isotopic and sediment transport data at different spatial scales are available to validate the model and to assess the physical consistency of the model output.
This work aims to: (i) assess the model validation at the plot scale in order to improve performances at the catchment scale; (ii) verify the usefulness of using multiple types of observations (snow, satellites, tracers, discharge) in order to assess the physical consistency and reduce the equifinality of the model output.
At the plot scale, the model was calibrated by a manual sensitivity analysis on predicted snow heights, water equivalent and duration compared with the corresponding snow depth data of two meteorological stations (at 1930 m and 3035 m a.s.l.) in the study area. Selected snow parameters controlling snow reflectivity and snow aging were calibrated. In addition to traditional snow depth data, photosynthetically active radiation (PAR) sensor data were used to derive snow duration of other four meteorological stations
In order to account for the spatial distribution of snow cover, best parameter settings of the plot scale models were transferred to catchment scale models. These models were assigned for two nested catchments, named LSG (19 km^2) and USG (11 km^2), which provided snow height and SWE in the catchment. At this scale, the model calibration was based on two types of remotely sensed snow maps: monthly Landsat images (30 m of resolution) and daily MODIS images (250 m of resolution).
To support the sensitivity analysis and the validation of the model, electrical conductivity, turbidity and stable water isotopes (δ^2H and δ18O) were measured in the stream from late spring to early fall 2011 and 2012. Furthermore, continuous discharge data were available for simulation period at LSG and USG. Two sampling approaches for tracers were defined to consider the spatial and temporal contribution to stream water: i) a monthly spatial distributed water sampling at LSG and USG and ii) an hourly water sampling over 24 hours simultaneously at LSG and USG at glacier melt- and snowmelt induced events. The stable isotope data were used in an end-member mixing model to identify the contribution of snowmelt in LSG and USG hydrograph. Additionally, time lags between the discharge and tracer curves peaks were analysed to infer flow paths and water origins. Finally, the calculated snowmelt contribution at daily and at monthly scale could be applied as an important dataset for validating the simulated snowmelt and snow cover of the catchment models.