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Observed and modeled trends and extremes in terrestrial water storage – can GRACE satellite gravity help to evaluate climate models?

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Changes in terrestrial water storage (TWS) play an important role in the climate system and the satellite gravity mission GRACE (Gravity Recovery And Climate Experiment) is currently the only sensor which directly observes all parts of TWS (soil moisture, snow cover, groundwater, surface water) with global coverage. The limited time span of so far 15 years of satellite gravity data makes the identification of climate-related signals challenging, but the record starts to reveal a complex picture of low-frequency natural variability, long-term (climate) change, and other anthropogenic modifications (e.g. groundwater abstraction) in TWS. Our goal is to investigate if and how GRACE data are (or will be in the future) suitable for evaluating climate models in terms of storage-relevant variables such as soil moisture and snow.

We use a GRACE-derived global TWS time series extended backwards in time with a “GRACE-like” reconstruction of water storage variability calculated from atmospheric reanalyses (Humphrey et al., 2017). We compare this 32-year data set to multi-model ensembles and individual runs from several CMIP5 models using different RCP scenarios.

The focus of the comparison is to identify feasible methods to reliably detect trends, extreme events (floods, droughts) and possible changes of the occurrence frequency of such events. By applying a variety of statistical and time series analysis tools (e.g. extreme value statistics, STL, SSA) to observational and modeled data we assess the potential of satellite gravimetry from GRACE and its follow-on mission GRACE-FO for climate model evaluation. Such an observational constraint on storage-relevant model variables would provide an additional source of information for interpreting climate model results, and could aid in separating natural from anthropogenic climate variability.

Humphrey, V., Gudmundsson, L., Seneviratne, S.I., 2017. A global reconstruction of climate-driven subdecadal water storage variability. Geophys. Res. Lett. 44, 2017GL072564. doi:10.1002/2017GL072564