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Benchmarking multimodel terrestrial water storage seasonal cycle against Gravity Recovery and Climate Experiment (GRACE) observations over major global river basins

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List of abbreviations

TWS	Terrestrial Water Storage
GRACE	Gravity recovery and climate experiment
GHMs	Global hydrological models
LSMs	Land Surface Models
CSR-M	University of Texas Center for Space Research mascon solutions
JPL-M	Jet Propulsion Laboratory mascon solutions
WRR1	Water Resources Reanalysis 1 and 2
WRR2	
E2O	eartH2Observe
EU-FP7	European Union's Seventh Framework Programme
WATCH	WATer and global CHange
WFDEI	WATCH Forcing Data applied to the ERA-Interim data
MSWEP	Multi-Source Weighted Ensemble Precipitation
LISFLOOD	-
HBV-SIMREG	-
W3RA	Worldwide water Resources Assessment
SWABM	Simple Water Balance Model
WaterGAP3	Water – Global Assessment and Prognosis-3
HTESSEL	Hydrology Tiled ECMWF Scheme for Surface Exchanges over Land
JULES	Joint UK Land Environment Simulator
Surfex-Trip	Surface Externalisée-Trip

Correlation coefficient (R)

The correlation coefficient (R) is the frequently used statistic to quantify the patterns of similarity between two variables (f) and (r) which are defined at N discrete points (in time and/or space).

$$R = \frac{\frac{1}{N}\sum_{n=1}^{N}(f_n-\bar{f})(r_n-\bar{r})}{\sigma_f\,\sigma_r} \quad (3)$$

where $\bar{f}$ and $\bar{r}$ are the mean values and σ_f and σ_r are the standard deviations of "f" and "r", respectively.

R reaches to 1 (maximum value) when for all n, $(f_n - \bar{f}) = \alpha(r_n - \bar{r})$, where α is a positive constant. In this instance, the two fields are not equal unless α = 1, despite sharing the same centered pattern of variation. Therefore, it is unlikely that the two models have the same amplitude of variance as R alone.

RMS difference (E)

RMS is the most frequently used statistic to quantify differences between two fields (f and r) and is defined by

$$E = \frac{1}{N}\sum_{n=1}^{N}\left[(f_n-\bar{f}) - (r_n-\bar{r})\right]^2 \quad (4)$$

The standard deviation of "f" (σ_f) is defined as following

$$E = \frac{1}{N}\sum_{n=1}^{N}\left(f_n-\bar{f}\right)^2 \quad (5)$$

And of "r" (σ_r) is

$$E = \frac{1}{N}\sum_{n=1}^{N}(r_n-\bar{r})^2 \quad (6)$$

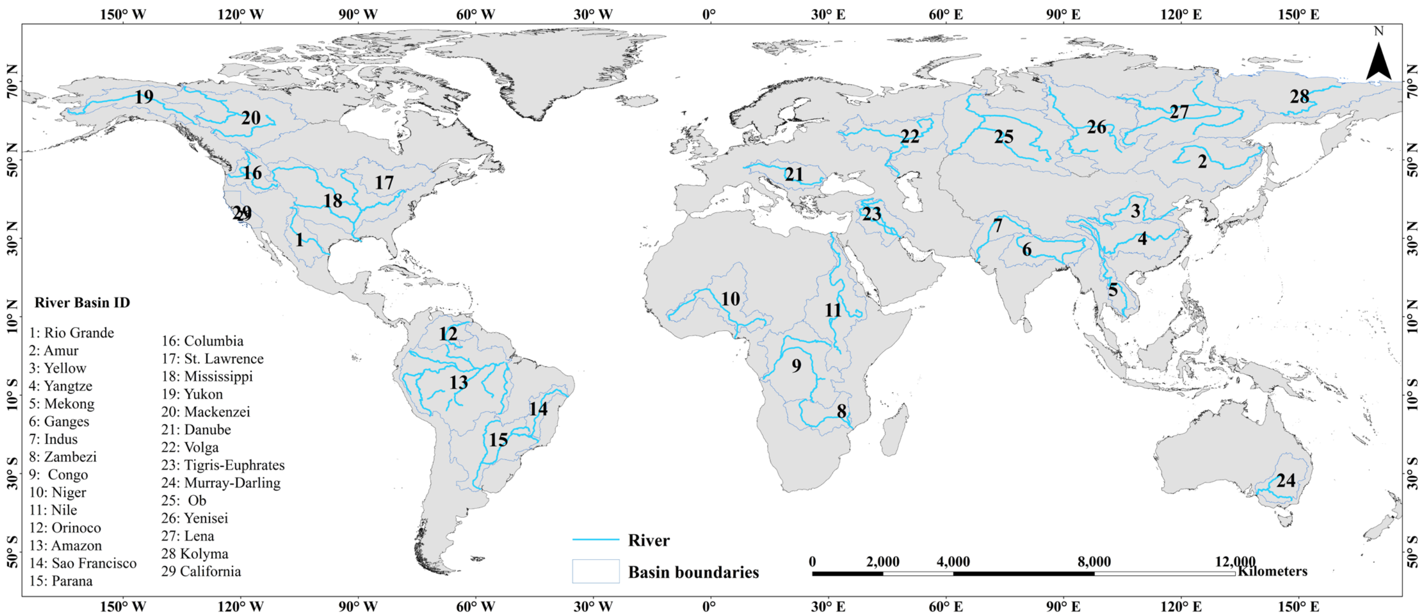

Figure S1: Selected 29 major global river basins.

Nine river basins including Amur (2), Saint Lawrence (17), Yukon (19), Mackenzie (20), Volga (22), Ob (25), Yenisei (26), Lena (27), and Kolyma (28) were selected from the boreal zone. Among them, five basins (i.e., Yukon, Mackenzie, Yenisei, Lena, and Kolyma) have heterogeneous climate conditions from polar to boreal and one basin (i.e., Saint Lawrence) is in boreal to temperate zones. Eleven river basins in the temperate zone were selected. Out of these, three basins i.e., Columbia (16), Mississippi (18), and the Danube (21) are located in the cold to temperate zone, and four basins i.e., Rio Grande (1), Euphrates (23), Murray-Darling (24), and California (29) in temperate to arid zone while four river basins Yellow River (3), Yangtze (4), Brahmaputra-Ganga (6), Indus (7) shares polar to the temperate and arid climate. Five basins, including Zambezi (8), Niger (10), Nile (11), São Francisco (14), and Prana (15), were selected from the arid zone and four major river basins in the tropical zone, including Mekong (5), Congo (9), Orinoco (12), and Amazon (13).

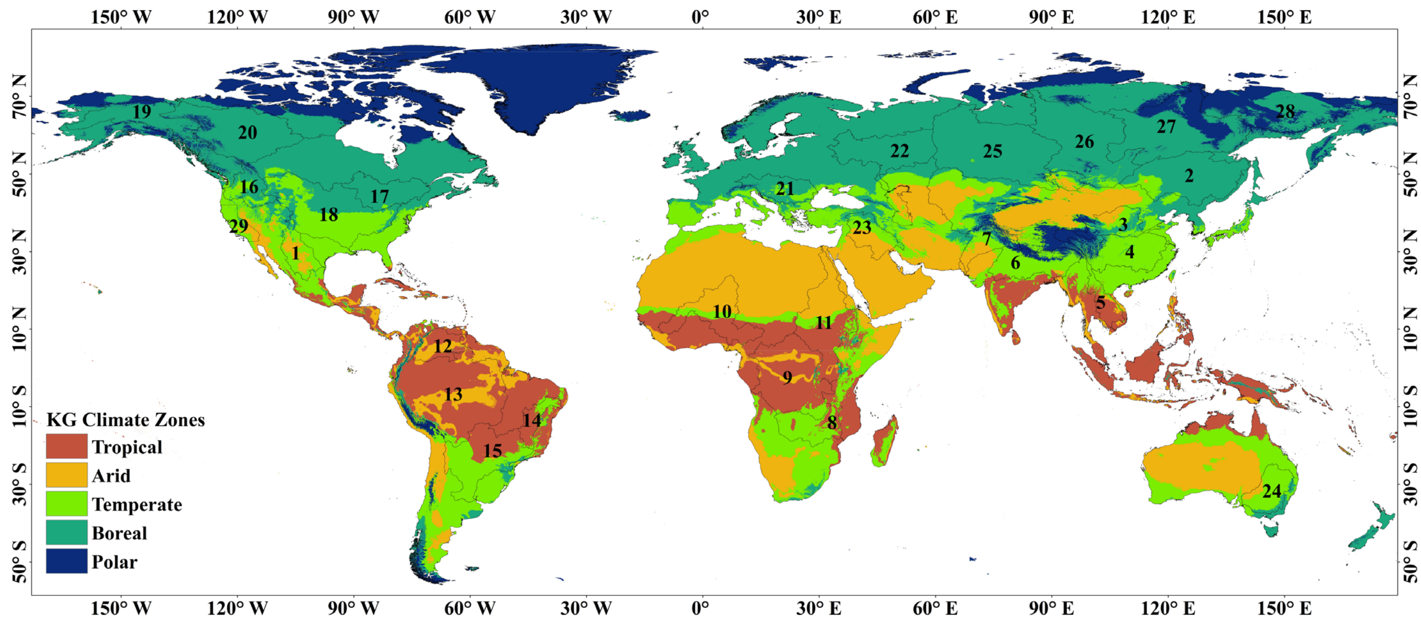

Figure S2: KGClim Climate Zones (1983-2013) classification

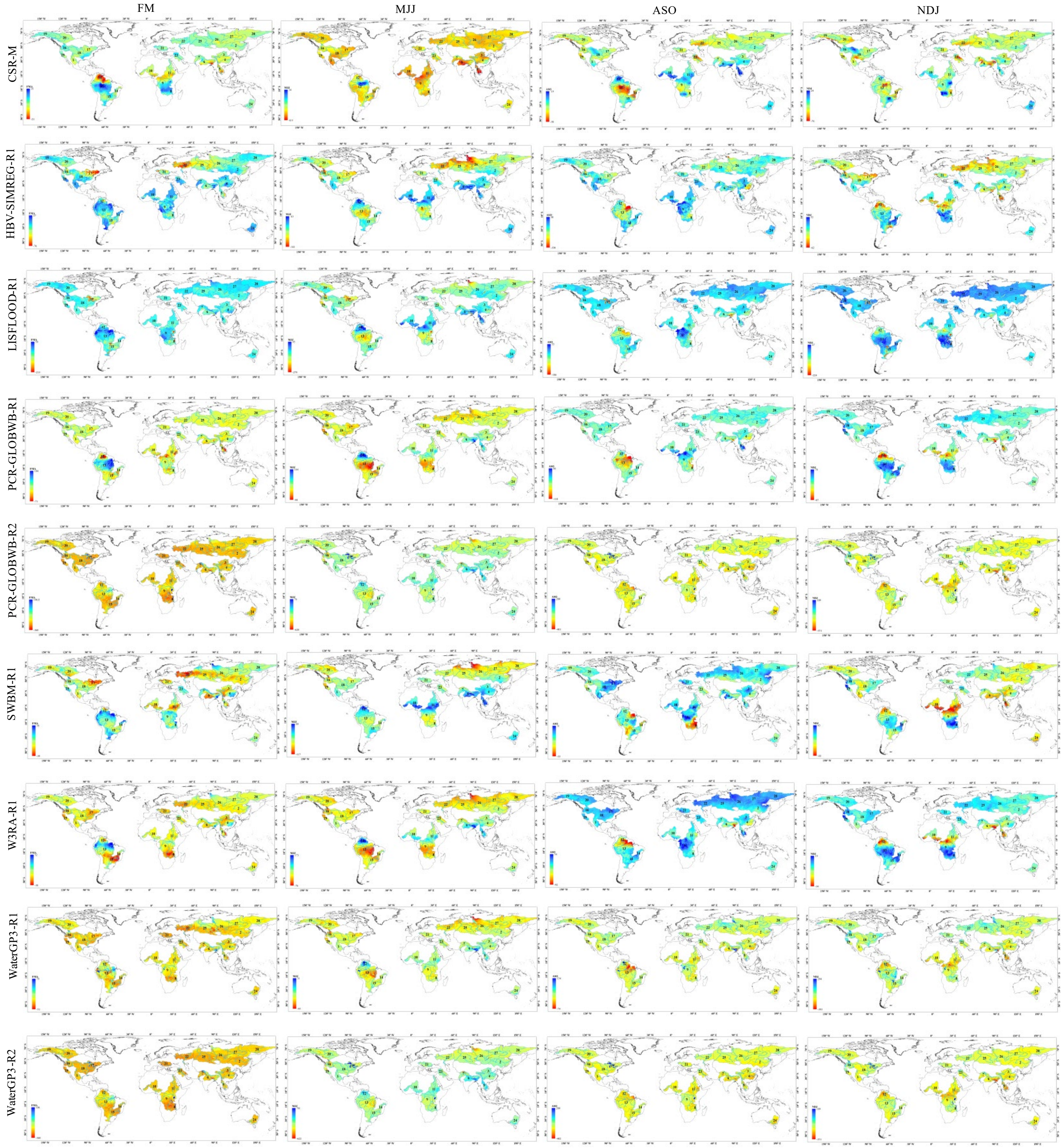

Figure S3: Seasonal maps for GRACE CSR-M and GHM R1 and R2

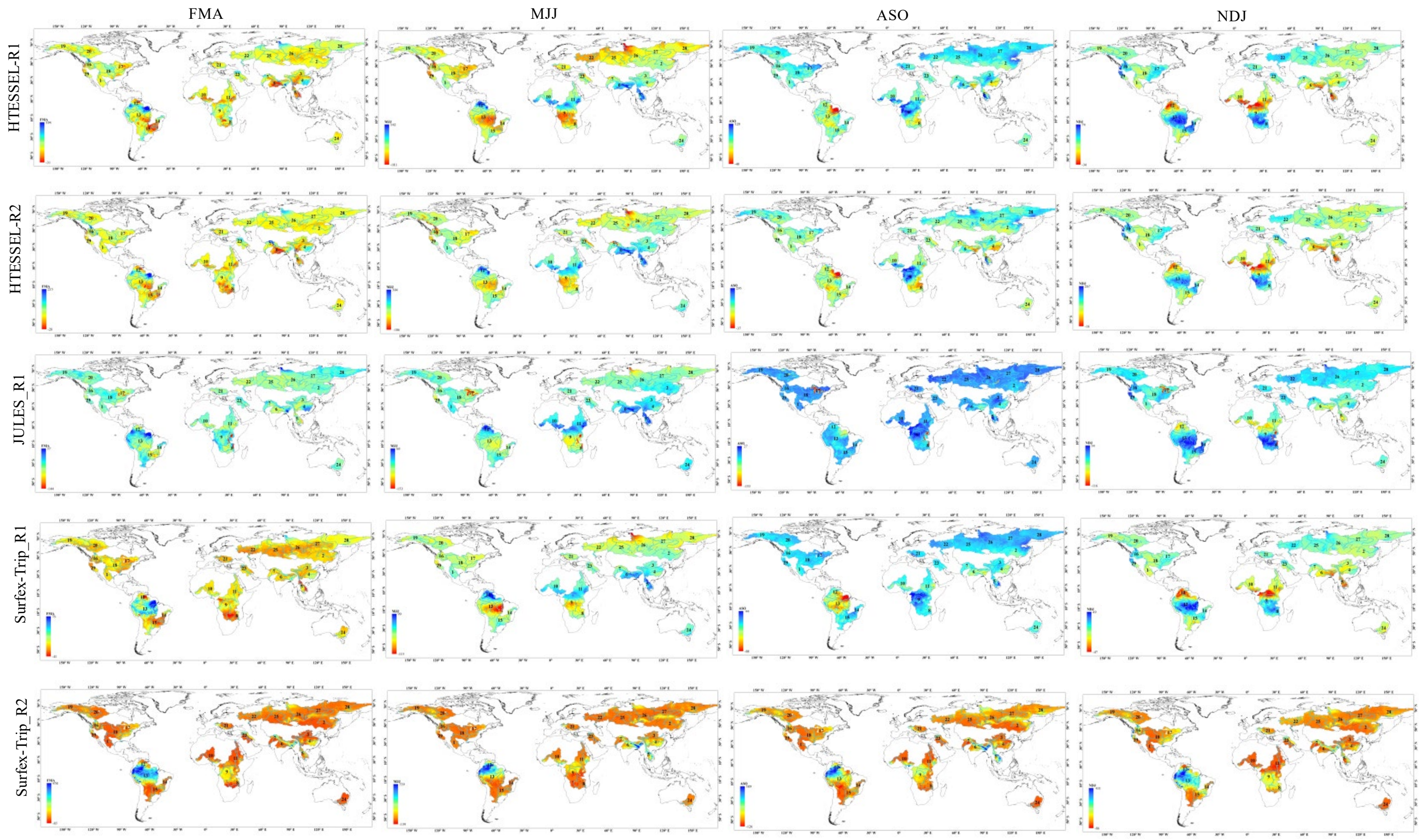

Figure S4: Seasonal maps of LSM R1 and R2

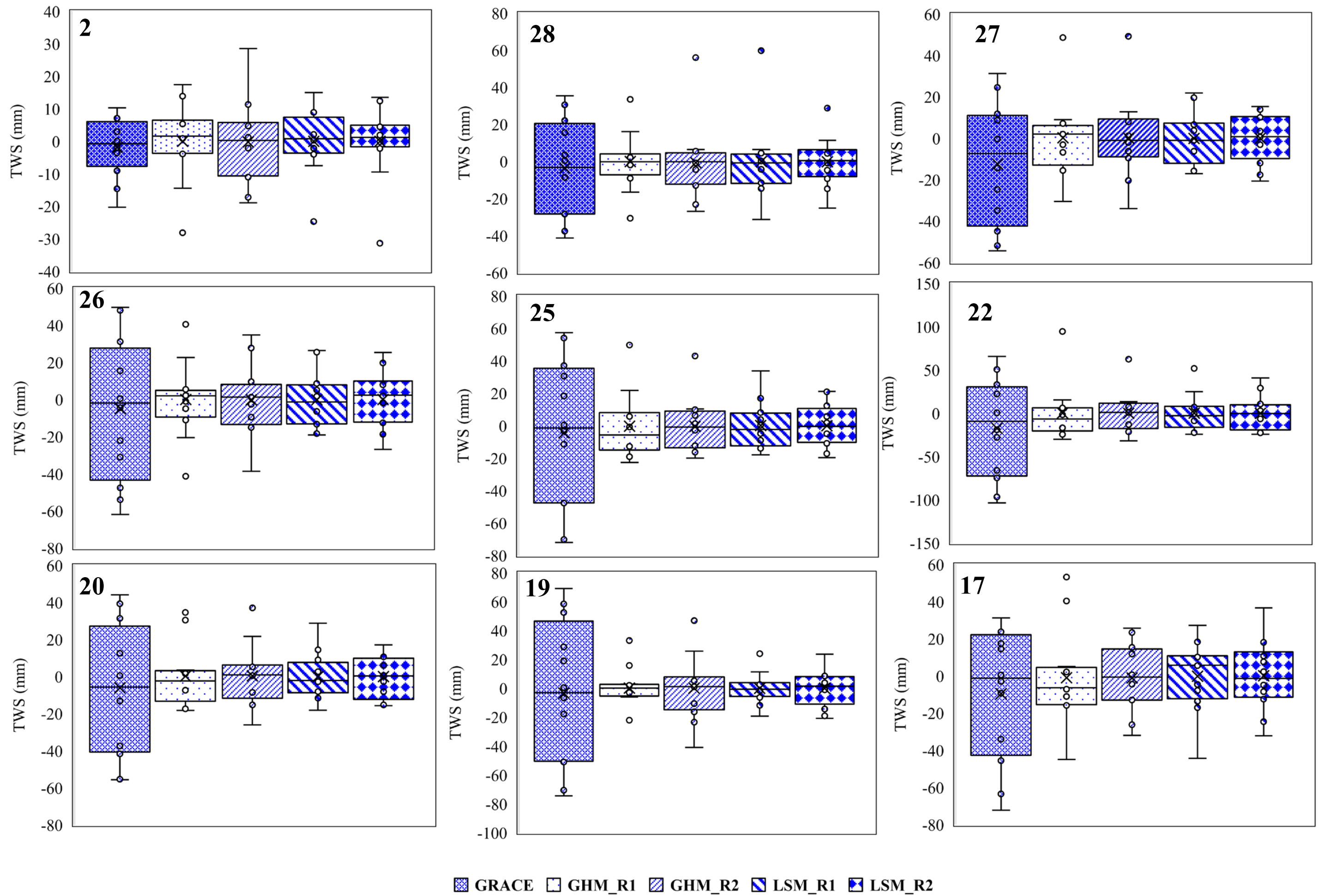

Figure S5: Distribution of GRACE and grouped model type (GHM or LSM) and forcing resolution (R1 and R2) in the Boreal zone.

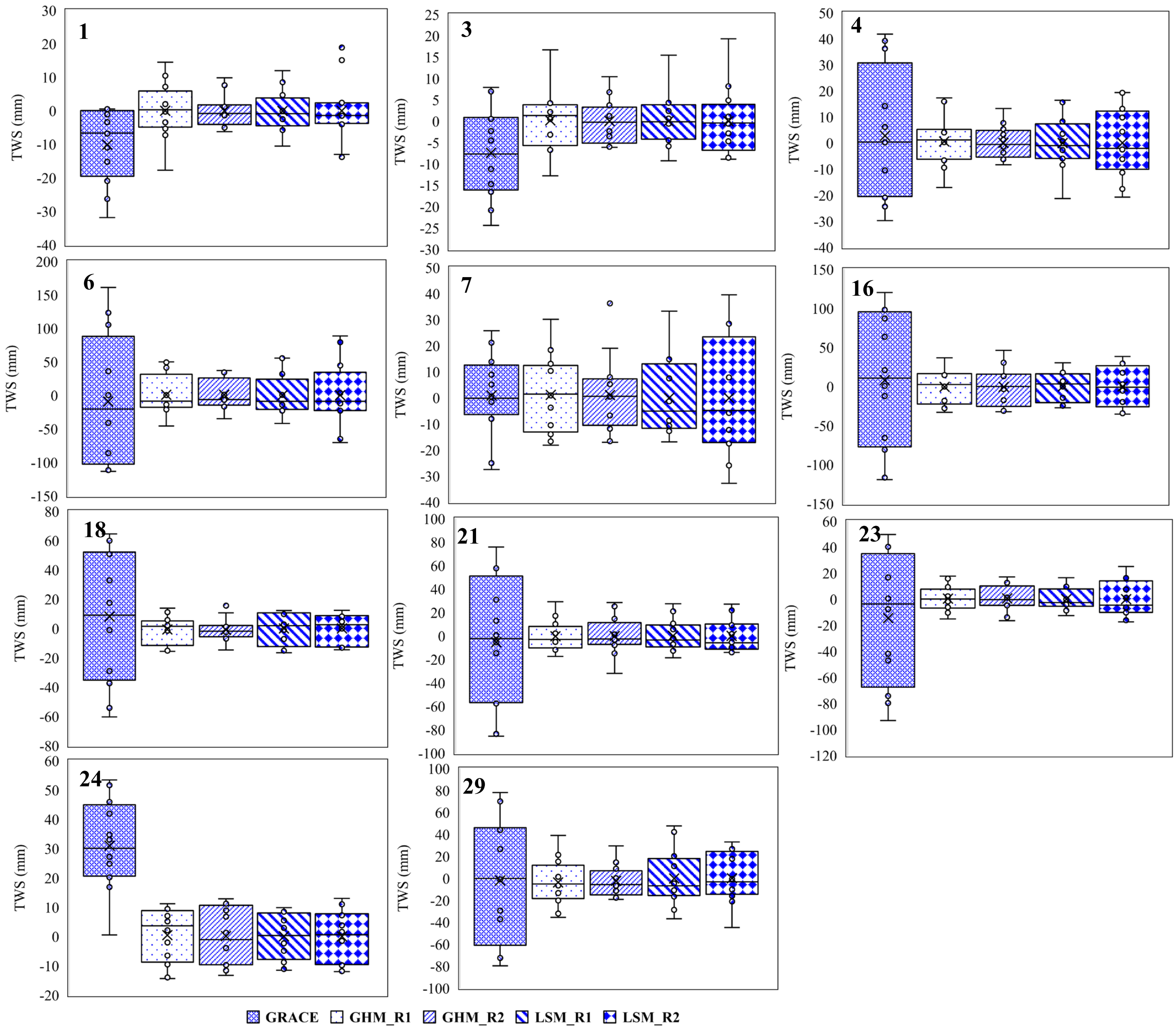

Figure S6: Distribution of GRACE and grouped model type (GHM or LSM) and forcing resolution (R1 and R2) in the Temperate zone.

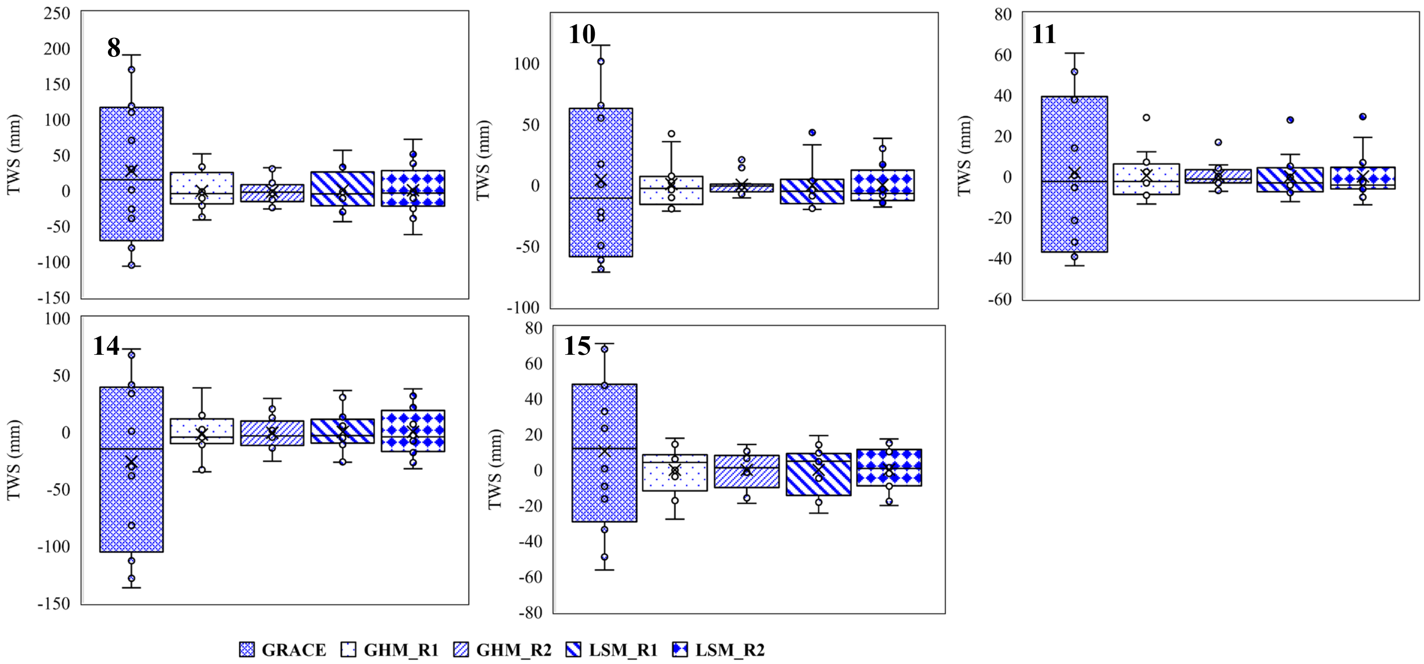

Figure S7: Distribution of GRACE and grouped model type (GHM or LSM) and forcing resolution (R1 and R2) in the Arid zone.

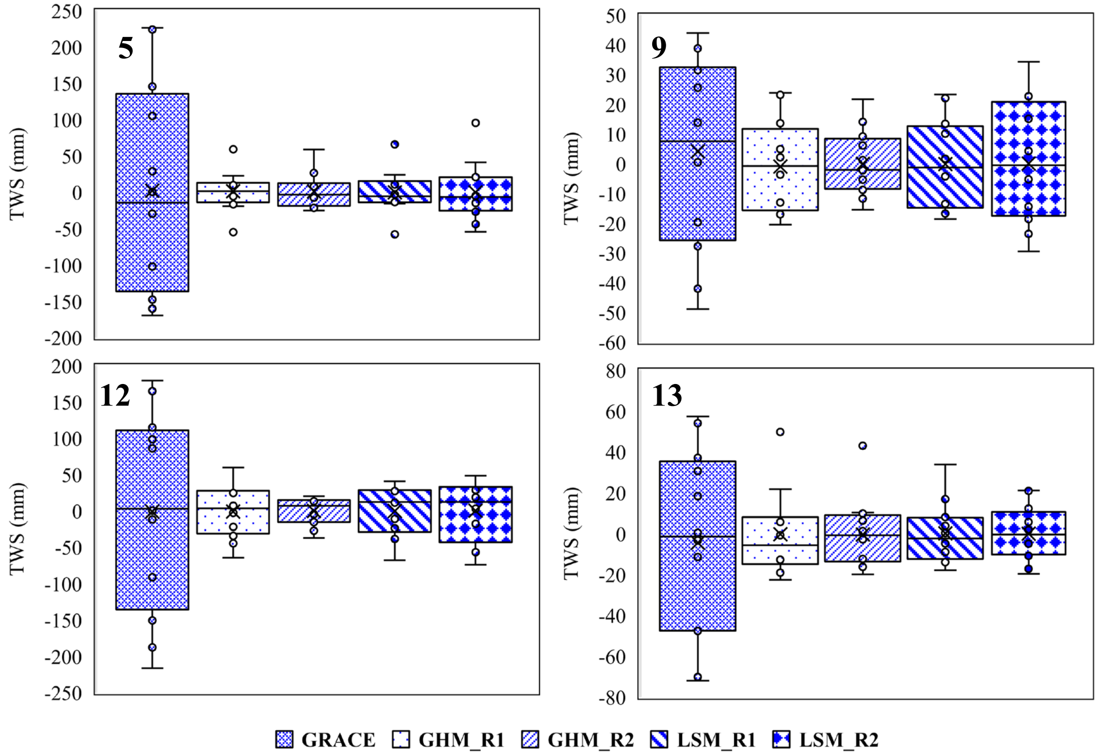

Figure S8: Distribution of GRACE and grouped model type (GHM or LSM) and forcing resolution (R1 and R2) in the Tropical zone.