



## **Variational Data Assimilation with Lumped Hydrologic Models for Real-Time State Updating in the Presence of Timing Errors**

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Experience with state updating of the Sacramento soil moisture accounting model (SAC) via 2-dimensional variational assimilation (2DVAR) of streamflow, precipitation and potential evaporation data indicates that by far the biggest issue is performance under significant timing errors. For example, too early or late a rise in the model-simulated hydrograph may force the assimilation procedure to adjust the model soil moisture states in the wrong direction, with unintended consequences. The situation arises because in the current version of 2DVAR, the unit hydrograph (UHG) routing model is assumed to be unique and perfectly known. In reality, however, the assumptions behind UHG are often not met and, as such, considerable timing errors often exist in model-simulated streamflow even if there are no other sources of error. In this work, we assess the uncertainty in UHG by deriving event-specific empirical UHGs for multiple basins in Texas, US, compare the performance of 2DVAR with and without the acknowledgment of timing errors, and discuss operational considerations and issues for future research.