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Improving the representation of spatial patterns with a distributed hydrologic model through multivariate parameter estimation using multiple satellite data sources

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Conventionally, hydrologic models are calibrated using streamflow data. However, a good prediction of streamflow does not guarantee a reliable spatial representation of other hydrological fluxes and states when using a spatially distributed hydrologic model. The increasing availability of satellite-based earth observation data has promoted the development of spatial hydrology and large domain water management applications including water accounting, and the monitoring of floods and droughts.

Multivariate parameter estimation based on the simultaneous use of multiple satellite-derived remote sensing data sources can reduce the feasible parameter search space and lead to better model performances by improving the internal model dynamics and the representation of spatial differences in hydrological processes. However, satellite data are not free of uncertainties and using different data from different satellite-derived remote sensing products simultaneously is not straightforward so that the value of such an approach remains rather under-explored.

In this study, we test a multivariate parameter estimation approach for modeling the daily hydrological response in the Volta River Basin (West Africa) for a study period of 2003-2012, based on the simultaneous incorporation of spatial patterns derived from three remote sensing products in the distributed Mesoscale Hydrologic Model (mHM). Each of the remote sensing products describes a different component of the hydrological system (i.e. evaporation from GLEAM, soil moisture from ESA-CCI and terrestrial water storage change from GRACE). To incorporate the different data sources in the calibration processes, we developed a new bias insensitive multicomponent spatial pattern metric as objective function. The goal is to investigate the potential improvement of the predictions of the spatiotemporal pattern together with the resulting effect on streamflow predictions in the study basin, as compared to traditional model calibration on streamflow data alone.

Preliminary results show an improvement in the prediction of spatial patterns of evaporation (10%) and soil moisture (17%), while a deterioration is observed in the temporal dynamics of streamflow (7%) and terrestrial water storage change (2%).