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Impact of GRACE Error Correlations on Hydrological Data Assimilation

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Recently, ensemble Kalman filters (EnKF) have found increasing application for merging hydrological models with total water storage anomaly (TWSA) fields from the Gravity Recovery And Climate Experiment (GRACE) satellite mission. Previous studies have disregarded the strong effect of GRACE spatial error correlation in their investigations. Here, for the first time, we show that it is important to consider the characteristic error structure by carrying out an in-depth assessment of the impact of spatially correlated GRACE-TWSA errors on the GRACE-adjusted water states. Our investigations include (i) assimilating gridded GRACE-derived TWSA into the WaterGAP Global Hydrology Model (WGHM) and, simultaneously, calibrating its parameters, (ii) introducing GRACE observations with different spatial scales, (iii) modeling observation errors as either white or correlated in the assimilation, and (vi) replacing the original EnKF algorithm with a square root analysis scheme (SQRA) or, alternatively, the Singular Evolutive Interpolated Kalman (SEIK) filter.
Results of a synthetic experiment for the Mississippi River Basin indicate that the hydrological parameters were sensitive to TWSA assimilation. We found a significant influence of the spatial error correlation for all implemented filter variants, mainly over subbasins with north-south spatial extensions on the adjusted water states. We conclude that considering the characteristic GRACE error correlations is at least as important as the selection of the resolution of TWSA observations, while the choice of the filter method should be based on the computational simplicity and efficiency.