Groundwater storage dynamics in the world’s large aquifer systems from GRACE: uncertainty and role of extreme precipitation

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The Supplementary Material contains supplementary Tables S1–S4 and supplementary Figures S1–S80.
**Supplementary Table S1.** Characteristics of the world’s 37 large aquifer systems according to the WHYMAP database including aquifer area, total number of population, proportion of groundwater (GW)-fed irrigation, mean aridity index, mean annual rainfall, variability in rainfall and total terrestrial water mass (ΔTWS), and correlation coefficients between monthly ΔTWS and precipitation with reported lags.

<table>
<thead>
<tr>
<th>WHYMAP aquifer number</th>
<th>Aquifer name</th>
<th>Continent</th>
<th>Population (million)</th>
<th>Aquifer area (km²)</th>
<th>GW irrigation (%)</th>
<th>Climate zones based on Aridity indices</th>
<th>Mean (2002-16) annual precipitation (mm)</th>
<th>Rainfall variability (%)</th>
<th>TWS variance (cm²)</th>
<th>Correlation between TWS and precipitation (lag in month)</th>
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<td>Area (sq km)</td>
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<td>Conductivity (mS/cm)</td>
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**Supplementary Table S2.** Characteristics of the world’s 37 large aquifer systems according to the WHYMAP database including mean annual rainfall, mean aridity index, and variability in total terrestrial water mass (ΔTWS), and correlation coefficients between ΔTWS and annual precipitation. The variance (cm$^2$) in the ensemble GRACE ΔTWS and the proportion of variance explained by surface water and snow water equivalent combined (SWS+SNS), soil moisture storage (SMS) and groundwater storage (GWS) are tabulated.

<table>
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<tr>
<th>WHYMAP aquifer number</th>
<th>Aquifer name</th>
<th>Mean (2002–2016) Annual precipitation (mm)</th>
<th>Climate zones based on Aridity indices</th>
<th>TWS variance (cm$^2$)</th>
<th>Correlation between annual changes in TWS and annual precipitation</th>
<th>TWS variance explained by SWS+SNS combined (%)</th>
<th>TWS variance explained by SMS (%)</th>
<th>TWS variance explained by GWS (%)</th>
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<td>Mean Depth (m)</td>
<td>Water Use Efficiency (%)</td>
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<td>Water Use (m³)</td>
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Supplementary Table S3. Characteristics of the relationships between CRU precipitation and GRACE ΔGWS in the world’s 37 large aquifer systems.

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<th>Mean (1901 to 2016) annual precipitation (mm)</th>
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Supplementary Table S4. Characteristics of the relationships between GPCC precipitation and GRACE ΔGWS in the world’s 37 large aquifer systems.

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<th>Positive change in non-linear trends in GRACE-ΔGWS over the period of 2002–2016 and reported values between two consecutive years (cm)</th>
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Supplementary Figure captions

**Fig. S1-S36.** Time-series data of terrestrial water storage anomaly (ΔTWS) from GRACE and individual water stores from GLDAS Land Surface Models (LSMs): (a) Ensemble monthly GRACE ΔTWS from three solutions (CSR, Mascons, GRGS), (b-c) ensemble monthly ΔSMS and ΔSWS + ΔSNS from four GLDAS LSMs (CLM, Noah, VIC, Mosaic), (d) computed monthly ΔGWS and (e) monthly precipitation from August 2002 to July 2016 for WHYMAP large aquifer systems from no. 1 to 37, except for the High Plains Aquifer System in the USA (no. 17) which is shown as Fig. 2. Values in the Y-axis of the top four panels show monthly water-storage anomalies (cm) and the bottom panel shows monthly precipitation (cm).

**Fig. S37.** Seasonal-trend decomposition (STL) of an ensemble monthly GRACE ΔTWS time-series data from three solutions (CSR, Mascons, GRGS) for the High Plains Aquifer System in the USA (no. 17)

**Fig. S38.** Comparison of ΔGWS time series datasets from GRACE and in situ piezometric observations. ΔGWS time-series records in the unconsolidated, alluvial aquifer within the humid Bengal Basin of Bangladesh (a), and a weathered crystalline rock aquifer in the semi-arid Limpopo Basin in South Africa (b). Shaded bands in light-pink and light-blue around ΔGWS lines denote the standard deviation of the estimated mean value. Monthly precipitation records are shown as stair-step lines in blue on both panels with a dashed blue line indicating the long-term monthly mean value.

**Fig. S39.** Time-series data of terrestrial water storage anomaly (ΔTWS) from GRACE and individual water stores from GLDAS Land Surface Models (LSMs): (a) Ensemble monthly GRACE ΔTWS from three solutions (CSR, Mascons, GRGS), (b-c) ensemble monthly ΔSMS and ΔSWS + ΔSNS from four GLDAS LSMs (CLM, Noah, VIC, Mosaic), (d) computed monthly ΔGWS and (e) monthly precipitation from August 2002 to July 2016 for the Bengal Basin of Bangladesh.

**Fig. S40.** Time-series data of terrestrial water storage anomaly (ΔTWS) from GRACE and individual water stores from GLDAS Land Surface Models (LSMs): (a) Ensemble monthly GRACE ΔTWS from three solutions (CSR, Mascons, GRGS), (b-c) ensemble monthly
ΔSMS and ΔSWS + ΔSNS from four GLDAS LSMs (CLM, Noah, VIC, Mosaic), (d) computed monthly ΔGWS and (e) monthly precipitation from August 2002 to July 2016 for the Limpopo Basin of South Africa.

Fig. S41-S77. Decomposition of time-series components of GRACE ΔGWS data for all 37 large aquifer systems using a non-parametric, Seasonal-Trend decomposition procedure based on Loess (STL) technique. The graph on the top shows monthly anomaly data and decomposed time-series components of the series into seasonal, trend and remainder components. The graph also shows monthly precipitation records from CRU data along with annual total precipitation values (cm) written next to each annual cycle. The pie chart at the bottom shows the proportion of variance (%) in GRACE ΔGWS explained by the time-series components (S=seasonal, T=trend, R=residual/remainder).

Fig. S78. Time series of ensemble mean GRACE ΔTWS (red), GLDAS ΔSMS (green), ΔSWS + ΔSNS (blue) and computed GRACE ΔGWS (black) showing the calculation of anomalously negative or positive values of GRACE ΔGWS that deviate substantially from underlying trends. Cases for the Upper Kalahari-Cuvelai-Zambezi Basin (11) under a semi-arid climate, the Congo Basin (10) under a tropical humid climate, and the Angara-Lena Basin (27) in given in Fig. 6.

Fig. S79. Uncertainty in the estimates of GRACE-derived GWS from 20 realisations using 3 GRACE (CSR, JPL-Mascons, GRGS) products and 4 LSMs (CLM, Noah, VIC, Mosaic) and their ensemble means for the WHYMAP large aquifer systems from no. 1 to 37, except for the High Plains Aquifer System in the USA (no. 17) which is shown as Fig. 2.

Fig. S80. Long-term in-situ groundwater-level records from Makutapora Wellfield in central Tanzania (n=5) and Limpopo Basin in South Africa (n=4). Groundwater levels of from Makutapora site are referenced to a fixed datum (mean sea level, msl) and thus indicate piezometric heads; records in Limpopo Basin are plotted below groundwater level (bgI), hence the negative sign. The frequency of these multi-decadal groundwater-level records varies from daily to monthly with irregular time intervals. Annual rainfall time-series records are shown below each graph with a dashed, grey line denoting the mean of the time series.

Supplementary Fig. S1–S80:
Fig. S1: Nubian Sandstone Aquifer System (1)

(a) Ensemble TWS
(b) Ensemble SMS
(c) Ensemble (SWS + SNS)
(d) Ensemble GWS
(e) Precipitation

Basin-averaged
Non-linear trend
Linear trend
Fig. S2: Northwestern Sahara Aquifer System (2)

(a) Ensemble TWS

(b) Ensemble SMS

(c) Ensemble (SWS + SNS)

(d) Ensemble GWS

(e) Precipitation

Basin-averaged  
Non-linear trend  
Linear trend

Water storage (cm)
Fig. S3: Murzuk–Djado Basin (3)

Basin-averaged Water storage (cm)

(a) Ensemble TWS
(b) Ensemble SMS
(c) Ensemble (SWS + SNS)
(d) Ensemble GWS
(e) Precipitation

Non-linear trend
Linear trend

Water storage (cm)

Fig. S4: Taoudeni–Tanezrouft Basin (4)

Basin-averaged
Non-linear trend
Linear trend

(a) Ensemble TWS

(b) Ensemble SMS

(c) Ensemble (SWS + SNS)

(d) Ensemble GWS

(e) Precipitation
Fig. S6: Iullemmeden–Irhazer Aquifer System (6)

(a) Ensemble TWS

(b) Ensemble SMS

(c) Ensemble (SWS + SNS)

(d) Ensemble GWS

(e) Precipitation

Basin–averaged  Non–linear trend  Linear trend

Water storage (cm)

Fig. S7: Lake Chad Basin (7)

(a) Ensemble TWS
(b) Ensemble SMS
(c) Ensemble (SWS + SNS)
(d) Ensemble GWS
(e) Precipitation

Water storage (cm)

Basin-averaged Non-linear trend Linear trend
Fig. S8: Umm Ruwaba Aquifer (Sudd Basin) (8)

(a) Ensemble TWS

(b) Ensemble SMS

(c) Ensemble (SWS + SNS)

(d) Ensemble GWS

(e) Precipitation

Basin-averaged

Non-linear trend

Linear trend
Fig. S9: Ogaden–Juba Basin (9)

Basin-averaged  Non-linear trend  Linear trend

(a) Ensemble TWS
(b) Ensemble SMS
(c) Ensemble (SWS + SNS)
(d) Ensemble GWS
(e) Precipitation
Fig. S11: Upper Kalahari–Cuvelai–Zambezi Basin (11)

(a) Ensemble TWS
(b) Ensemble SMS
(c) Ensemble (SWS + SNS)
(d) Ensemble GWS
(e) Precipitation

Basin-averaged  Non-linear trend  Linear trend
### Fig. S12: Lower Kalahari–Stampriet Basin (12)

#### (a) Ensemble TWS

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#### (b) Ensemble SMS

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#### (c) Ensemble (SWS + SNS)

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#### (d) Ensemble GWS

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<td>2006</td>
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#### (e) Precipitation

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<tr>
<td>2006</td>
<td>10</td>
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<td>10</td>
</tr>
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<td>2014</td>
<td>10</td>
</tr>
<tr>
<td>2016</td>
<td>10</td>
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Fig. S13: Karoo Basin (13)

Basin-averaged Non-linear trend Linear trend

Water storage (cm)

(a) Ensemble TWS

(b) Ensemble SMS

(c) Ensemble (SWS + SNS)

(d) Ensemble GWS

(e) Precipitation
Fig. S14: Northern Great Plains Aquifer (14)

Basin-averaged

(a) Ensemble TWS

(b) Ensemble SMS

(c) Ensemble (SWS + SNS)

(d) Ensemble GWS

(e) Precipitation

Water storage (cm)
Fig. S15: Cambro–Ordovician Aquifer System (15)

Basin–averaged  Non–linear trend  Linear trend

(a) Ensemble TWS

(b) Ensemble SMS

(c) Ensemble (SWS + SNS)

(d) Ensemble GWS

(e) Precipitation

Water storage (cm)

Fig. S16: California Central Valley Aquifer System (16)

(a) Ensemble TWS

(b) Ensemble SMS

(c) Ensemble (SWS + SNS)

(d) Ensemble GWS

(e) Precipitation

Basin-averaged  Non-linear trend  Linear trend
Fig. S17: Atlantic and Gulf Coastal Plains Aquifer (18)

Basin-averaged  Non-linear trend  Linear trend

(a) Ensemble TWS

(b) Ensemble SMS

(c) Ensemble (SWS + SNS)

(d) Ensemble GWS

(e) Precipitation
Fig. S18: Amazon Basin (19)

(a) Ensemble TWS
(b) Ensemble SMS
(c) Ensemble (SWS + SNS)
(d) Ensemble GWS
(e) Precipitation

Basin-averaged
Non-linear trend
Linear trend
Fig. S19: Maranhao Basin (20)

(a) Ensemble TWS

(b) Ensemble SMS

(c) Ensemble (SWS + SNS)

(d) Ensemble GWS

(e) Precipitation

Water storage (cm)

Basin-averaged
Non-linear trend
Linear trend

Fig. S20: Guarani Aquifer System (Parana Basin) (21)

(a) Ensemble TWS

(b) Ensemble SMS

(c) Ensemble (SWS + SNS)

(d) Ensemble GWS

(e) Precipitation
Fig. S21: Arabian Aquifer System (22)

(a) Ensemble TWS
(b) Ensemble SMS
(c) Ensemble (SWS + SNS)
(d) Ensemble GWS
(e) Precipitation

Basin-averaged
Non-linear trend
Linear trend

Water storage (cm)

Fig. S22: Indus River Basin (23)

(a) Ensemble TWS

(b) Ensemble SMS

(c) Ensemble (SWS + SNS)

(d) Ensemble GWS

(e) Precipitation

Basin-averaged
Non-linear trend
Linear trend

Water storage (cm)

Fig. S23: Ganges–Brahmaputra River Basin (24)

(a) Ensemble TWS

(b) Ensemble SMS

(c) Ensemble (SWS + SNS)

(d) Ensemble GWS

(e) Precipitation

Baseline-averaged  Non-linear trend  Linear trend
Fig. S24: West Siberian Artesian Basin (25)

Basin-averaged  Non-linear trend  Linear trend  

(a) Ensemble TWS  

(b) Ensemble SMS  

(c) Ensemble (SWS + SNS)  

(d) Ensemble GWS  

(e) Precipitation
Fig. S25: Tunguss Basin (26)

(a) Ensemble TWS
(b) Ensemble SMS
(c) Ensemble (SWS + SNS)
(d) Ensemble GWS
(e) Precipitation

Basin-averaged
Non-linear trend
Linear trend
Fig. S26: Angara–Lena Basin (27)

Basin-averaged  
Non-linear trend  
Linear trend  

(a) Ensemble TWS

(b) Ensemble SMS

(c) Ensemble (SWS + SNS)

(d) Ensemble GWS

(e) Precipitation

Water storage (cm)

Fig. S27: Yakut Basin (28)

Basin-averaged
Non-linear trend
Linear trend

(a) Ensemble TWS

(b) Ensemble SMS

(c) Ensemble (SWS + SNS)

(d) Ensemble GWS

(e) Precipitation
Fig. S28: North China Plains Aquifer System (29)

Basin-averaged

(a) Ensemble TWS

(b) Ensemble SMS

(c) Ensemble (SWS + SNS)

(d) Ensemble GWS

(e) Precipitation
Fig. S29: Song–Liao Plain (30)

(a) Ensemble TWS

(b) Ensemble SMS

(c) Ensemble (SWS + SNS)

(d) Ensemble GWS

(e) Precipitation

Basin-averaged Non-linear trend Linear trend
Fig. S30: Tarim Basin (31)

(a) Ensemble TWS

(b) Ensemble SMS

(c) Ensemble (SWS + SNS)

(d) Ensemble GWS

(e) Precipitation

Water storage (cm)

Basin-averaged
Non-linear trend
Linear trend
Fig. S31: Paris Basin (32)

(a) Ensemble TWS

(b) Ensemble SMS

(c) Ensemble (SWS + SNS)

(d) Ensemble GWS

(e) Precipitation
Fig. S32: East European Aquifer System (33)

Basin-averaged

(a) Ensemble TWS
(b) Ensemble SMS
(c) Ensemble (SWS + SNS)
(d) Ensemble GWS
(e) Precipitation

Non-linear trend
Linear trend
Fig. S33: North Caucasus Basin (34)

(a) Ensemble TWS

(b) Ensemble SMS

(c) Ensemble (SWS + SNS)

(d) Ensemble GWS

(e) Precipitation

Water storage (cm)

Basin-averaged
Non-linear trend
Linear trend


44
Fig. S34: Pechora Basin (35)

Basin-averaged
Non-linear trend
Linear trend

(a) Ensemble TWS

(b) Ensemble SMS

(c) Ensemble (SWS + SNS)

(d) Ensemble GWS

(e) Precipitation

Water storage (cm)

Fig. S35: Great Artesian Basin (36)

Basin-averaged Non-linear trend Linear trend

(a) Ensemble TWS

(b) Ensemble SMS

(c) Ensemble (SWS + SNS)

(d) Ensemble GWS

(e) Precipitation

Water storage (cm)
Fig. S36: Canning Basin (37)

Basin-averaged  
Non-linear trend  
Linear trend

(a) Ensemble TWS

(b) Ensemble SMS

(c) Ensemble (SWS + SNS)

(d) Ensemble GWS

(e) Precipitation
Fig. S37: STL decomposition of ensemble GRACE–TWS signal
High Plains Aquifer System (17)
Fig. S38

(a) Bengal Basin GWS anomaly

(b) Limpopo Basin GWS anomaly
Fig. S39: Bengal Basin

Basin-averaged  Non-linear trend  Linear trend  

(a) Ensemble TWS

(b) Ensemble SMS

(c) Ensemble (SWS + SNS)

(d) Ensemble GWS

(e) Precipitation

Water storage (cm)

Fig. S40: Limpopo Basin

(a) Ensemble TWS

(b) Ensemble SMS

(c) Ensemble (SWS + SNS)

(d) Ensemble GWS

(e) Precipitation

Water storage (cm)

-5 -4 -3 -2 -1 0 1 2 3 4 5 6 7 8 9 10

-5 -4 -3 -2 -1 0 1 2 3 4 5


Basin-averaged

Non-linear trend

Linear trend

-5 -4 -3 -2 -1 0 1 2 3 4 5

-4 -3 -2 -1 0 1 2 3 4 5

-5 -4 -3 -2 -1 0 1 2 3 4 5

-4 -3 -2 -1 0 1 2 3 4 5

-5 -4 -3 -2 -1 0 1 2 3 4 5

-5 -4 -3 -2 -1 0 1 2 3 4 5
Fig. S41: Nubian Sandstone Aquifer System (1)

Seasonal–Trend–Remainder (GRACE GWS)
Proportion of variance

- T = 30%
- S = 21%
- R = 49%
Fig. S42: Northwestern Sahara Aquifer System (2)

Seasonal–Trend–Remainder (GRACE GWS)
Proportion of variance

T = 56% 
S = 15% 
R = 29%
Fig. S43: Murzuk–Djado Basin (3)

Seasonal–Trend–Remainder (GRACE GWS)
Proportion of variance

- S = 29%
- T = 31%
- R = 39%
Fig. S44: Taoudeni–Tanezrouft Basin (4)

Seasonal–Trend–Remainder (GRACE GWS)
Proportion of variance

- T = 32%
- S = 22%
- R = 46%
Fig. S45: Senegal–Mauritanian Basin (5)

Seasonal–Trend–Remainder (GRACE GWS)
Proportion of variance

- **S= 27%**
- **T= 52%**
- **R= 21%**
Fig. S46: Iullemmeden–Irhazer Aquifer System (6)

Seasonal–Trend–Remainder (GRACE GWS)
Proportion of variance

\[ T = 53\% \]
\[ S = 10\% \]
\[ R = 37\% \]
Fig. S47: Lake Chad Basin (7)

Seasonal–Trend–Remainder (GRACE GWS)
Proportion of variance

S = 62%
T = 13%
R = 25%
Fig. S48: Umm Ruwaba Aquifer (Sudd Basin) (8)

Seasonal–Trend–Remainder (GRACE GWS)
Proportion of variance

S = 82%
T = 7%
R = 11%
Fig. S49: Ogaden–Juba Basin (9)

Seasonal−Trend−Remainder (GRACE GWS)
Proportion of variance

T= 42%
S= 18%
R= 40%
Fig. S50: Congo Basin (10)

Seasonal–Trend–Remainder (GRACE GWS)
Proportion of variance

- **T** = 45%
- **S** = 13%
- **R** = 42%
Fig. S51: Upper Kalahari–Cuvelai–Zambezi Basin (11)

Seasonal–Trend–Remainder (GRACE GWS)
Proportion of variance

S = 15%
T = 63%
R = 22%
Fig. S52: Lower Kalahari–Stampriet Basin (12)

Seasonal–Trend–Remainder (GRACE GWS)
Proportion of variance

T = 41%
S = 15%
R = 44%
Fig. S53: Karoo Basin (13)

Seasonal–Trend–Remainder (GRACE GWS)
Proportion of variance

- **T** = 83%
- **S** = 6%
- **R** = 11%
Fig. S54: Northern Great Plains Aquifer (14)

Seasonal–Trend–Remainder (GRACE GWS)
Proportion of variance

S = 13%
T = 76%
R = 11%
Fig. S55: Cambro–Ordovician Aquifer System (15)

Seasonal–Trend–Remainder (GRACE GWS)
Proportion of variance

- S = 29%
- T = 42%
- R = 29%
Seasonal–Trend–Remainder (GRACE GWS)
Proportion of variance

- S = 24%
- T = 64%
- R = 12%
Fig. S57: Ogallala Aquifer (High Plains) (17)

Seasonal–Trend–Remainder (GRACE GWS)
Proportion of variance

- T = 77%
- S = 9%
- R = 14%
Fig. S58: Atlantic and Gulf Coastal Plains Aquifer (18)

Seasonal–Trend–Remainder (GRACE GWS)
Proportion of variance

T = 51%
S = 10%
R = 39%
Fig. S59: Amazon Basin (19)

Seasonal–Trend–Remainder (GRACE GWS)
Proportion of variance

S = 72%
T = 16%
R = 12%
Fig. S60: Maranhao Basin (20)

Seasonal–Trend–Remainder (GRACE GWS)
Proportion of variance

S = 39%
T = 14%
R = 48%
Fig. S61: Guarani Aquifer System (Parana Basin) (21)

Seasonal–Trend–Remainder (GRACE GWS)
Proportion of variance

T = 57%
S = 7%
R = 36%
Fig. S62: Arabian Aquifer System (22)

Seasonal–Trend–Remainder (GRACE GWS)
Proportion of variance

T = 90%
S = 3%
R = 7%
Fig. S63: Indus River Basin (23)

Seasonal−Trend−Remainder (GRACE GWS)
Proportion of variance

- $S = 23\%$
- $T = 34\%$
- $R = 43\%$
Fig. S64: Ganges–Brahmaputra River Basin (IGB) (24)

Seasonal–Trend–Remainder (GRACE GWS)
Proportion of variance

S = 48%
T = 45%
R = 7%
Fig. S65: West Siberian Artesian Basin (25)

Seasonal–Trend–Remainder (GRACE GWS)
Proportion of variance

S = 55%
T = 40%
R = 5%
Fig. S66: Tunguss Basin (26)

Seasonal–Trend–Remainder (GRACE GWS)
Proportion of variance

S = 9%
T = 84%
R = 7%
Fig. S67: Angara–Lena Basin (27)

Seasonal−Trend−Remainder (GRACE GWS)
Proportion of variance

T = 49%
S = 16%
R = 35%
Fig. S68: Yakut Basin (28)

Seasonal–Trend–Remainder (GRACE GWS)
Proportion of variance

S = 35%
T = 54%
R = 11%
Fig. S69: North China Plains Aquifer System (29)

Seasonal–Trend–Remainder (GRACE GWS)
Proportion of variance

- \( S = 25\% \)
- \( T = 55\% \)
- \( R = 20\% \)
Fig. S70: Song–Liao Plain (30)

Seasonal–Trend–Remainder (GRACE GWS)
Proportion of variance

T = 49%
S = 20%
R = 31%
Fig. S71: Tarim Basin (31)

Seasonal–Trend–Remainder (GRACE GWS)
Proportion of variance

S = 47%
T = 15%
R = 38%
Fig. S72: Paris Basin (32)

Seasonal–Trend–Remainder (GRACE GWS)
Proportion of variance

S = 21%
T = 60%
R = 19%
Fig. S73: East European Aquifer System (33)

Seasonal–Trend–Remainder (GRACE GWS)
Proportion of variance

S = 68%
T = 18%
R = 14%
Fig. S74: North Caucasus Basin (34)

Seasonal–Trend–Remainder (GRACE GWS)
Proportion of variance

S = 39%
T = 39%
R = 23%
Fig. S75: Pechora Basin (35)

Seasonal–Trend–Remainder (GRACE GWS)
Proportion of variance

S = 40%
T = 52%
R = 8%
Fig. S76: Great Artesian Basin (36)

Seasonal–Trend–Remainder (GRACE GWS)
Proportion of variance

T = 71%
S = 6%
R = 23%
Fig. S77: Canning Basin (37)

Seasonal–Trend–Remainder (GRACE GWS)
Proportion of variance

T = 81%
S = 4%
R = 15%
Fig. S78 Computational uncertainty in GRACE-GWS

Legend
- TWS
- SMS
- SWS+SNS
- GWS
- Precipitation
Fig. S79: Uncertainty in the estimates of GRACE-derived GWS from 20 realisations
Fig. S79: Uncertainty in the estimates of GRACE-derived GWS from 20 realisations
Fig. S79: Uncertainty in the estimates of GRACE-derived GWS from 20 realisations

Atlantic and Gulf Coastal Plains Aquifer (18)

Amazon Basin (19)

Maranhao Basin (20)

Guarani Aquifer System (Parana Basin) (21)

Arabian Aquifer System (22)

Indus River Basin (23)

Ganges–Brahmaputra River Basin (IGB) (24)

West Siberian Artesian Basin (25)
Fig. S79: Uncertainty in the estimates of GRACE-derived GWS from 20 realisations
Fig. S79: Uncertainty in the estimates of GRACE-derived GWS from 20 realisations

North Caucasus Basin (34)

Pechora Basin (35)

Great Artesian Basin (36)

Canning Basin (37)
Fig. S80 (a) Makutapora Basin, Tanzania

Fig. S80 (b) Limpopo Basin, South Africa