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Assimilation of inundation extent observations into a flood forecasting system: a tempered particle filter for combatting degeneracy and sample impoverishment.

Concetta Di Mauro, Renaud Hostache, Patrick Matgen, Peter Jan van Leeuwen, Nancy Nichols, and Günter Blöschl
Luxembourg institute of science and technology (concetta.dimauro@list.lu)

Data assimilation uses observation for updating model variables and improving model output accuracy. In this study, flood extent information derived from Earth Observation data (namely Synthetic Aperture Radar images) are assimilated into a loosely coupled flood inundation forecasting system via a Particle Filter (PF). A previous study based on a synthetic experiment has shown the validity and efficiency of a recently developed PF-based assimilation framework allowing to effectively integrate remote sensing-derived probabilistic flood inundation maps into a coupled hydrologic-hydraulic model. One of the main limitations of this recent framework based on sequential importance sampling is the sample degeneracy and impoverishment, as particles loose diversity and only few of them keep a substantial importance weight in the posterior distribution. In order to circumvent this limitation, a new methodology is adopted and evaluated: a tempered particle filter. The main idea is to update a set of state variables, namely through a smooth transition (iterative and adaptative process). To do so, the likelihood is factorized using small tempering factors. Each iteration includes subsequent resampling and mutation steps using a Monte Carlo Metropolis Hasting algorithm. The mutation step is required to regain diversity between the particles after the resampling. The new methodology is tested using synthetic twin experiments and the results are compared to the one obtained with the previous approach. The new proposed method enables to substantially improve the predictions of streamflow and water levels within the hydraulic domain at the assimilation time step. Moreover, the preliminary results show that these improvements are longer lasting. The proposed tempered particle filter also helps in keeping more diversity within the ensemble.