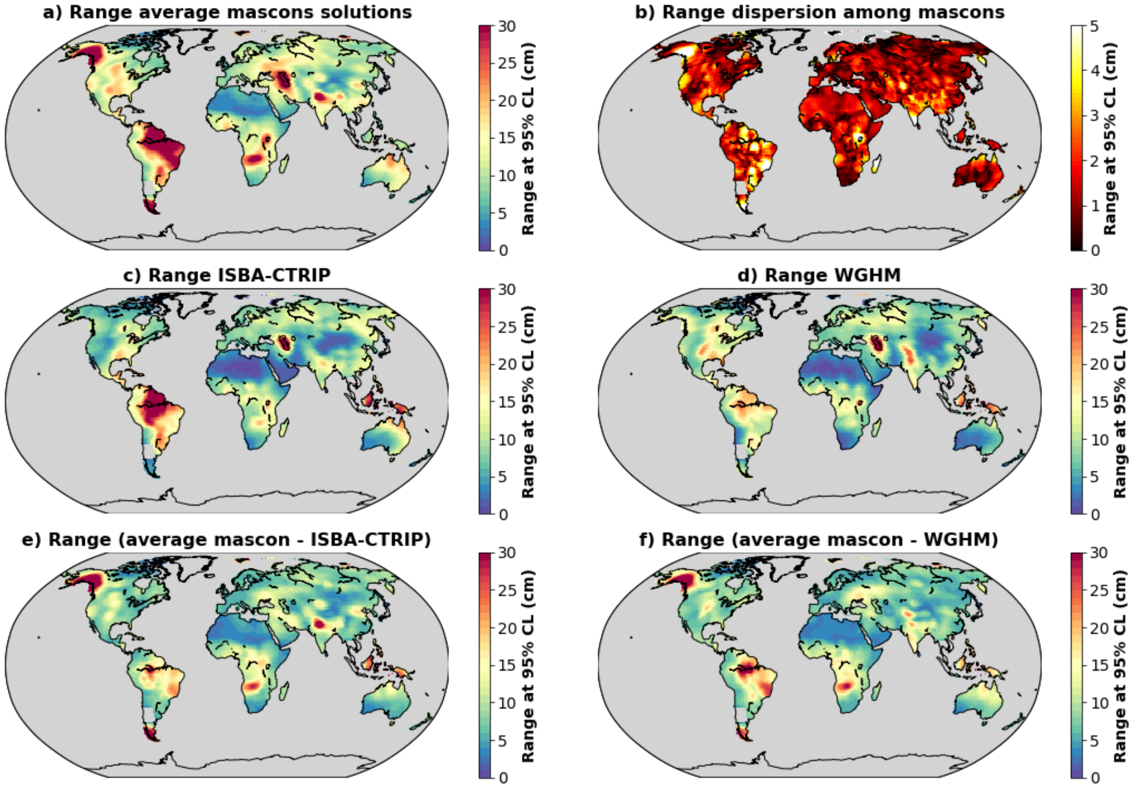

Figure S1: Comparison of TWS anomalies estimated from an ensemble of three GRACE mascon solutions and two global hydrological models. The amplitude of the non-seasonal TWS variability is expressed as the range at 95% CL, calculated as the difference between the 97.5 and 2.5 percentiles of the TWS anomalies obtained in each grid cell over the entire study period. a) Range of TWS anomalies estimated as the average of three GRACE mascons solutions. b) Dispersion of the range of TWS anomalies among three GRACE mascons solutions. Range of TWS anomalies estimated with ISBA-CTRIP (c) and WGHM (d). Range of residual TWS anomalies estimated as the difference between the average of three GRACE mascon solutions and ISBA-CTRIP (e) or WGHM (f).

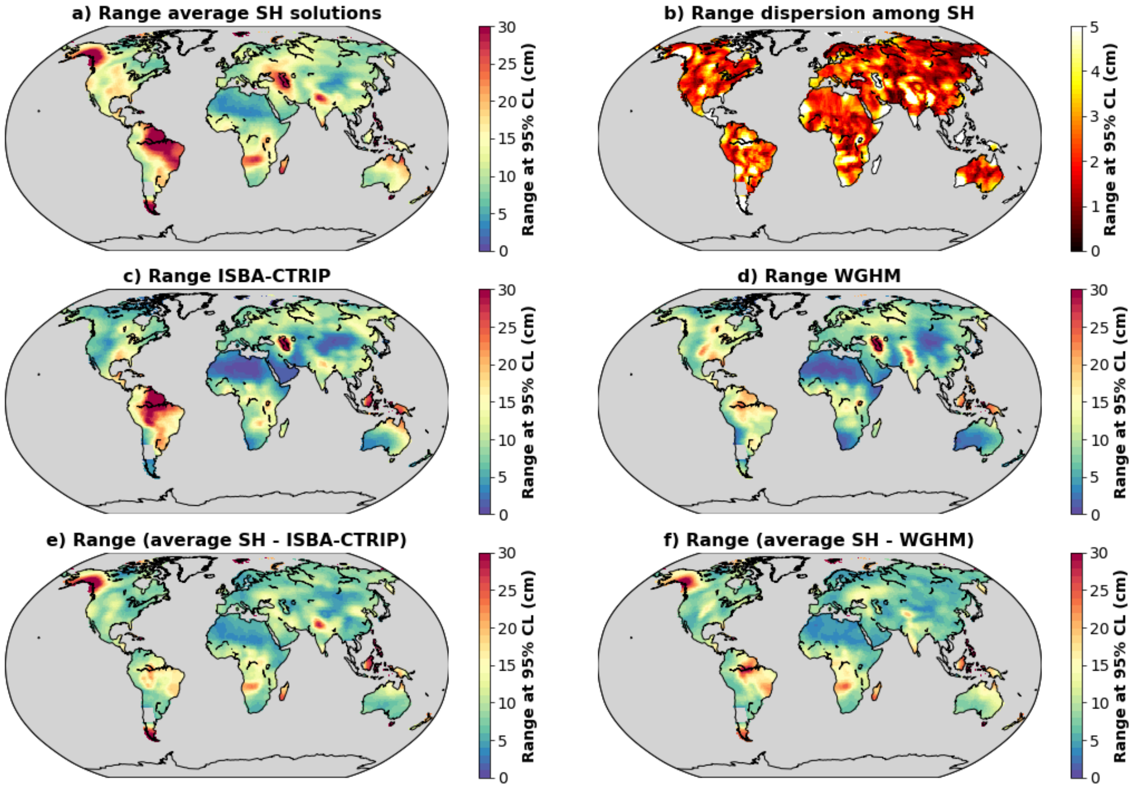

Figure S2: Comparison of TWS anomalies estimated from an ensemble of six GRACE spherical harmonic solutions and two global hydrological models. The amplitude of the non-seasonal TWS variability is expressed as the range at 95% CL, calculated as the difference between the 97.5 and 2.5 percentiles of the TWS anomalies obtained in each grid cell over the entire study period. a) Range of TWS anomalies estimated as the average of six GRACE spherical harmonics solutions. b) Dispersion of the range of TWS anomalies among six GRACE spherical harmonics solutions. Range of TWS anomalies estimated with ISBA-CTRIP (c) and WGHM (d). Range of residual TWS anomalies estimated as the difference between the average of six GRACE spherical harmonic solutions and ISBA-CTRIP (e) or WGHM (f).

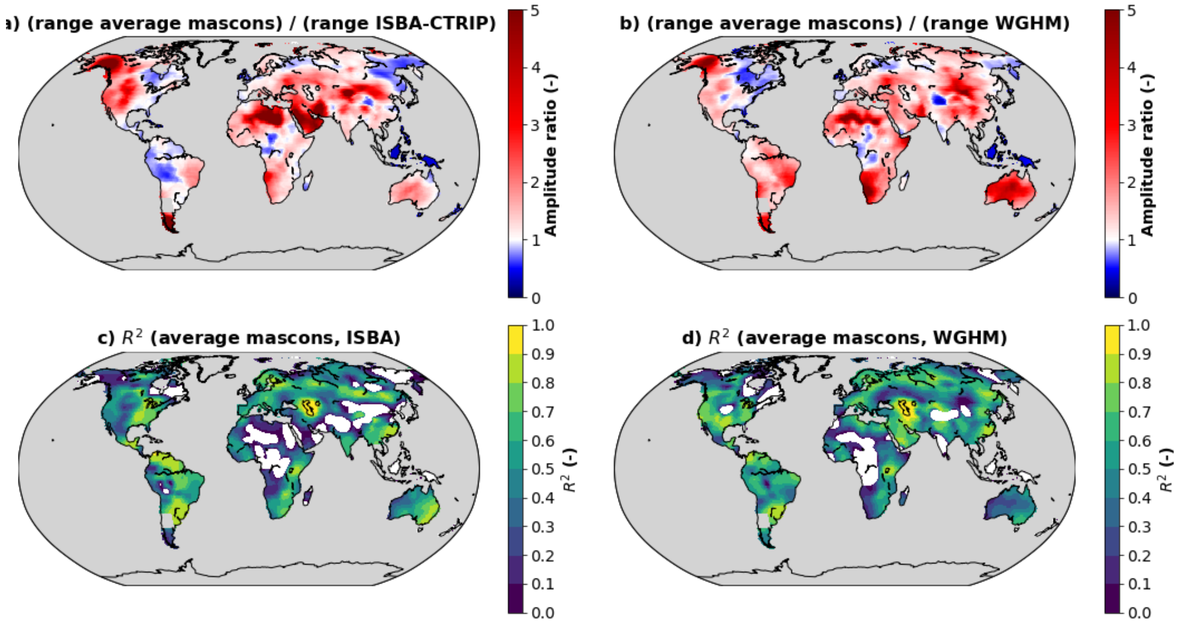

Figure S3: Range ratios between the average of three GRACE mascon solutions and the hydrological models ISBA-CTRIP (a) and WGHM (b). Determination coefficients between the average GRACE mascon solution and the hydrological models ISBA-CTRIP (c) and WGHM (d). Regions, where the coefficient of determination is negative, are shown in white

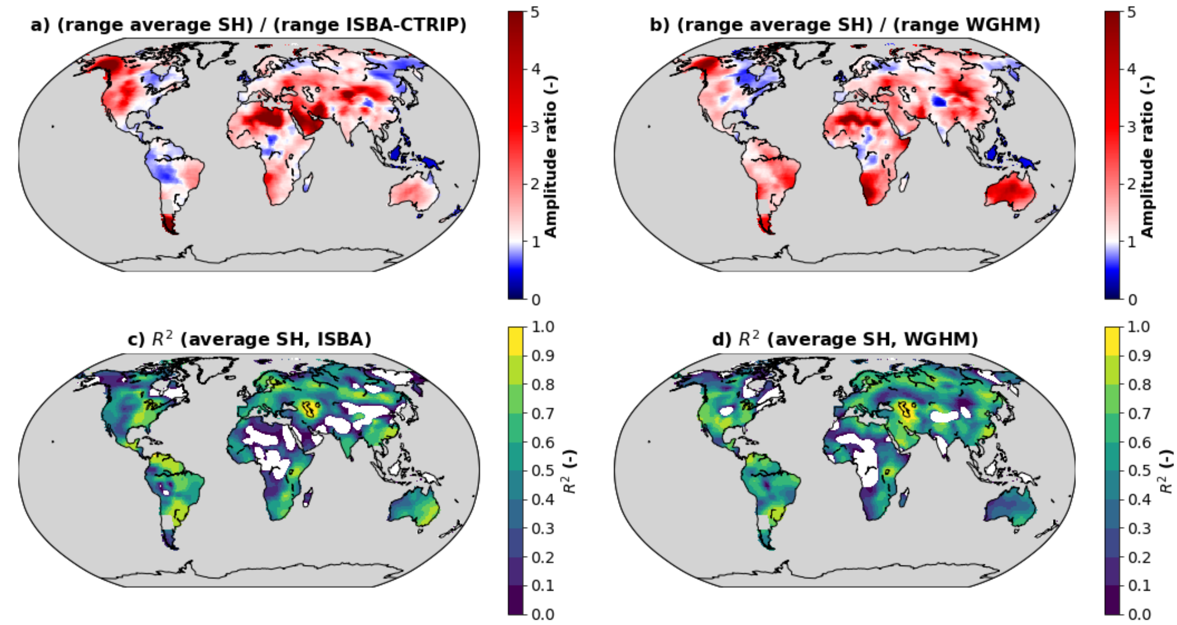

Figure S4: Range ratios between the average of six GRACE spherical harmonic solutions and the hydrological models ISBA-CTRIP (a) and WGHM (b). Determination coefficients between the average GRACE spherical harmonic solution and the hydrological models ISBA-CTRIP (c) and WGHM (d). Regions, where the coefficient of determination is negative, are shown in white

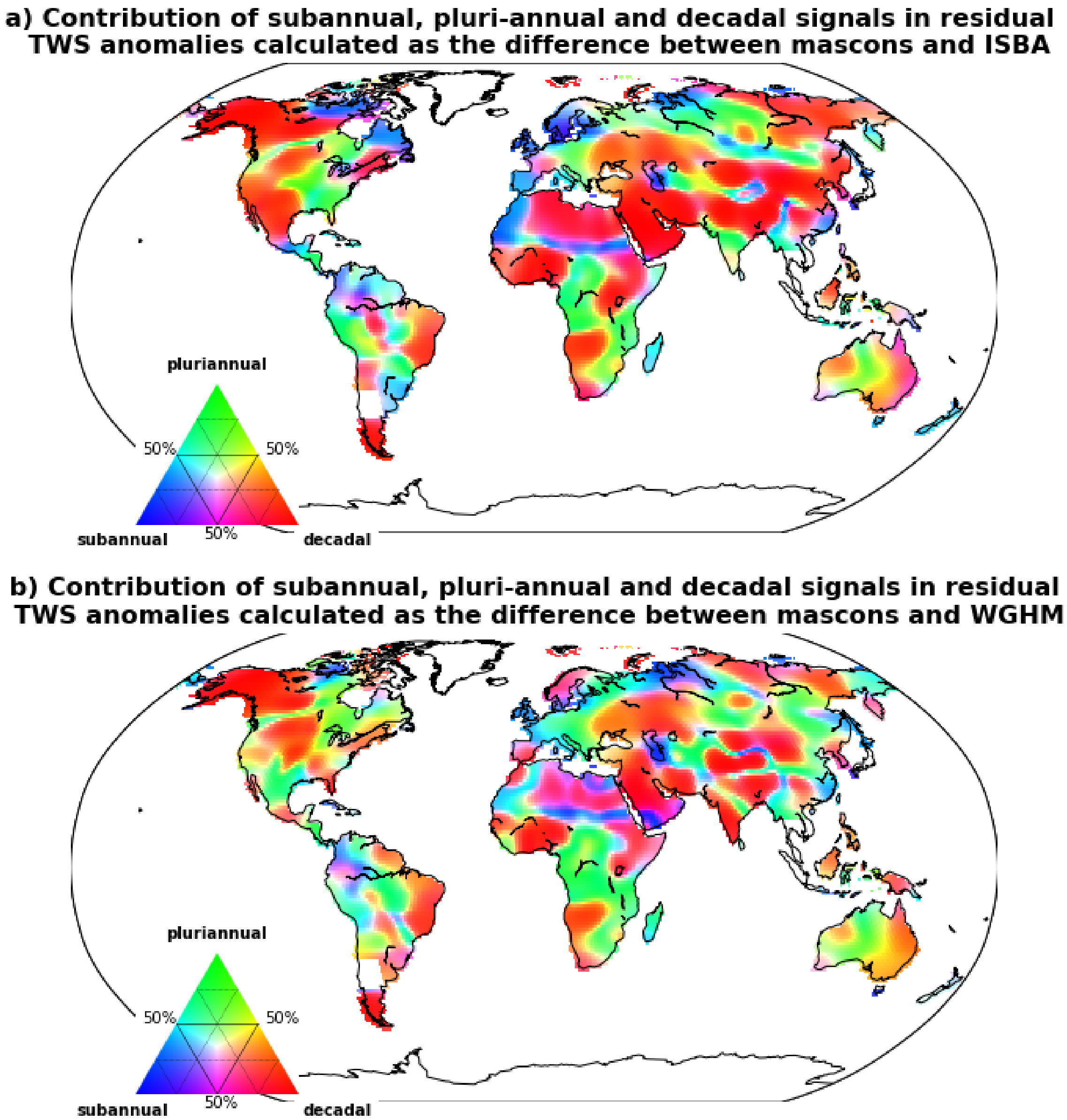

Figure S5: Characteristic time scales in residual TWS anomalies calculated as the differences between the average of three GRACE mascon solutions and ISBA-CTRIP (a) or WGHM (b). Subannual, pluriannual and decadal contributions have been computed with high-pass (cut-off period at 1.5 years), band-pass (cut-off periods at 1.5 and 10 years) and low-pass (cut-off period at 10 years) filters respectively. The percentage of variance explained by one contribution has been calculated as the coefficient of determination with respect to the full residual signal.

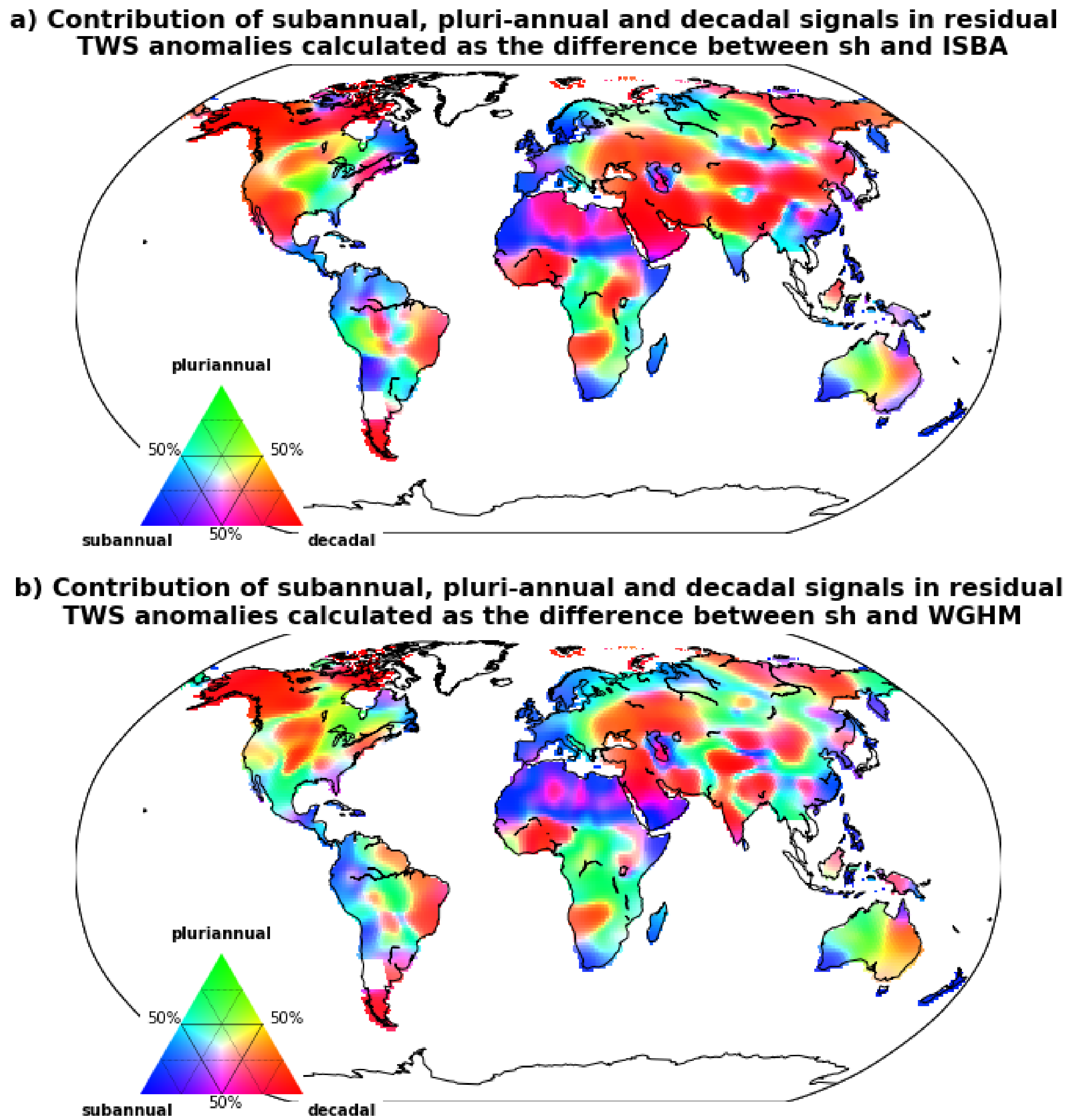

Figure S6: Characteristic time scales in residual TWS anomalies calculated as the differences between the average of six GRACE spherical harmonic solutions and ISBA-CTRIP (a) or WGHM (b). Subannual, pluriannual and decadal contributions have been computed with high-pass (cut-off period at 1.5 years), band-pass (cut-off periods at 1.5 and 10 years) and low-pass (cut-off period at 10 years) filters respectively. The percentage of variance explained by one contribution has been calculated as the coefficient of determination with respect to the full residual signal.

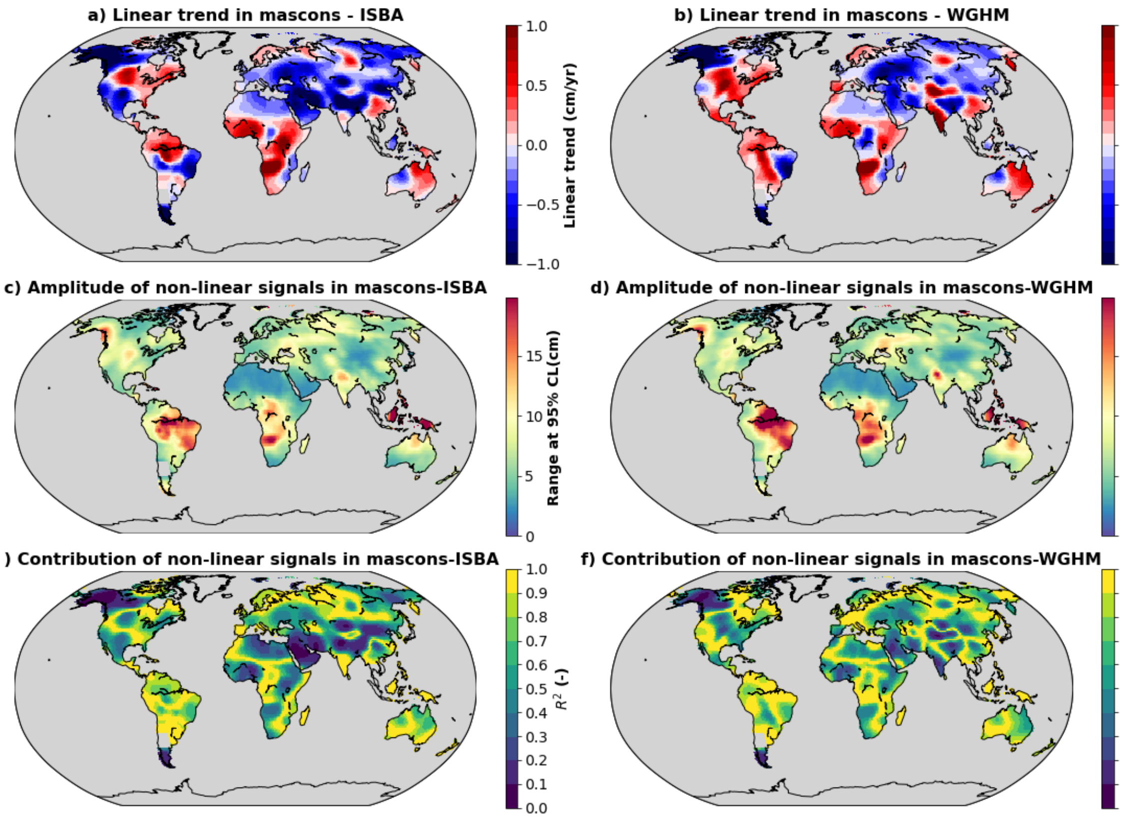

Figure S7: a) Linear trends in residual TWS anomalies calculated as the difference between the average of three GRACE mascon solutions and ISBA-CTRIP. b) Same as (a) with WGHM. c) Amplitude of non-linear signals in residual TWS anomalies calculated as the difference between the average of three GRACE mascon solutions and ISBA-CTRIP. The amplitude is calculated as the difference between the 97.5 and 2.5 percentiles. d) Same as (c) with WGHM. e) Coefficient of determination calculated for non-linear signals with respect to TWS anomalies calculated as the difference between the average GRACE mascon solution and ISBA-CTRIP. f) Same as (e) with WGHM.

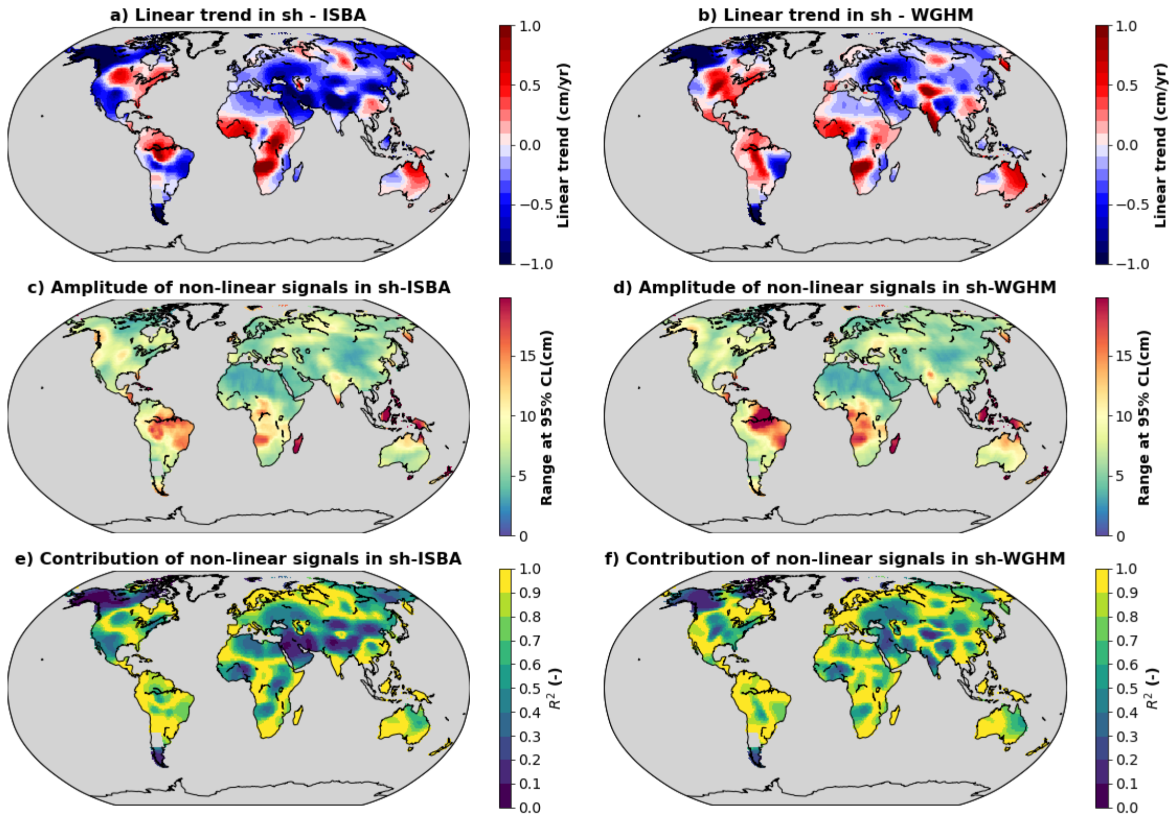

Figure S8: a) Linear trends in residual TWS anomalies calculated as the difference between the average of six GRACE spherical harmonic solutions and ISBA-CTRIP. b) Same as (a) with WGHM. c) Amplitude of non-linear signals in residual TWS anomalies calculated as the difference between the average of six GRACE spherical harmonic solutions and ISBA-CTRIP. The amplitude is calculated as the difference between the 97.5 and 2.5 percentiles. d) Same as (c) with WGHM. e) Coefficient of determination calculated for non-linear signals with respect to TWS anomalies calculated as the difference between the average GRACE mascon solution and ISBA-CTRIP. f) Same as (e) with WGHM.