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Comparison of different data assimilation techniques based on sub-optimal filters in a distributed hydrologic model

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The use of data assimilation techniques based on ensemble filtering or smoothing is widely recognized to be the most fruitful approach to calibration and state estimation in many non-linear models. Implementation of statistically quasi-optimal techniques, such as the Ensemble Kalman Filter, in operational distributed models is very often impractical because of the too large number of replicas needed to update the covariance matrix. Various sub-optimal techniques, such as the ones based on a null-space identification, have been proposed in ocean and atmosphere models. Distributed hydrologic models, however, differ from other geophysical fluid dynamics in some substantial aspects. These aspects include threshold processes, the preferential paths for advection and diffusion, the scarce observability of primary state variables and the large parameter uncertainty. The present study addresses these issues with some numerical experiments with a continuous distributed model. The model, named MOBIDIC, includes water and surface energy balance and can assimilate a large variety of data, from river gauge observations to Meteosat retrievals of land surface temperature. Experiments are performed on a 700 km2 watershed in central Italy, with hourly data over an 8 months period including dry as well flooding conditions. The first experiment, taken as reference test, uses a full EnKF on a coarse resolution square grid (3.2 km) version of the model. A second set of experiments uses two different less-optimal but more parsimonious techniques, namely a simple reduce rank and a more advanced complementary orthogonal subspace filter. The effects of spatial resolution is then investigated in a third set of experiments with the parsimonious techniques only, where the spatial resolution is increased to 0.8 km. Performances of the various assimilation techniques are evaluated in terms of flow predictions at the watershed closure with lag times ranging from 1 to 8 hours, i.e. up to the order of the basin concentration time.