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Using GRACE and Climate Models to Identify Regions with Long-term Wetting or Drying Trends

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The representation of long-term wetting and drying trends in total soil moisture and snow in response to anthropogenic climate change is a challenge for coupled climate models such as those participating in the CMIP5 (Coupled Model Intercomparison Project Phase 5). As a result, the inter-model spread regarding trends in such variables is large. In order to identify hot spot regions of climate-driven wetting and drying tendencies, we investigate whether satellite observed terrestrial water storage (TWS) trends obtained from 14 years (2002/04-2016/08) of GRACE (Gravity Recovery And Climate Experiment) data can be used for comparison to long-term (1861/01-2099/12) model derived TWS trends from 21 CMIP5 models.

To account for discrepancies in physical representation of TWS in the CMIP5 models and GRACE as well as for interannual climate variability masking long-term trends in observations, we perform multiple analysis steps: First, we evaluate the spread in the long-term trends among the CMIP5 models and identify regions of large model consensus. Second, we relate long-term trends to trends from a historical period (1861/01-2016/08) to investigate if they are in principle detectable in present-day observations. Third, we assess the extent to which 14-year tendencies observed by GRACE can be expected to represent long-term trends. Based on this analysis, we identify hot spots of water storage trends characterized by 1) a strong model consensus, 2) a trend direction that is in agreement with GRACE.

The reasons behind the wetting and drying trends in these hot spot regions are subsequently investigated by analyzing long-term changes in atmospheric conditions in the CMIP5 models. In doing so, we find that in 71% of these regions, the trends might be related to either long-term changes in vertical fluxes of precipitation, evaporation and sublimation (48%) or decrease in snowpack (23%).