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Snow multivariable data assimilation for hydrological predictions in Alpine sites

Gaia Piazzi (1), Guillaume Thirel (2), Lorenzo Campo (1), Simone Gabellani (1), and Hervè Stevenin (3)

(1) CIMA Research Foundation, Savona, Italy (gaia.piazzi@cimafoundation.org), (2) Hydrosystems and Bioprocesses Research Unit (HBAN), IRSTEA, Antony Cedex, France (guillaume.thirel@irstea.fr), (3) Dipartimento Territorio, Ambiente e Risorse Idriche, Regione Autonoma Valle d'Aosta, Italy

Snowpack dynamics (snow accumulation and ablation) strongly impacts on hydrological processes in Alpine areas. During the winter season the presence of snow cover (snow accumulation) reduces the drainage in the basin with a resulting lower watershed time of concentration in case of possible rainfall events. Moreover, the release of the significant water volume stored in winter (snowmelt) considerably contributes to the total discharge during the melting period. Therefore when modeling hydrological processes in snow-dominated catchments the quality of predictions deeply depends on how the model succeeds in catching snowpack dynamics.
The integration of a hydrological model with a snow module allows improving predictions of river discharges. Besides the well-known modeling limitations (uncertainty in parameterizations; possible errors affecting both meteorological forcing data and initial conditions; approximations in boundary conditions), there are physical factors that make an exhaustive reconstruction of snow dynamics complicated: snow intermittence in space and time, stratification and slow phenomena like metamorphism processes, uncertainty in snowfall evaluation, wind transportation, etc.
Data Assimilation (DA) techniques provide an objective methodology to combine several independent snow-related data sources (model simulations, ground-based measurements and remote sensed observations) in order to obtain the most likely estimate of snowpack state.
This study presents SMASH (Snow Multidata Assimilation System for Hydrology), a multi-layer snow dynamic model strengthened by a multivariable DA framework for hydrological purposes.
The model is physically based on mass and energy balances and can be used to reproduce the main physical processes occurring within the snowpack: accumulation, density dynamics, melting, sublimation, radiative balance, heat and mass exchanges. The model is driven by observed forcing meteorological data (air temperature, wind velocity, relative air humidity, precipitation and incident solar radiation) to provide a complete estimate of snowpack state.
The implementation of a DA scheme enables to assimilate simultaneously ground-based observations of different snow-related variables (snow depth, snow density, surface temperature and albedo).
SMASH performances are evaluated by using observed data supplied by meteorological stations located in three experimental Alpine sites: Col de Porte (1325 m, France); Torgnon (2160 m, Italy); Weissfluhjoch (2540 m, Switzerland).
A comparison analysis between the resulting performaces of Particle Filter and Ensemble Kalman Filter schemes is shown.