

Supplementary Material

Text S1. Sensitivity of groundwater inversion results to the deformation-rate screening criterion.

To evaluate the sensitivity of the groundwater inversion results to the deformation-rate screening criterion, we conducted a sensitivity test by relaxing the upper deformation-rate threshold from 0 to +0.50 mm/a while retaining all other screening criteria. The lower threshold of -0.65 mm/a was maintained based on the forward-model estimates. This adjustment retained 142 additional InSAR observations, increasing the total number of observations from 795 to 937. The spatial distributions of the original and additionally retained observations are shown in Figure S1.

We repeated the groundwater inversion using the expanded set of 937 observations and compared the resulting basin-average groundwater variations with those obtained using the original set of 795 observations. For the period from January 2017 to December 2019, the 795-observation solution yielded a groundwater trend of 39.2 ± 11.1 mm/a and an annual amplitude of 27.7 ± 16.1 mm. The corresponding values for the 937-observation solution were 34.1 ± 13.5 mm/a and 27.5 ± 16.0 mm, respectively. For the longer period from January 2017 to December 2021, the 795-observation solution yielded a groundwater trend of 12.5 ± 5.5 mm/a and an annual amplitude of 38.5 ± 11.1 mm, compared with 11.2 ± 5.3 mm/a and 37.5 ± 10.7 mm, respectively, for the 937-observation solution.

Overall, relaxing the deformation-rate screening threshold has a negligible impact on the estimated basin-average groundwater trends and annual amplitudes, with only minor differences between the two observation sets.

To further assess the spatial sensitivity of the inversion results to the observation screening criterion, we compared the spatial distributions of

groundwater trends and annual amplitudes derived using two surface-water correction models, ERA5 and GLDAS, for the full 2017–2021 period. The results obtained using the expanded set of 937 observations were compared with those obtained using the original set of 795 observations (Figure S3).

The spatial distributions of groundwater trends and annual amplitudes remain broadly consistent between the two observation sets for both surface-water correction models (Figure S3). For the ERA5-corrected results, the groundwater trend ranges from 0.27 to 17.2 mm/a for the expanded 937-observation set, compared with 0.50–18.2 mm/a for the original 795-observation set. The corresponding trend ranges for the GLDAS-corrected results are –3.3 to 20.1 mm/a and –3.2 to 20.9 mm/a, respectively. The annual-amplitude ranges also show only minor differences between the two observation sets, changing from 22.5–51.7 mm to 21.2–50.0 mm for ERA5 and from 24.7–50.5 mm to 23.0–50.3 mm for GLDAS.

These comparisons demonstrate that including the additional observations produces only minor changes in the overall spatial distributions and magnitude ranges of the inferred groundwater trends and annual amplitudes. This further supports the robustness of the inversion results to the adopted deformation-rate screening criterion.

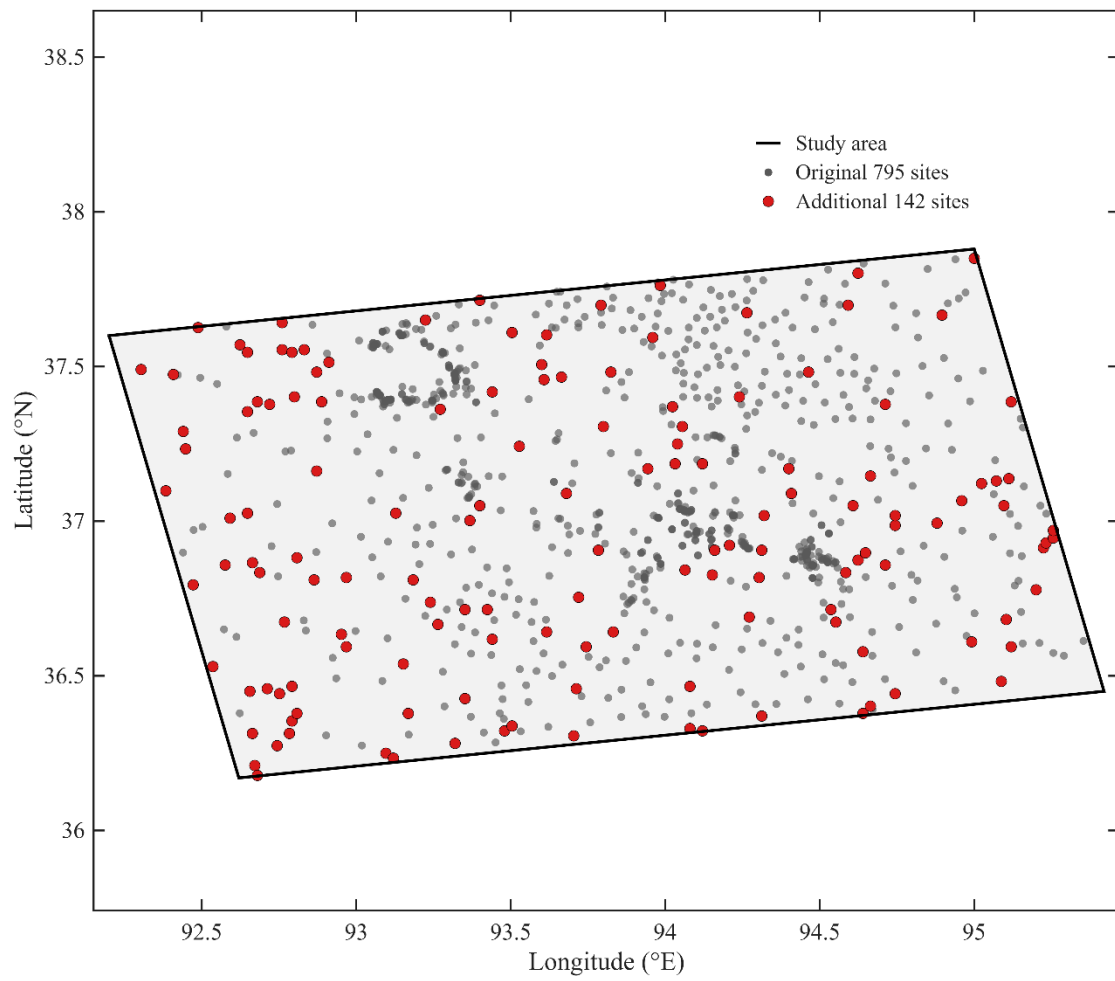


Figure S1. Spatial distribution of the original and additionally retained InSAR observations after relaxing the deformation-rate screening criterion.

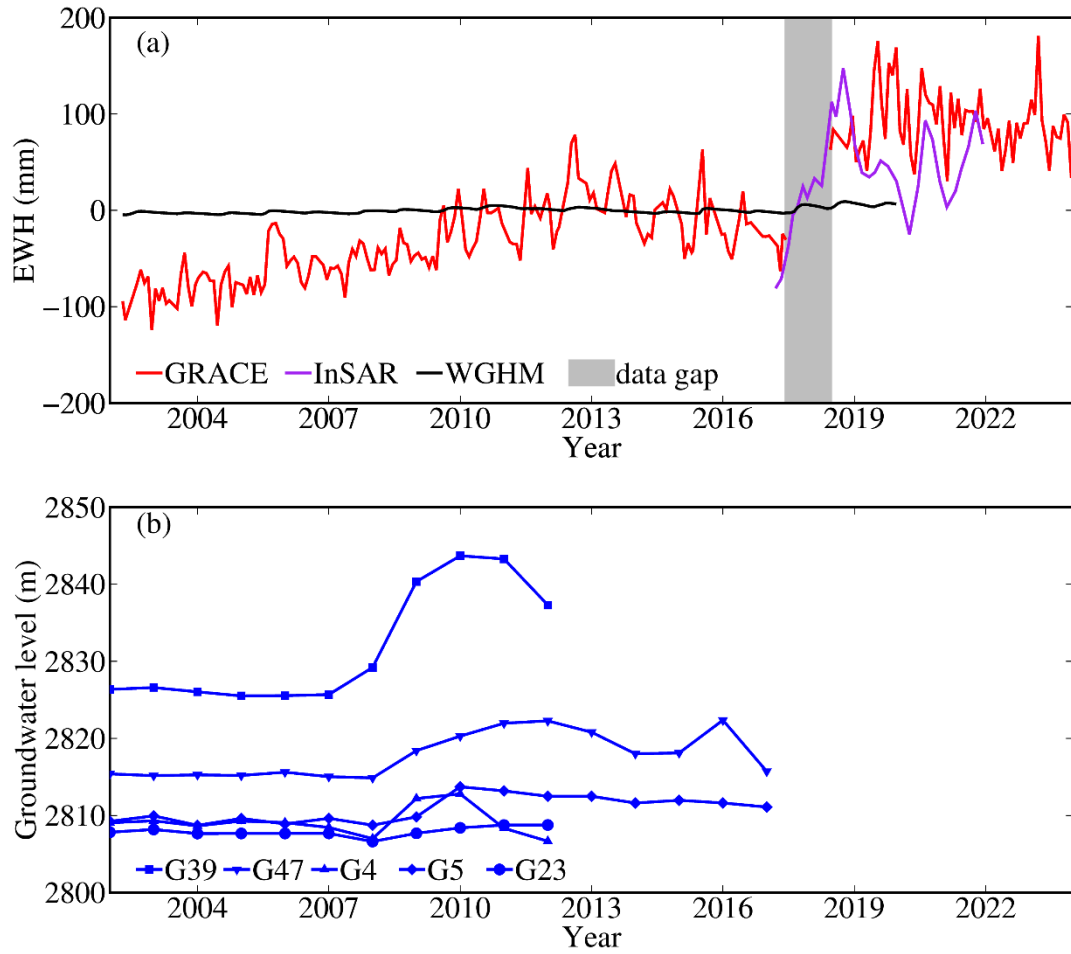


Figure S2. Comparison of groundwater variation time series obtained from different approaches based on the expanded set of 937 InSAR observations. (a) GRACE, InSAR, and WGHM results, where the equivalent water height values represent the mean variations within the parallelogram area shown in Figure 1c; (b) groundwater well observations.

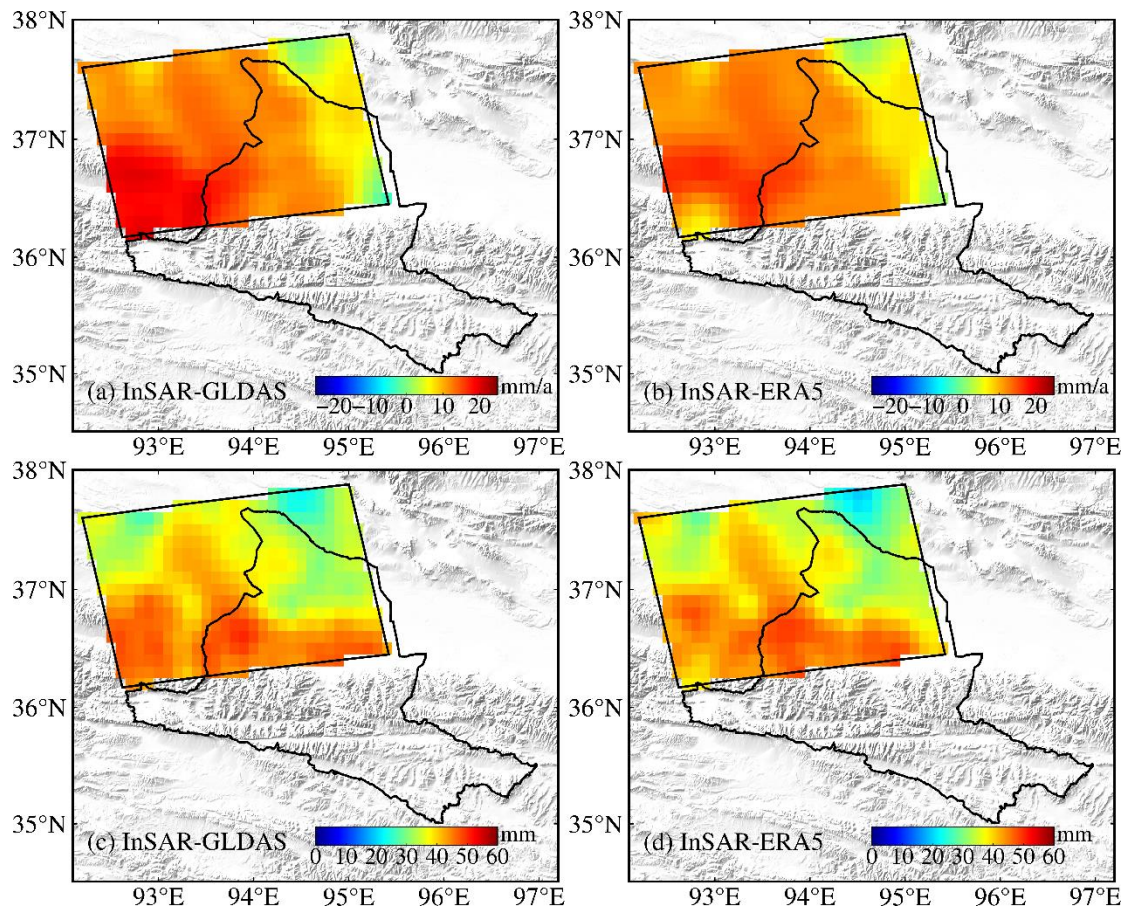


Figure S3. InSAR-derived groundwater variations in the Golmud River Basin during 2017–2021 based on the expanded set of 937 InSAR observations retained after relaxing the deformation-rate screening criterion, using two different surface water correction models. (a–b) Groundwater change rates; (c–d) annual amplitudes of groundwater variations.