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Enhanced Conceptual Rainfall-Runoff Modelling through Ensemble Kalman Filtering

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The overwhelming complexity and variability of the processes and media that transform rainfall on a catchment into river runoff cause inaccuracies and uncertainties when these systems are modelled using rainfall-runoff model approaches. This is why operational streamflow forecasting should incorporate information sources such as recent measurement data to correct for model deficiencies and thereby increase forecast accuracy and reliability.

Data assimilation techniques such as Kalman Filters (KFs) are statistical methods for combining model estimates and measurement data. Filter algorithms require quantitative uncertainty information on both sources and are able to combine the two in a statistically optimal sense. The algorithms are often applied in a sequential way, and they divide the problem into a prediction step, in which a new model state is estimated, and a correction step, in which the model state estimate is updated using measurement information. This results in an updated model state estimate and updated uncertainty information about this estimate, which subsequently leads to an enhanced stochastic flow forecast by the rainfall-runoff model.

Traditional KF methods assume (near) linear model dynamics. However, recently introduced variants such as the Ensemble Kalman Filter (EnKF) are able to deal with the nonlinearity that is inherent in rainfall-runoff modelling. The EnKF is based on Monte Carlo methods: it represents the statistical properties of the model data and measurement data by an ensemble of possible model states and measurement values. The EnKF is statistically sub-optimal because a finite ensemble size only provides an

estimation of the full probability density function.

The EnKF is tested on a conceptual rainfall-runoff model approach for the Somme basin (France). The EnKF is applied to update both the model parameters and state variables using discharge measurements. The results of the filtered forecasts are promising and prove the value of data assimilation in rainfall-runoff modelling.