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How robust are estimates of hydrology–driven global sea level change based on modelling and GRACE data?

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One of the less well-known contributions to global sea level change is the net mass loss or gain of non-cryospheric land water storage, here abbreviated as hydrology-driven global mean sea level rise (HDGMSL). HDGMSL is due to natural variability in the climate system and direct and indirect anthropogenic processes, such as reservoir building, deforestation and land use change, land glacier mass imbalance, groundwater depletion, and changes in the atmosphere-ocean water fluxes. It has a large inter-annual variability, as otherwise only observed in the thermo-steric contribution to sea level, and the sign of its net rate over the last decades is still debated.

Here, we revisit estimates of HDGMSL from GRACE and from global hydrological models. We scrutinize the robustness of estimates in the presence of climate variability within the limited GRACE time-frame, in particular large ENSO modes. To this end we make use of an ensemble of three GRACE solutions and a 32-member ensemble of the WGHM hydrological model where various parameters were realistically perturbed. Moreover we consider two different 40-year reconstructions of terrestrial water storage that were trained on GRACE data, two methods of mode decomposition, and we employ different trend estimators including a state-space parameterization. We conclude that HDGMSL was positive in the GRACE time frame with different estimators pointing to rates between -0.01 and 0.30 mm/a, which is probably not representative for a 40-year span. In addition, all conventional error estimates are found to be over-optimistic.