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Effect of joint assimilation of GRACE and discharge observations on simulated water storages and fluxes

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Several applications, from water resource management to the prediction of extreme events, require a realistic representation of the global water cycle. Global hydrological models simulate continental water fluxes and individual storages. However, they poorly reproduce observations of discharge and total water storage anomalies (TWSA). To improve the realism of the simulations, TWSA derived from the Gravity Recovery and Climate Experiment (GRACE) mission are usually assimilated into hydrological models.
However, while assimilating GRACE-TWSA yields more realistic TWSA simulations, it is not clear how it affects the simulation of individual storages and fluxes. Therefore, assimilating discharge, in-situ or derived from satellite-altimetry, has been suggested to improve simulated discharge which is especially important for ungauged parts of basins.

In this study, we jointly assimilate GRACE-TWSA and discharge observations and, for the first time, simultaneously calibrate the model parameters in order to improve the simulation skills of the model beyond the observational time frame. For this, we couple the WaterGAP 2.2d model with the Parallel Data Assimilation Framework and apply an Ensemble Kalman Filter for the Mississippi River Basin from 2003 to 2016. Furthermore, we compare our results to single-data assimilation and validate them against discharge observations that were not used for calibration/assimilation. Additionally, we analyze the effect of the calibrated parameters on the model's realism.