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Assimilating water levels of 8 Swiss lakes into a distributed hydrological model to improve low flow forecasts for the river Rhine at Basel with the AEnKF and wflow-OpenDA

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Under the prospect of more extreme droughts under a changing climate, the Dutch water authority looks to improve their low flow forecasts for the river Rhine. For the 10-day forecast of extreme low flows, the forecast skill is mostly dependent on the estimation of, and memory contained in, the hydrological initial states. A large part of this hydrological memory can be found in the storage of upstream reservoirs, making lake levels a prime candidate for usage in state updating of the hydrological model. The scientific interest is to see how much information the measured lake levels can provide about upstream model states, and therewith improve the flow forecasts downstream. In addition, the use of either lake level measurements (more accurate) versus independent downstream discharge measurements (less accurate) will be tested.

In this work we therefore investigate the following: 1) How are the upstream distributed hydrological states updated differently under assimilation of lake outflow or lake level measurements? 2) What is the effect of state updating of multiple upstream discharge measurements and/or levels of the eight largest lakes of Switzerland on the forecast skill of (extreme) low flows for the Rhine at Basel?

To answer these questions, we first performed a synthetic twin experiment in which one ensemble member from an open-loop ensemble run of the wflow_hbv model is chosen as synthetic truth to investigate the working of the assimilation scheme under ideal conditions, followed by a reforecast using observed discharges and lake levels and ‘perfect forcing’ for a long historical period (1997-2015) of the High Rhine and Alpine Rhine using the Asynchronous Ensemble Kalman Filter (AEnKF). Results show that the assimilation of lake levels with wflow-OpenDA is very effective in improving the accuracy of forecasted lake outflows, and therewith the forecasted flows and water levels at the Rhine at Basel.