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Comparison of Sequential and Variational Data Assimilation

Rodolfo Alvarado Montero (1), Dirk Schwanenberg (2), Albrecht Weerts (3,4)

(1) University of Duisburg-Essen, Institute of Hydraulic Engineering and Water Resources Management, Essen, Germany (rodolfo.alvarado-montero@uni-due.de), (2) Kisters AG, Business Unit Water, Aachen, Germany (dirk.schwanenberg@kisters.de), (3) Deltares, Delft, The Netherlands (albrecht.weerts@deltares.nl), (4) Wageningen University, The Netherlands (albrecht.weerts@deltares.nl)

Data assimilation is a valuable tool to improve model state estimates by combining measured observations with model simulations. It has recently gained significant attention due to its potential in using remote sensing products to improve operational hydrological forecasts and for reanalysis purposes. This has been supported by the application of sequential techniques such as the Ensemble Kalman Filter which require no additional features within the modeling process, i.e. it can use arbitrary black-box models. Alternatively, variational techniques rely on optimization algorithms to minimize a pre-defined objective function. This function describes the trade-off between the amount of noise introduced into the system and the mismatch between simulated and observed variables.
While sequential techniques have been commonly applied to hydrological processes, variational techniques are seldom used. In our believe, this is mainly attributed to the required computation of first order sensitivities by algorithmic differentiation techniques and related model enhancements, but also to lack of comparison between both techniques. We contribute to filling this gap and present the results from the assimilation of streamflow data in two basins located in Germany and Canada. The assimilation introduces noise to precipitation and temperature to produce better initial estimates of an HBV model. The results are computed for a hindcast period and assessed using lead time performance metrics. The study concludes with a discussion of the main features of each technique and their advantages/disadvantages in hydrological applications.