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Operational aspects of asynchronous filtering for improved flood forecasting

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Hydrological forecasts can be made more reliable and less uncertain by recursively improving initial conditions. A common way of improving the initial conditions is to make use of data assimilation (DA), a feedback mechanism or update methodology which merges model estimates with available real world observations. The traditional implementation of the Ensemble Kalman Filter (EnKF; e.g. Evensen, 2009) is synchronous, commonly named a three dimensional (3-D) assimilation, which means that all assimilated observations correspond to the time of update. Asynchronous DA, also called four dimensional (4-D) assimilation, refers to an updating methodology, in which observations being assimilated into the model originate from times different to the time of update (Evensen, 2009; Sakov 2010).

This study investigates how the capabilities of the DA procedure can be improved by applying alternative Kalman-type methods, e.g., the Asynchronous Ensemble Kalman Filter (AEnKF). The AEnKF assimilates observations with smaller computational costs than the original EnKF, which is beneficial for operational purposes. The results of discharge assimilation into a grid-based hydrological model for the Upper Ourthe catchment in Belgian Ardennes show that including past predictions and observations in the AEnKF improves the model forecasts as compared to the traditional EnKF. Additionally we show that elimination of the strongly non-linear relation between the soil moisture storage and assimilated discharge observations from the model update becomes beneficial for an improved operational forecasting, which is evaluated using several validation measures.

In the current study we employed the HBV-96 model built within a recently developed open source modelling environment OpenStreams (2013). The advantage of using OpenStreams (2013) is that it enables direct communication with OpenDA (2013), an open source data assimilation toolbox. OpenDA provides a number of algorithms for model calibration and assimilation and is suitable to be connected to any kind of environmental model. This setup is embedded in the Delft Flood Early Warning System (Delft-FEWS, Werner et al., 2013) for making all simulations and forecast runs and handling of all hydrological and meteorological data.

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