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Assessing parameter, precipitation, and predictive uncertainty in a distributed hydrological model using sequential data assimilation with the particle filter

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Sequential data assimilation techniques offer the possibility to handle different sources of uncertainty explicitly in hydrological models and hence improve their predictive capabilities. Amongst the different techniques, particle filter methods offer the capability to handle nonlinear/non-Gaussian state-space models while preserving the spatial variability of updated state variables, both desirable features when assimilating data in distributed hydrological models. In this work we apply the residual resampling particle filter to assess parameter, precipitation, and predictive uncertainty in the distributed rainfall-runoff model LISFLOOD by assimilating observed discharge at a gauging station. First, we compare estimated posterior parameter distributions considering only parameter uncertainty with results of the Shuffled Complex Evolution Metropolis global optimization algorithm obtained using identical input data for the Meuse catchment. Then, we illustrate the effect of considering additionally precipitation uncertainty on the predictive uncertainty. We present an analysis of the posterior parameter distributions and the posterior precipitation uncertainty. We also demonstrate that the concept of equifinality not only applies to simple conceptual models but is also valid for complex distributed models. We conclude with a brief discussion on the importance of taking into account model structural uncertainty even when using a distributed model that should theoretically provide an improved description of the hydrological system dynamics.