Operational hydrological data assimilation with the REnKF filter: use of observed discharge to update past and present model states for flow forecasts

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The paper describes the application of the REnKF developed by Pauwels and de Lannoy (2006) using the model/setup developed by Clark et al. (2006) in an operational setting in NZ.

My main concern is the introduction and the analysis of the results. Especially, the section on time delay (p 9536 line 6-23) and EnFK. The main problem may stem from the way a time lag is modeled (e.g. for instance an unit hydrograph) which cause that states at time t not only depend on the states of time t-1 but also t-2, t-3 etc depending on the concentration time). For example, by using a physically based model for the routing, the time delay and attenuation are modeled more realistically. In this way the states and discharge at time t only depend on the states of time t-1 (see Rakovec et al, 2012) and there is no problem in applying EnKF or (lagged) Particle Filtering. However, as shown by Rakovec et al (2012) the EnKF filter will mainly affect the states of the physically based model for the routing (kinematic wave) which makes sense. A similar issue/problem (the way a time lag is modeled) as mentioned above seems to be present in the saturation-excess runoff part of the model of Clark et al. (2008, see A6), this was also noted by Mendoza et al (2012).

Another important issue is the way the hydrological model is made stochastic (perturbed) (Bouttier and Courtier, 1999, page 21) and how it affects the outcome. Unrealistic perturbation (for instance spatially or independent/uncorrelated perturbation to model states/parameters) may cause spurious correlations to occur in the Kalman filter scheme and subsequently erroneous updates. However, for practical applications spurious correlations can be suppressed (see Mitchel and Houtekamer, 2001 or more readable Sorensen et al., 2004).

To get a better handle on what is going when applying EnKF ("numerical artefacts") the paper needs to include one or more twin experiment(s). In this manuscript, it remains unclear what the main cause (not explicit treatment of time delay by model or spurious correlation due to the model perturbations or other cause) of this behavior is. Additionally, the experiments carried out should be described clearly in the material and methods section (separated from the results). Also I would expect the results to include an analysis of the forecast improvements as a function of lead time (and maybe relevant other verification statistics).

One other issue is to include a discussion why variational methods are not considered in the present study.

References

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