C302

# Fill in the GRACE/GRACE-FO Data gap in the Mega 37 aquifers

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## 1. Introduction

The Gravity Recovery and Climate Experiment (GRACE) was a scientific mission that monitored the change in Earth's gravity. Earth's gravity is a primary attribute of the water cycle. After the filter modules and ellipsoidal correction, it provided gridded terrestrial water storage anomalies (TWSA) data, which was the vertical water equivalent. Therefore, GRACE provided an effective method to explore groundwater variation. The GRACE was launched in March 2002 and worked until October 2017. Then the GRACE Follow-On (GRACE-FO) was launched in May 2018 to continue this mission. There was an 11-month mission gap between GRACE and GRACE-FO. It was an inconvenience for trend analysis and the monthly drought study. Many researchers have tried to fill in the data gap using the data-driven, satellite and interpolation methods. In this study, we use an interpolation method based on the relationship between cumulative precipitation and TWSA.

The objective of this study is to explore the following parts:

(1) The relationship between cumulative precipitation and TWSA.

（1）Filled in the mission gap on the aquifer scale.

（3）Explored the TWSA trend in the last two decades.

## 2. Data

*GRACE/GRACE-FO data*

We used the Gravity Recovery and Climate Experiment (GRACE) data and GRACE-FO data from Release 6.0 version 04[1]. These were available from April 2002 to June 2017, and from July 2018 to April 2023. The baseline was Jan 2005 to Dec 2010.

*Temperature, Evaporation and Precipitation data*

We used the temperature and precipitation data from JRA3Q[2]. The resolution is 1° × 1°. The time range from April 2002 to April 2023. The evaporation data from the SiBUC model output.

*Precipitation data*

The precipitation used in this study was provided by GSWP3-W5E5[3]. The time range is from April 2002 to December 2019. In this study, it was used to calculate the cumulative precipitation.

## 3. Methods

First, the cumulative precipitation month **i** and TWSA in each month **m** and the aquifer. Then select the highest correlation corresponding to the **i**. Next, the linear relationship between the TWSA and the highest cumulative precipitation month **i**. At last, predict the mission gap based on the linear method. The yearly trend of TWSA was estimated by using the Mann–Kendall and Theil–Sen method.

## 4. Results

(1) Strong correlations were observed in aquifers in the Americas, high-latitude regions of Europe and Eurasia, and Australia. Moderate correlations occur in aquifers influenced by bimodal rainfall in the Ogaden-Juba Basin (#9) and the Congo Basin (#10), or by monsoon-dominated regimes in the Indus Basin (#23), the Ganges Basin (#24), and the North China Aquifer (#29). The very weak and weak correlations are concentrated in hot, arid regions of North Africa, the Arabian and Tarim Basins(#22, #31), where precipitation is scarce, with large interannual

variability, rainfall events are irregular, and recharge is limited, making it difficult to generate a coherent and persistent terrestrial water storage response. The TWSA variability controlled by long-term (longer than 8 months) cumulative precipitation occurred across most climatological months, indicating a delayed groundwater response to precipitation. The TWSA responded to the short- to mid-term (less than 7 months) cumulative precipitation in monsoon and tropical regions, such as the Amazon Basin (#19), the Guarani Aquifer (#21), and the Indus Basin (#23). Overall, TWSA was positively correlated with cumulative precipitation, punctuated by a few weakly negative months.

(2) The filled data shows high accuracy in most regions(Fig.1). However, the aquifer which has a significant decrease/increase trend, affects the accuracy of the estimated results.

(3) We found that 18 aquifers exhibit a declining trend in TWSA, primarily located in arid and sub-humid regions(Fig.2). The five aquifers with the largest-magnitude negative TWSA trends are the North Caucasus Basin (#34; −16.03 ± 5.81 mm $yr^{-1}$), Ganges–Brahmaputra Basin (#24; −12.47 ± 6.19 mm $yr^{-1}$), Indus Basin (#23; −9.99 ± 5.58 mm $yr^{-1}$), California Central Valley Aquifer System (#16; −6.28 ± 1.54 mm $yr^{-1}$), and Arabian Aquifer System (#22; −6.11 ± 3.05 mm $yr^{-1}$). TWSA shows a declining trend in the arid area (Nubian Aquifer (#1), Northwestern Sahara Aquifer (#2), Murzuk-Djado Basin (#3), Arabian Aquifer (#22), Tarim Basin (#31), indicating that the dry area has become drier in the last two decades. On the contrast, TWSA shows an increasing trend in per-humid area, including Congo Basin (#10), Amazon Basin (#19), and Maranhao Basin (#20), indicating the wet area becomes wetter in the last two decades.

**5. Conclusion**

In this study, the mission gap between GRACE and GRACE-FO was filled by the relationship between cumulative precipitation and TWSA. Strong and moderate correlations were observed in the majority aquifers and months. The TWSA variability controlled by the long-term cumulative precipitation was dominant worldwide. 18 aquifers exhibit a declining trend in TWSA, primarily located in arid and sub-humid regions. There has been a wetter region getting wetter, drier region getting drier trend in TWSA.

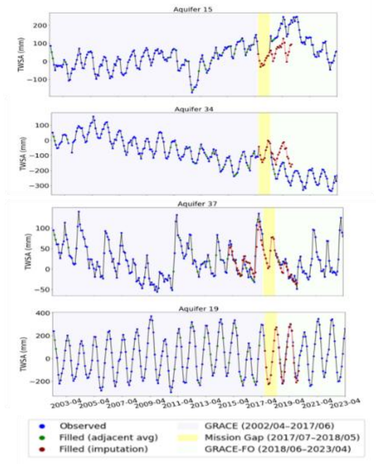


Fig.1 Time series of TWSA from GRACE/GRACE-FO and the reconstructed estimates.

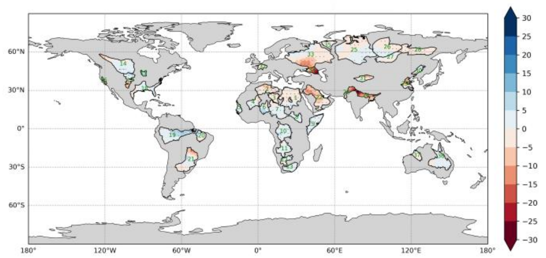

Fig.2 The yearly trend of TWSA using the Mann-Kendall method in 37 aquifers. Stippling indicates regions that have significant trends(P＜0.05)

**References**

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