A coupled surface water-groundwater multi-objective optimization framework for coordinated water-ecosystem-agriculture management in arid inland river basin

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S1 Evaluation of snowmelt runoff model's performance

The following results present the performance of the SRM model across the sub-catchments in the study area. The spatial distribution and numbering of the sub-catchments are shown in Figure S1.

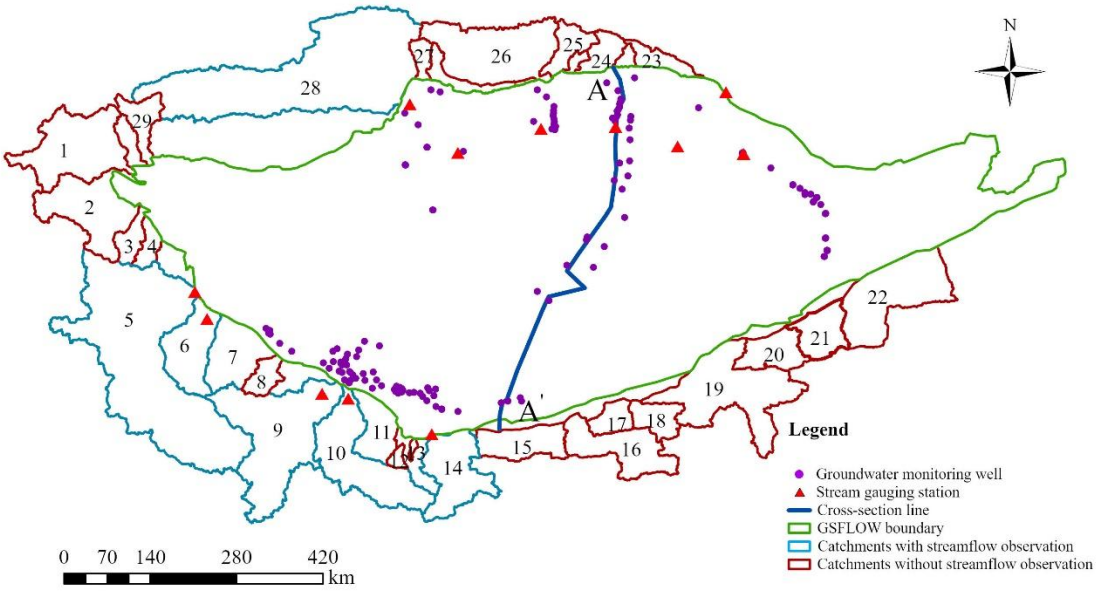

Figure S1. Spatial distribution and numbering of sub-basins in the study area

For the catchments with observed streamflow data (i.e., No.5, No.6, No.9, No.10, No.14, and No.28), the calibration and validation results of the SRM model are summarized in Figure S2. The left column shows the time series of observed and simulated monthly streamflow during the calibration period (2002-2015) and the validation period (2016-2021), while the two columns on the right present scatter comparisons between modeled and observed runoff for the corresponding periods.

For the catchments without observed streamflow data (i.e., No.1, No.2, No.4, No.7, No.8, No.11, No.12, No.15, No.19, No.20, No.21, No.24, No.25, No.26, No.27, and No.29), SRM model parameters were derived from calibrated catchments using a hydrological similarity approach. Model performance was evaluated using multi-year mean streamflow series, and the results are shown in Figure S3.

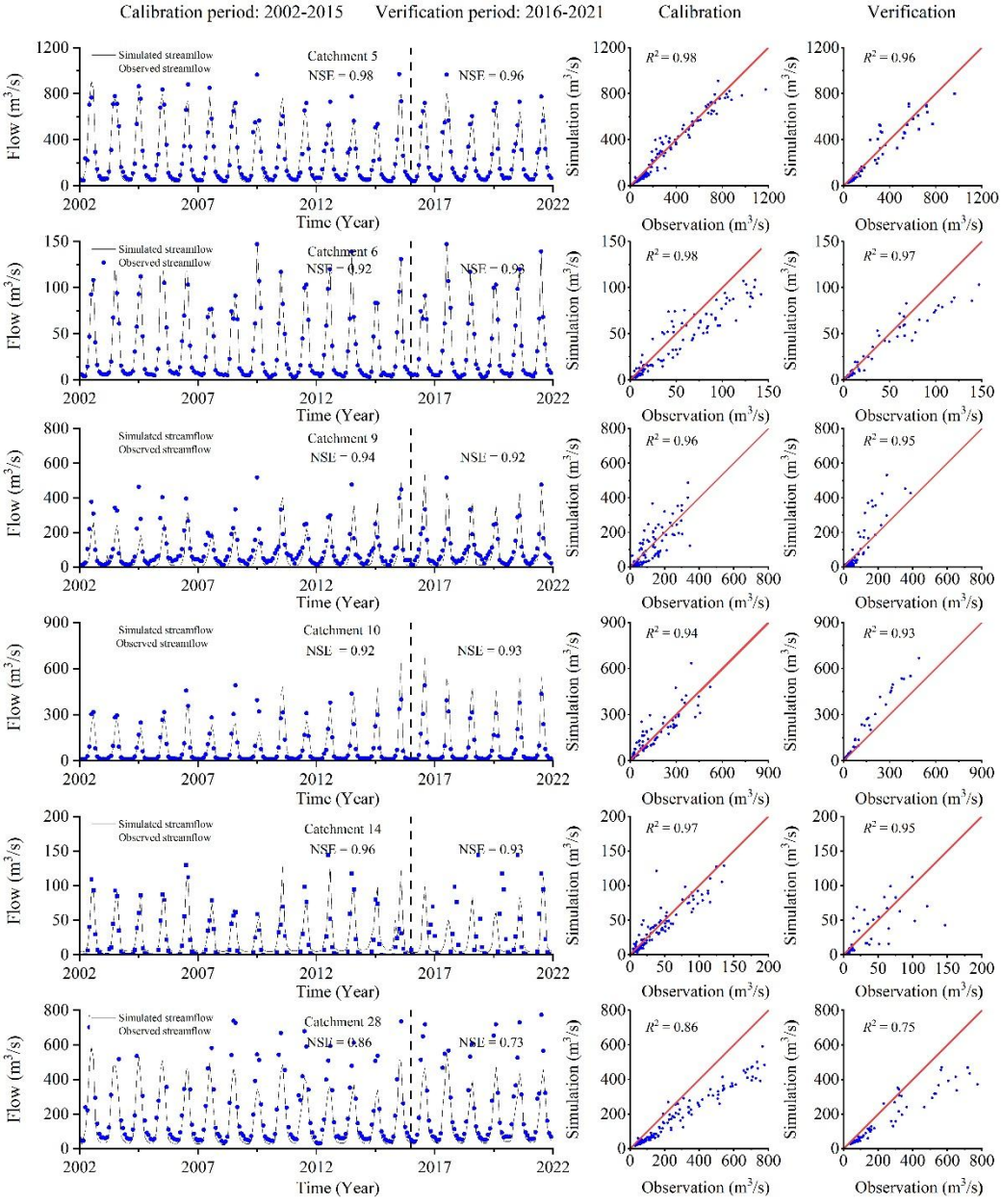

Figure S2. Observed and simulated monthly streamflow for catchments No.5, No.6, No.9, No.10, No.14, and No.28. The left column shows the time series of observed and simulated streamflow during the calibration (2002-2015) and validation (2016-2021) periods. The two right columns present scatter comparisons between observed and simulated monthly streamflow for the calibration and validation periods, respectively.

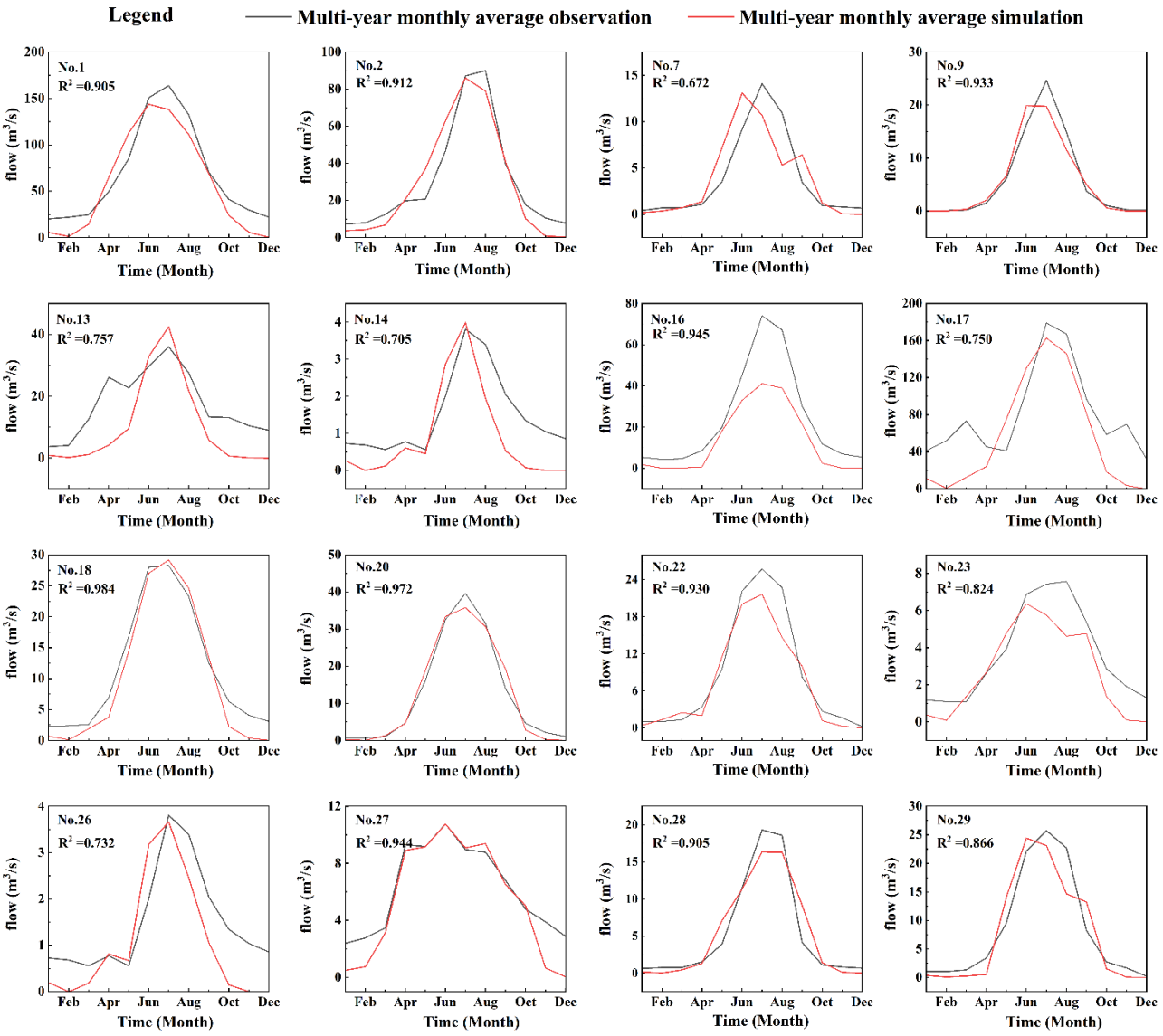

Figure S3. Comparison between simulated and observed multi-year mean streamflow for ungauged catchments, including No.1, No.2, No.4, No.7, No.8, No.11, No.12, No.15, No.19, No.20, No.21, No.24, No.25, No.26, No.27, and No.29.

S2 Evaluation of the surface water-groundwater model performance using remote sensing data

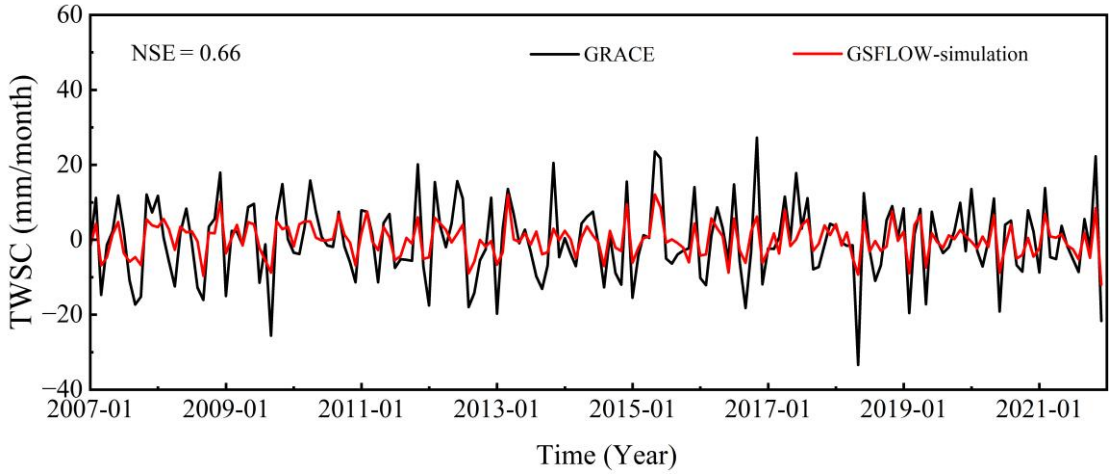

Figure S4. Comparison of monthly variations in total water storage change (TWSC) derived from the GSFLOW simulations and GRACE.

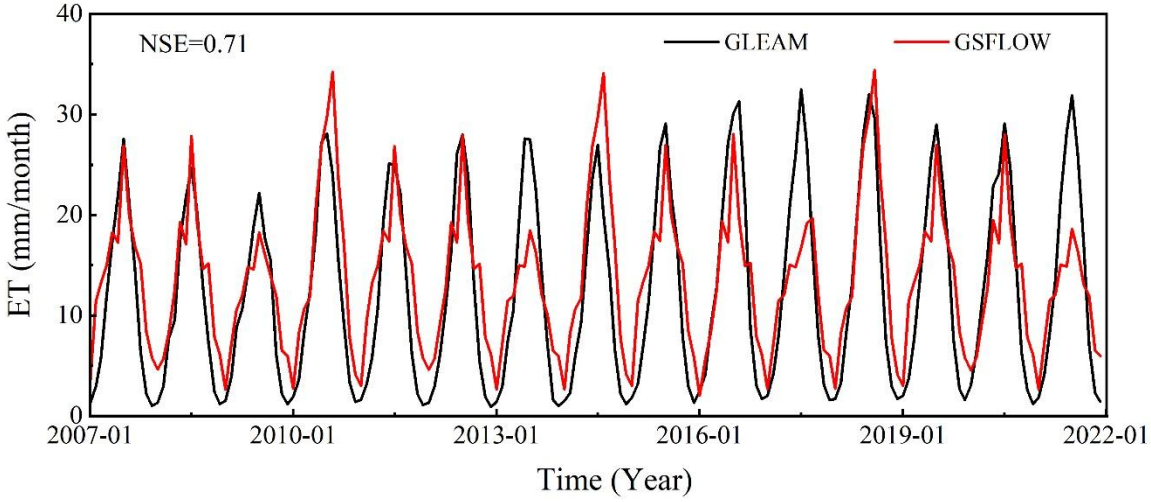

Figure S5. Evaluation of monthly evapotranspiration (ET) simulated by the GSFLOW model against GLEAM-based estimates for the period 2007-2021.

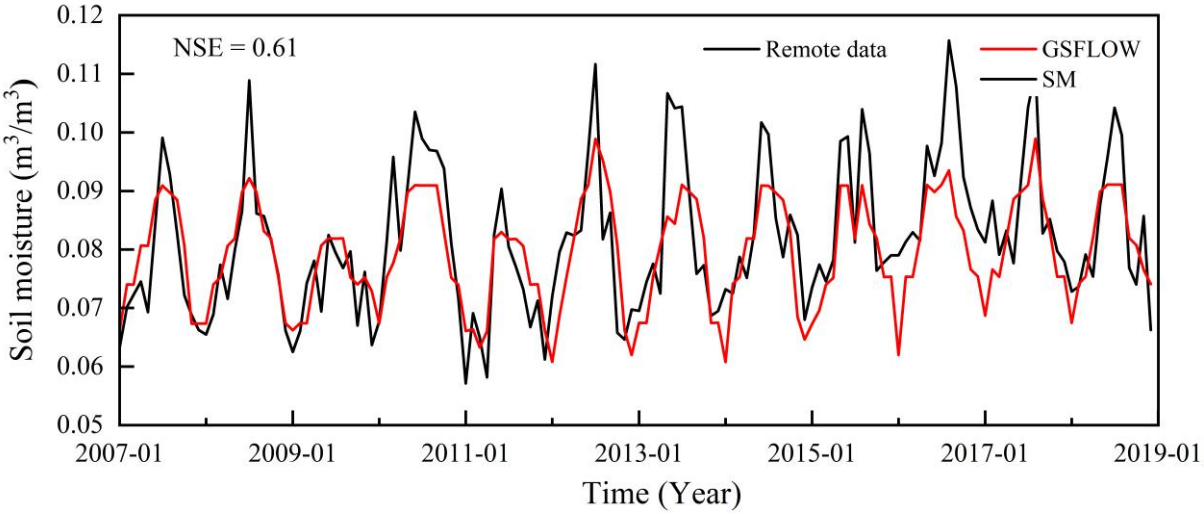

Figure S6. Comparison between GSFLOW-simulated and remotely sensed monthly soil moisture during 2007-2018.

S3 Evaluation of the surrogate model performance

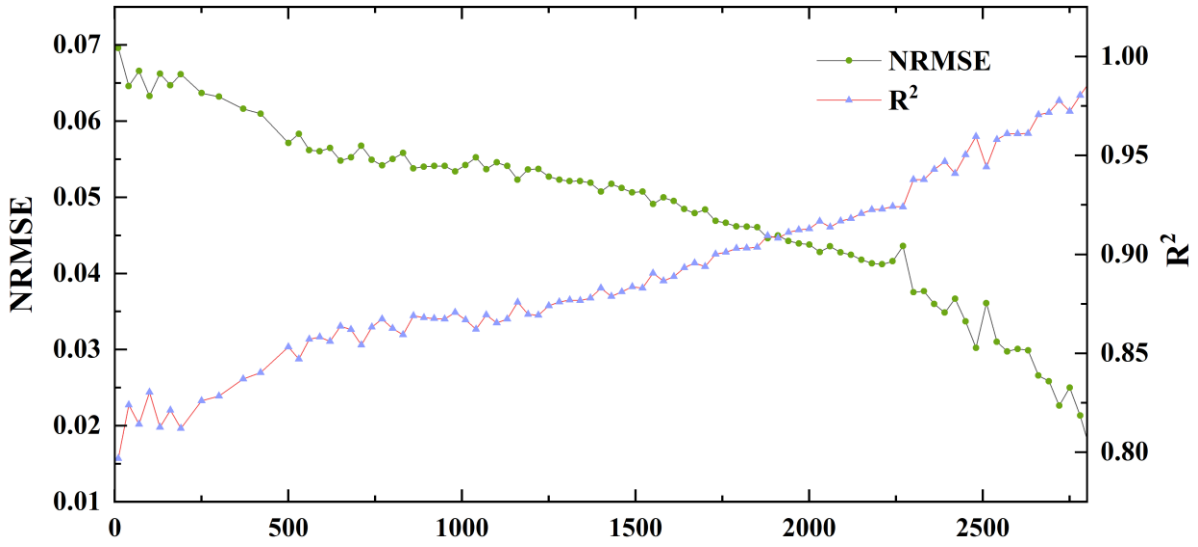

Figure S7. Variation of the surrogate model's NRMSE and R^2 with the number of training samples.