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Employing satellite retrieved soil moisture for parameter estimation of the hydrologic model mHM

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Hydrological models are usually calibrated against observed streamflow at the catchment outlet and thus they are conditioned by an integral catchment signal. Rakovec et al. 2016 (JHM) recently demonstrated that constraining model parameters against river discharge is a necessary, but not a sufficient condition. Such a procedure ensures the fulfillment of the catchment's water balance but can lead to high predictive uncertainties of model internal states, like soil moisture, or a lack in spatial representativeness of the model. However, some hydrologic applications, as e.g. soil drought monitoring and prediction, rely on this information.

Within this study we propose a framework in which the mesoscale Hydrologic Model (mHM) is calibrated with soil moisture retrievals from various sources. The aim is to condition the model on soil moisture (SM), while preserving good performance in streamflow estimation. We identify the most appropriate objective functions by conducting synthetic experiments. The best objective function is determined based on: 1) deviation between synthetic and simulated soil moisture, 2) nonparametric comparison of SM fields (e.g. copulas), and 3) by euclidian distance of model parameters, which is zero if the parameters of the synthetic data are recovered. Those objective functions performing best are used to calibrate mHM against different satellite soil moisture products, e.g. ESA-CCI, H-SAF, and in situ observations. This procedure is tested in three distinct European basins (upper Sava, Neckar, and upper Guadalquivir basin) ranging from snow domination to semi arid climatic conditions.

Results obtained with the synthetic experiment indicate that objective functions focusing on the temporal dynamics of SM are preferable to objective functions aiming at spatial patterns or catchment averages. Since the deviation of soil moisture fields (1) and their copulas (2) don't lead to conclusive results, the decision of the best performing objective function is based on the parameter distance (3). Thus, the temporal correlation and the sum of squared distances from soil moisture anomalies of reference and estimated soil moisture revealed best performances. Employing satellite retrieved SM for calibrating the hydrological model leads to model parameters which are able to catch soil moisture dynamics but deteriorates the skill on streamflow prediction. Discharge estimates are ranging between 0.1-0.3 Nash-Sutcliffe Efficiency, whereas the coefficient of correlation between modeled and satellite retrieved soil moisture exceeds 0.7.