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Ensemble-based assimilation of discharge into rainfall-runoff models: a comparison of approaches to mapping observational information to state space

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The optimization of hydrologic models using the Ensemble Kalman Filter (EnKF) has received increasing attention during the last decade. The advantage of this approach is that no linearization of the hydrologic model is required to propagate the error covariance. However, in many applications, the observation system is still being linearized in order to calculate the optimal Kalman gain with the equation for linear systems. When the observed system output is strongly nonlinearly related to the state, this can lead to difficulties in the state estimation. The objective of this paper is to assess a number of approaches to the EnKF, in which this linearization of the observation system is bypassed or simplified. For this purpose, discharge observations are assimilated into three rainfall-runoff models. The performance of the assimilation algorithms is analyzed using the one-hour ahead forecasts. The results indicate that assimilation of discharge does not lead to improved model forecasts if a unit hydrograph is used for runoff routing. The application of the EnKF with a linearized observation system does not improve the model forecasts, while the full covariance-based approximation of the Kalman Gain improves the discharge forecasts. If the observations are assumed to be very accurate, an a priori ensemble verification needs to be performed. Under low observation errors, Monte-Carlo Reinitialization leads to the best model performance, but it is computationally more demanding. The overall conclusion of this paper is that assimilation of fluxes using an EnKF is most efficient if the linearization of the observation system is bypassed.