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GRACE Assimilation into Hydrological Model Improves Representation of Drought-induced Groundwater Trend over Murray-Darling Basin, Australia

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The Murray-Darling Basin, one of the largest and driest river basins over the world, experienced a long-term drought (over 2003-2009), the so-called Millennium Drought. As a result, the terrestrial water storage in the region decreased, which was attributed to dry meteorological conditions and extensive irrigation for agriculture. We used simulations of the WaterGAP Global Hydrology Model (WGHM) driven by monthly climate fields from the Climate Research Unit's Time Series (CRU TS 3.2) and precipitation data from the Global Precipitation Climatology Center (GPCC) to estimate linear trends in soil, surface and groundwater compartments, as well as total water storage changes (TWSC). However, the model was not able to capture the effect of the Millennium Drought on the storage compartments likely due to missing processes in dry regions or climate forcing uncertainties. Particularly, TWSC simulated by standard WGHM did not reproduce the negative trend during 2003-2009. Therefore, in this study, we investigate whether assimilating TWSC from the Gravity Recovery And Climate Experiment (GRACE) satellite mission into WGHM enables a more realistic representation of the Millennium Drought on the basin hydrology. Firstly, the quality of monthly GRACE TWSC and its post-processing over the Murray-Darling Basin was assessed. An improved calibration and data assimilation (C/DA) approach (Schumacher et al., JoG-2016) was then applied to integrate GRACE TWSC along with its full error covariance information into WGHM during 2003-2009. Independent observations of soil moisture, groundwater and surface water extent were used to validate the model outputs after C/DA. Our investigations indicate that the integration of GRACE data indeed introduces a negative trend to TWSC simulations of WGHM, which occurred predominantly in the south (Murray Basin). The trend was found to be associated with the changes in groundwater storage, which was confirmed through validation with in-situ groundwater observations. This study gives confidence in transferring the C/DA framework to data-sparse regions that currently are facing drought conditions.