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Estimation of hydrological drought recovery based on precipitation and Gravity Recovery and Climate Experiment (GRACE) water storage deficit

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Supplementary material

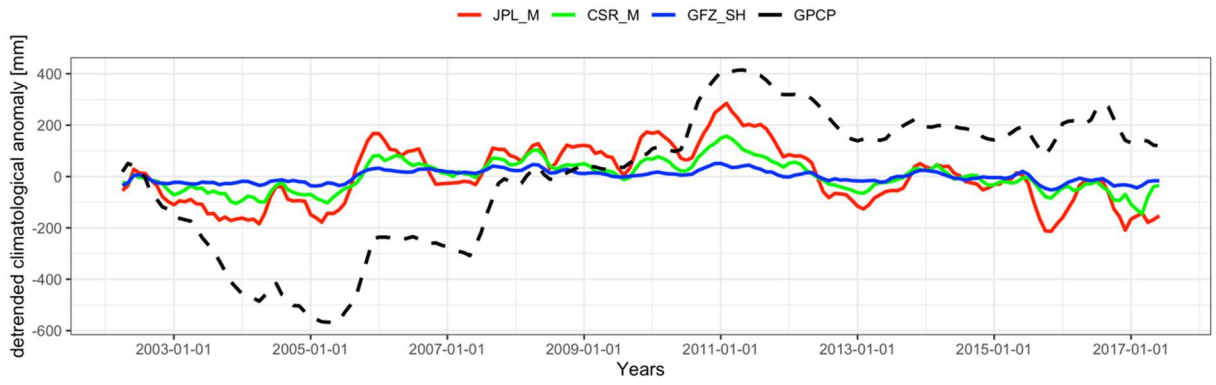
This supplementary material shows possible discrepancies in the calculation of required precipitation for the drought recovery caused by difference in the available GRACE solutions from different centers. Three different example locations are plotted to demonstrate that though there are difference in the amplitude of datasets but the phase coherence between the datasets is consistent globally. Figure S1 compares detrended climatological anomalies of different GRACE solutions and GPCP precipitation. Figure S2 shows GRACE derived water storage deficit and Figure S3 demonstrate the estimated required precipitation to overcome the drought.

The official GRACE Science Data System continuously released monthly GRACE solution for three different processing centers: GeoforschungsZentrum Potsdam (GFZ), Center for Space Research at University of Texas, Austin (CSR), and Jet Propulsion Laboratory (JPL). These three solutions used different parameters and strategies, such as different degree and order, spherical harmonic coefficient, spatial filter and smoothing factor (Jing et al., 2019). The JPL mascon (JPL-M) and CSR mascon (CSR-M) solutions were provided at 0.5 degrees at https://grace.jpl.nasa.gov/data/get-data/monthly-mass-grids-land/ and http://www2.csr.utexas.edu/grace/RL05_mascons.html respectively. GFZ produces only spherical harmonic solution (GFZ-SH), which is downloaded from http://isdc.gfz-potsdam.de/grace-isdc/.

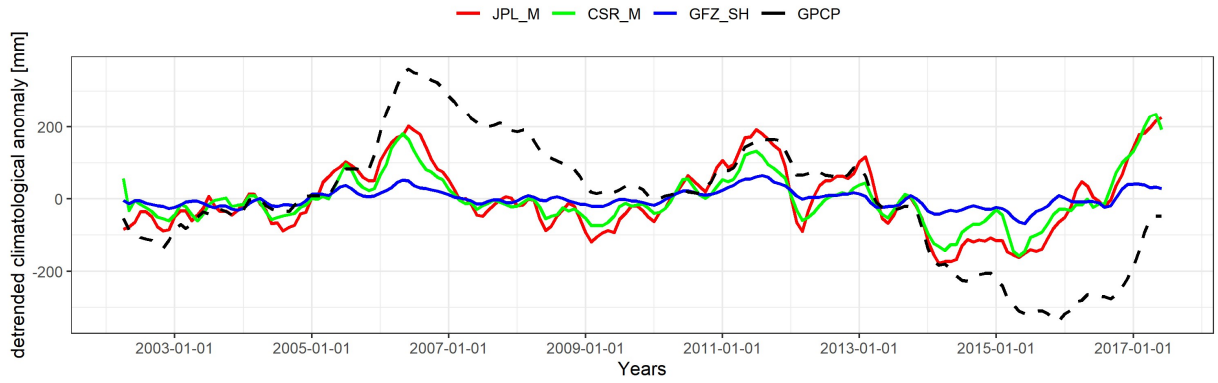
Following figures show water storage deficit and estimated required extra precipitation to overcome the drought based on three different GRACE solutions, using the method described in the article for three example location in southern India (centered on 77.25°E 15.25°N), California USA (40.25 °E,-120.25 °N) and northern Australia (-16.75 °E, 133.75 °N). Sakumura et al., 2014 demonstrated that at a basin-scale, the differences between them are very less. However, the plot shows that there are discrepancies between the amount of missing water at 0.5degree grid because every center has a different method to downscale GRACE inherent spatial resolution to high-resolution grid.

Figure S1 shows the detrended climatological anomaly of the three GRACE solutions and cumulative GPCP precipitation has similar variability. The negative anomaly from climatology is considered as drought and is plotted in figure S2. It shows that the difference between CSR and JPL solutions are relatively less than GFZ solution because the first two are the mascon-based solution and are available at 0.5-degree grid (after scaling), while GFZ solution is spherical harmonics based and is re-gridded to 0.5 degree from 1-degree spatial resolution by simple bilinear interpolation. Based on the linear relationship between cumulative detrended GPCP anomaly and detrended GRACE anomalies, required extra precipitation is estimated (figure S3). The figure shows that the required precipitation varies based on GRACE solutions. Nevertheless, all three GRACE solutions are consistent with the detection of drought duration.

a.



b.



c.

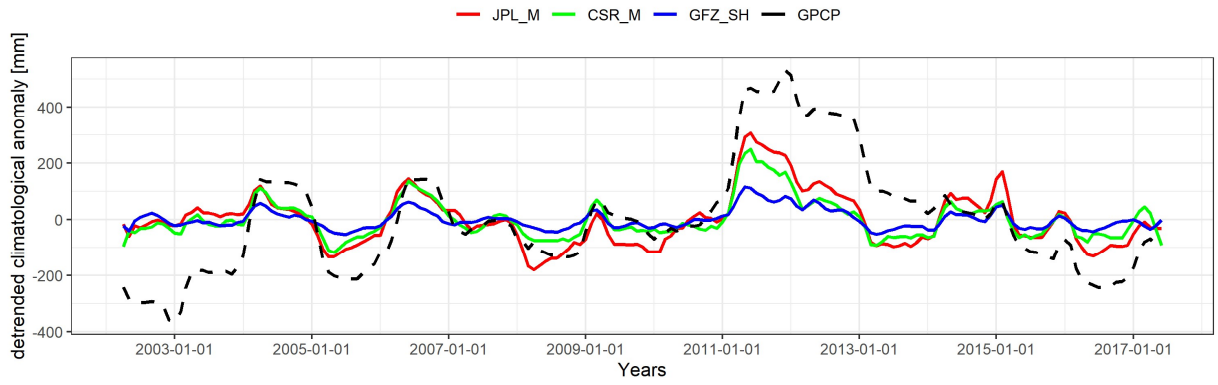
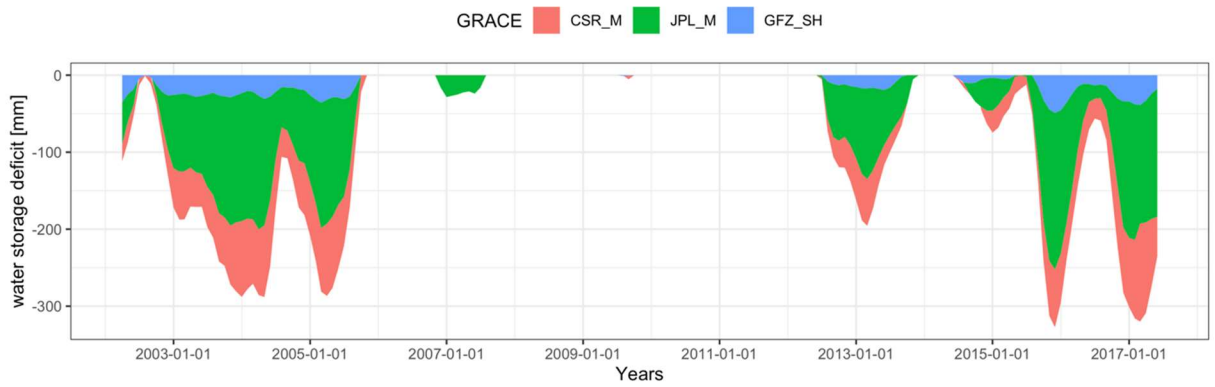
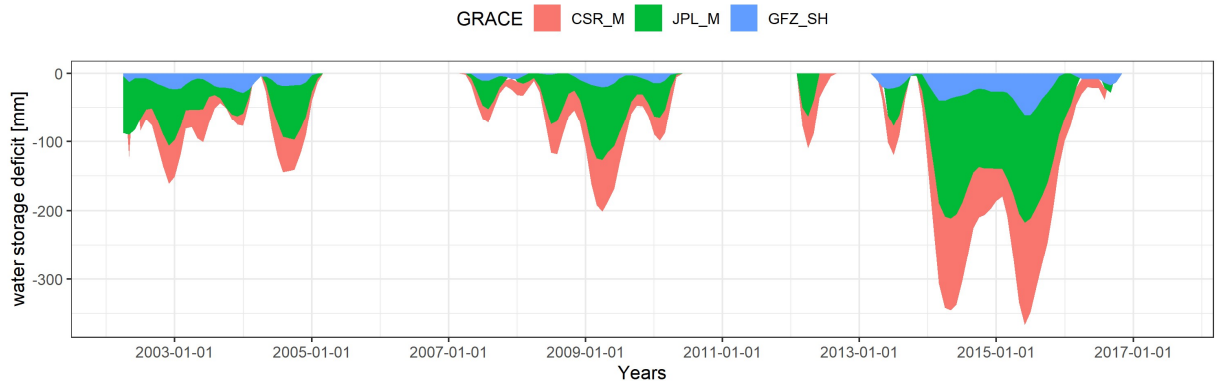


Figure S1: Cumulative detrended precipitation anomaly (cdPA) compared with the detrended storage anomaly (dTWSA) estimated by using the spherical harmonic solution from GFZ and the mascon solutions from CSR and JPL .a) southern India (centered on 77.25°E 15.25°N), b) California USA (40.25 °E,-120.25 °N) and c) northern Australia (-16.75 °E, 133.75 °N).

a.



b.



c.

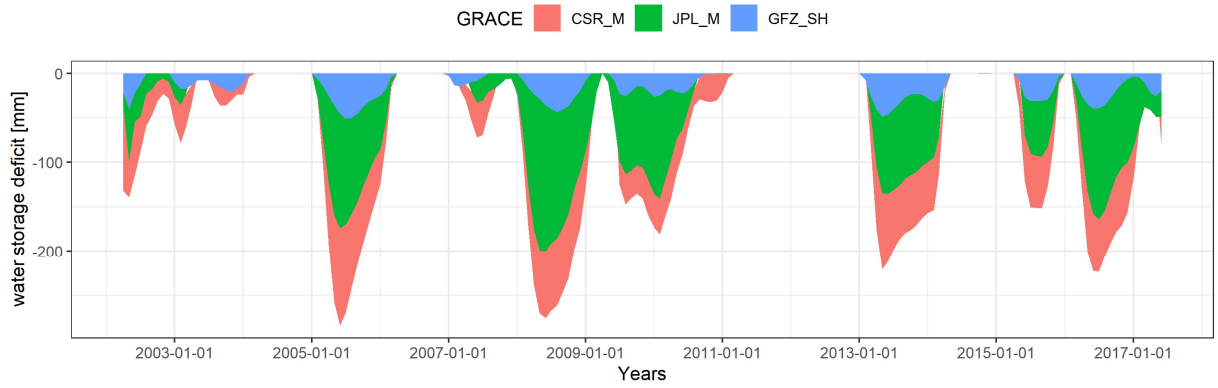
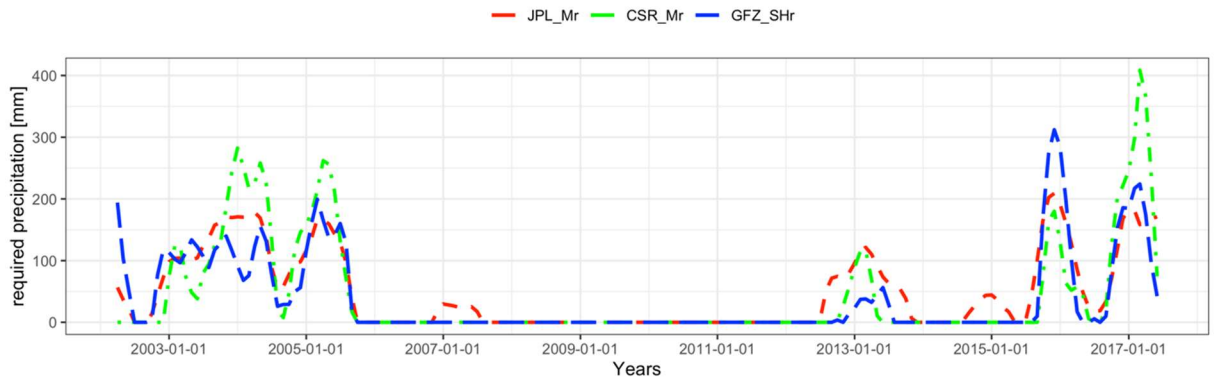
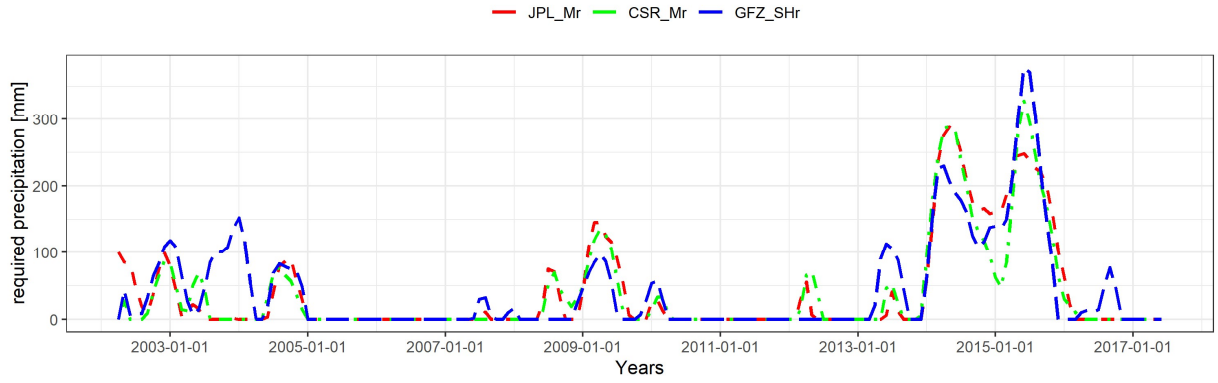


Figure S2: The negative residuals from the GRACE climatology considered as drought, which is estimated by the spherical harmonic solution from GFZ (blue) and the mascon solutions from CSR (red) and JPL (green) .a) southern India (centered on 77.25°E 15.25°N), b) California USA (40.25 °E,-120.25 °N) and c) northern Australia (-16.75 °E, 133.75 °N).

a.



b.



c.

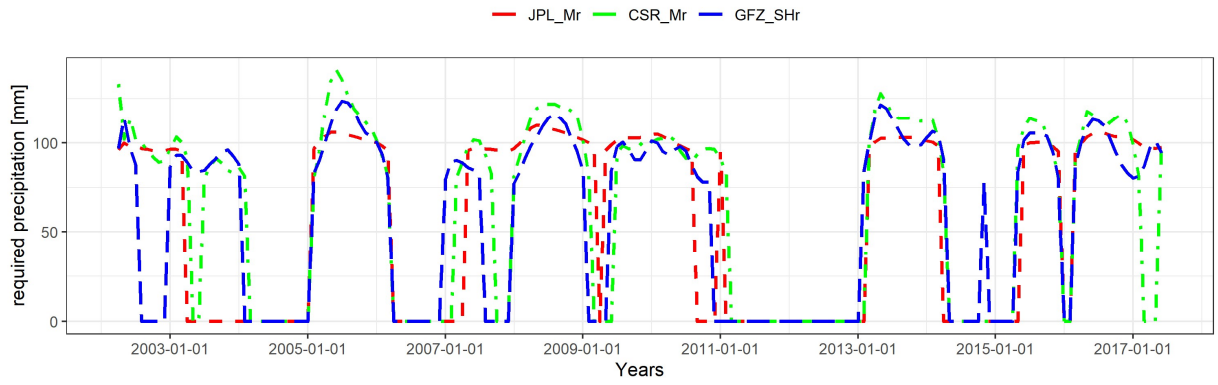


Figure S3: Surplus required-precipitation to fill the storage deficit, estimated by the linear relationship between dTWSA and cdPA. a) southern India (centered on 77.25°E 15.25°N), b) California USA (40.25 °E,-120.25 °N) and c) northern Australia (-16.75 °E, 133.75 °N).

Reference

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Sakumura, C., Bettadpur, S. and Bruinsma, S.: Ensemble prediction and intercomparison analysis of GRACE time-variable gravity field models, Geophysical Research Letters, 41(5), 1389–1397, doi:10.1002/2013GL058632, 2014.