Supplement of

Achieving Water Budget Closure through Physical Hydrological Processes Modelling: Insights from a Large-Sample Study

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Table S1. Summary of the 18 excluded basins, including the id, location, area and excluded reasons.

HRU ID	Lat	Lon	Area (km^2)	Excluded reason
01118300	41.49	-71.84	13.71	Data is missing between 1998 and 2010
01121000	41.87	-72.17	94.70	Data is missing between 1998 and 2010
01187300	42.08	-72.98	54.22	Data is missing between 1998 and 2010
01510000	42.69	-75.81	382.93	Data is missing between 1998 and 2010
02125000	35.39	-80.35	145.08	Incomplete observation in 2010
02202600	32.28	-81.63	623.35	Data is missing between 1998 and 2010
03281100	37.05	-83.75	425.26	Data is missing between 1998 and 2010
03300400	37.76	-85.07	1128.56	Data is missing between 1998 and 2010
05062500	47.29	-95.74	2435.96	Data is missing between 1998 and 2010
06154410	47.96	-108.63	47.72	No observation in 2010
06291500	45.04	-107.74	220.73	No observation in 2010
07290650	31.94	-90.55	1694.64	Data is missing between 1998 and 2010
07295000	31.17	-91.18	466.89	Data is missing between 1998 and 2010
08079600	33.24	-101.86	3512.32	Data is missing between 1998 and 2010
09497800	34.04	-110.51	751.79	Data is missing between 1998 and 2010
10173450	37.63	-112.69	281.69	Data is missing between 1998 and 2010
12383500	47.14	-113.92	17.70	Incomplete observation in 2010
12388400	47.24	-114.40	76.56	Incomplete observation in 2010

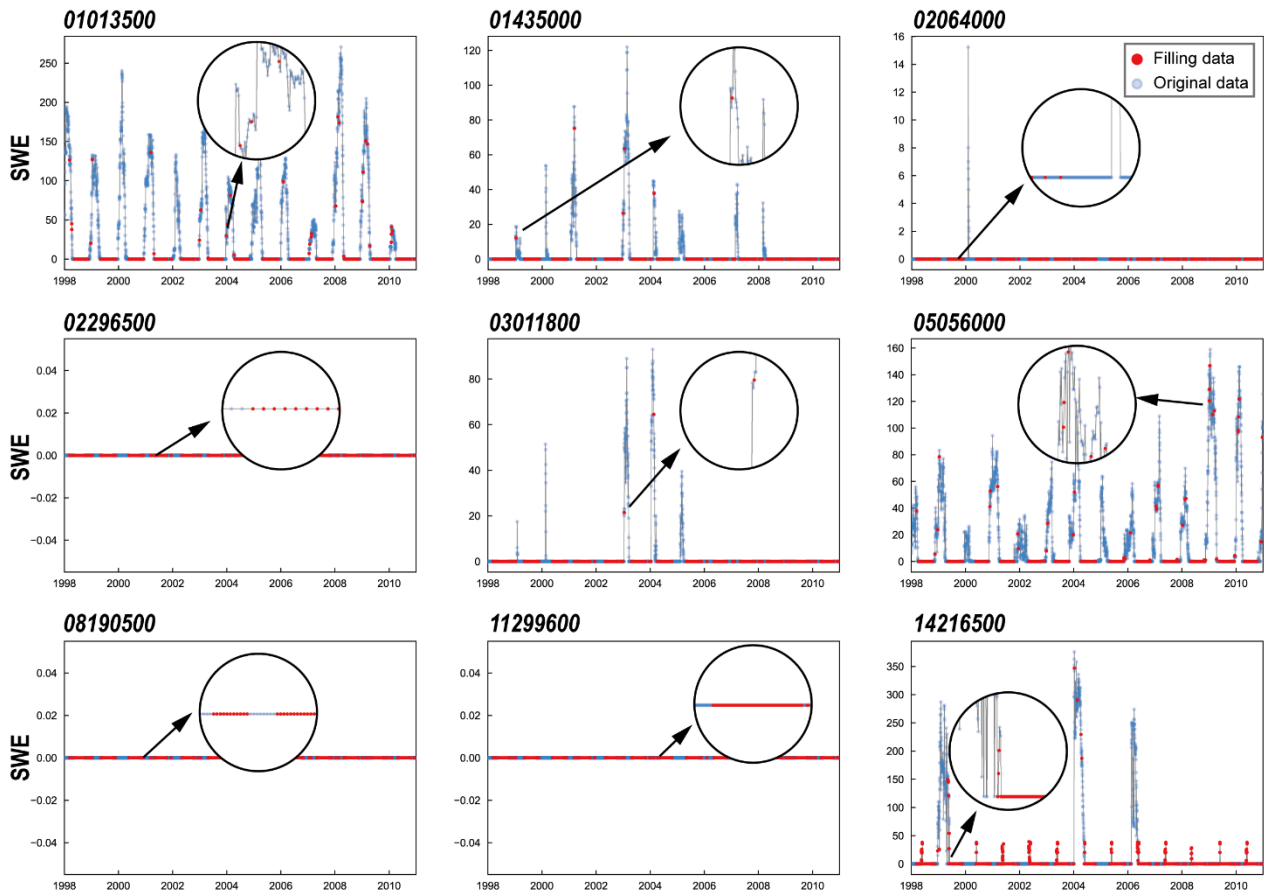
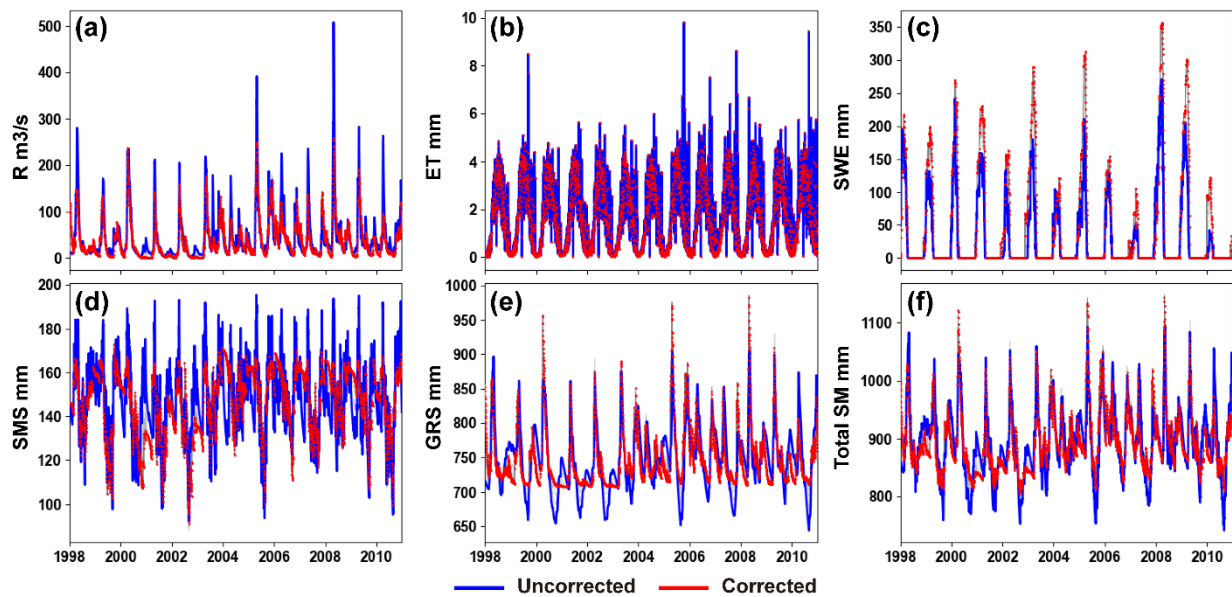



Figure S1. Schematic diagram of the gap filling process for GlobSnow SWE at nine randomly selected basins.

15 **Figure S2.** Time series of water budget variables before and after correction at basin 1013500. Note the total SM is the combination of SMS and GRS.

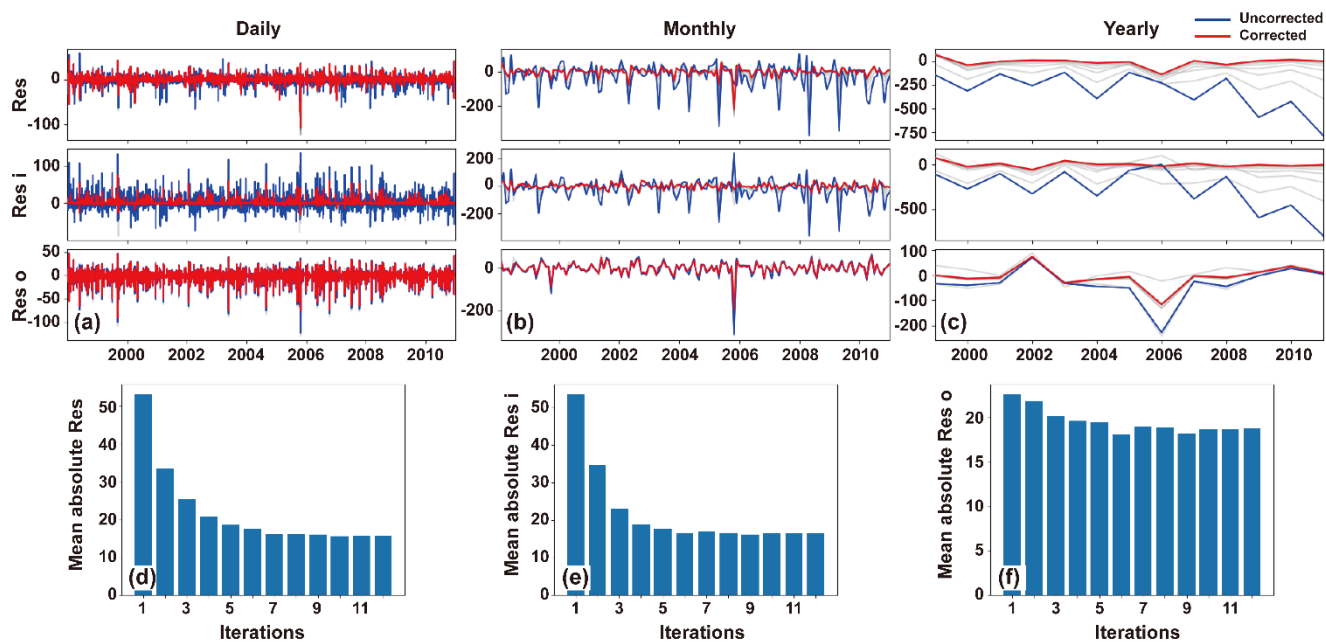
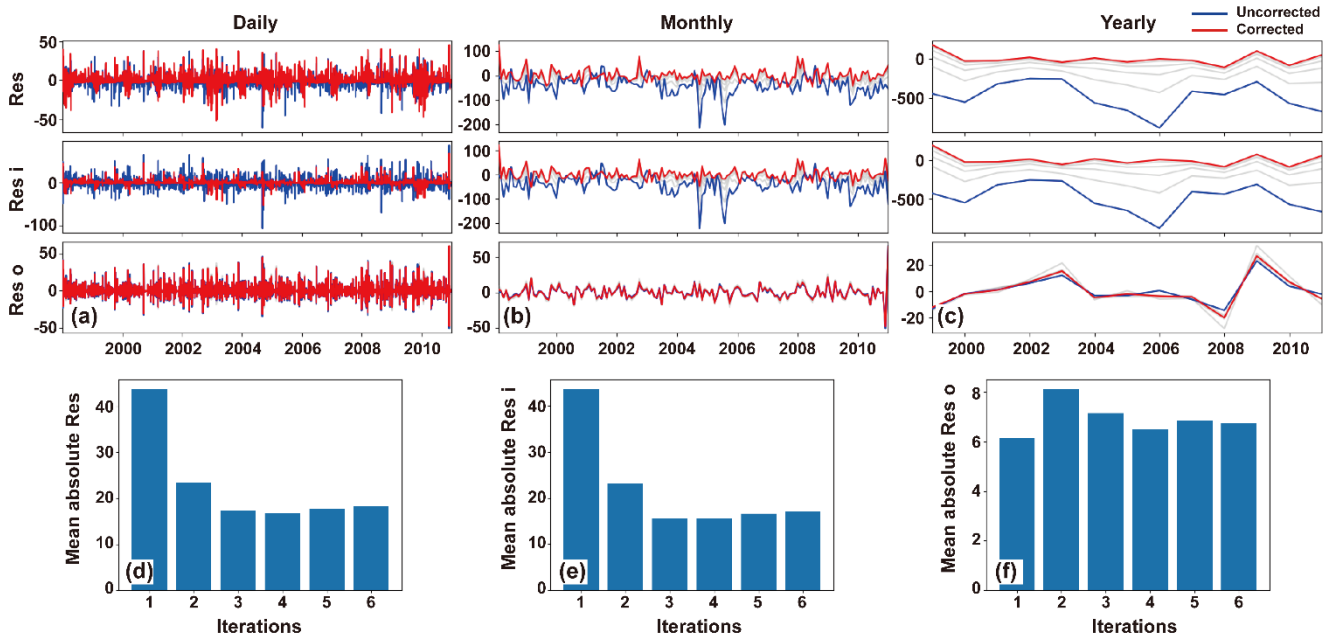



Figure S3. Same as Fig. 6, but for basin 1137500.

20   **Figure S4.** Same as Fig. 6, but for basin 2177000.

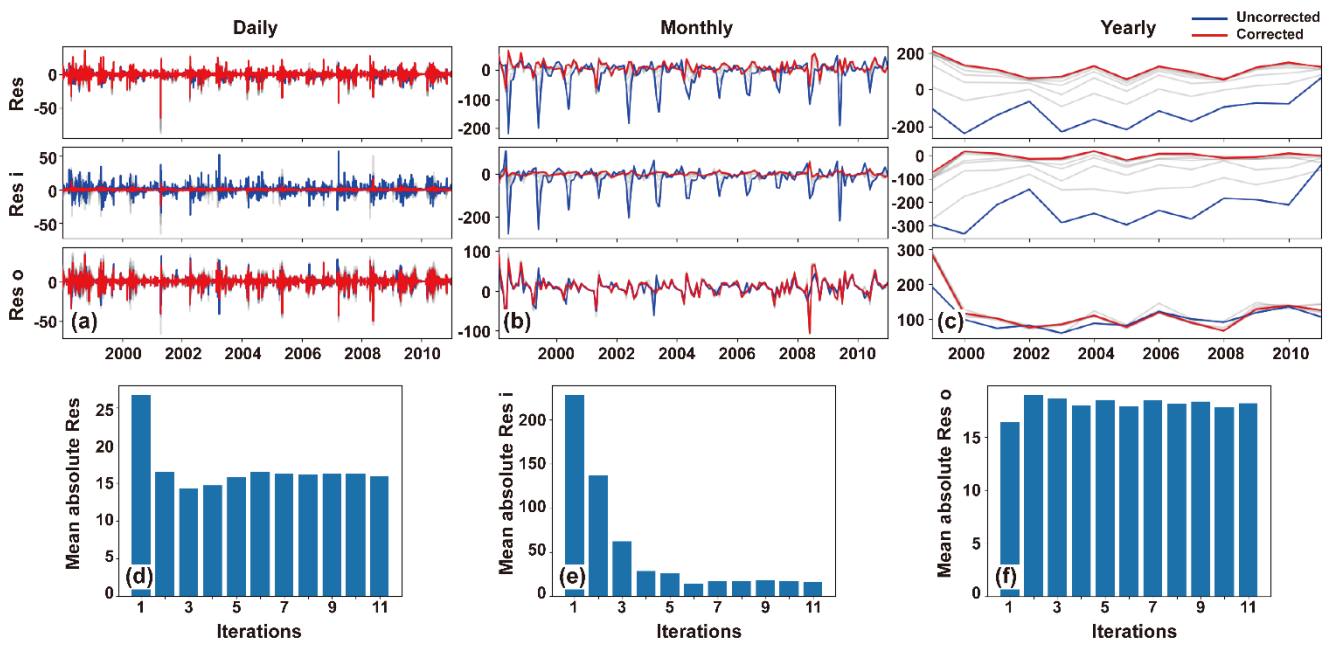



Figure S5. Same as Fig. 6, but for basin 6311000.

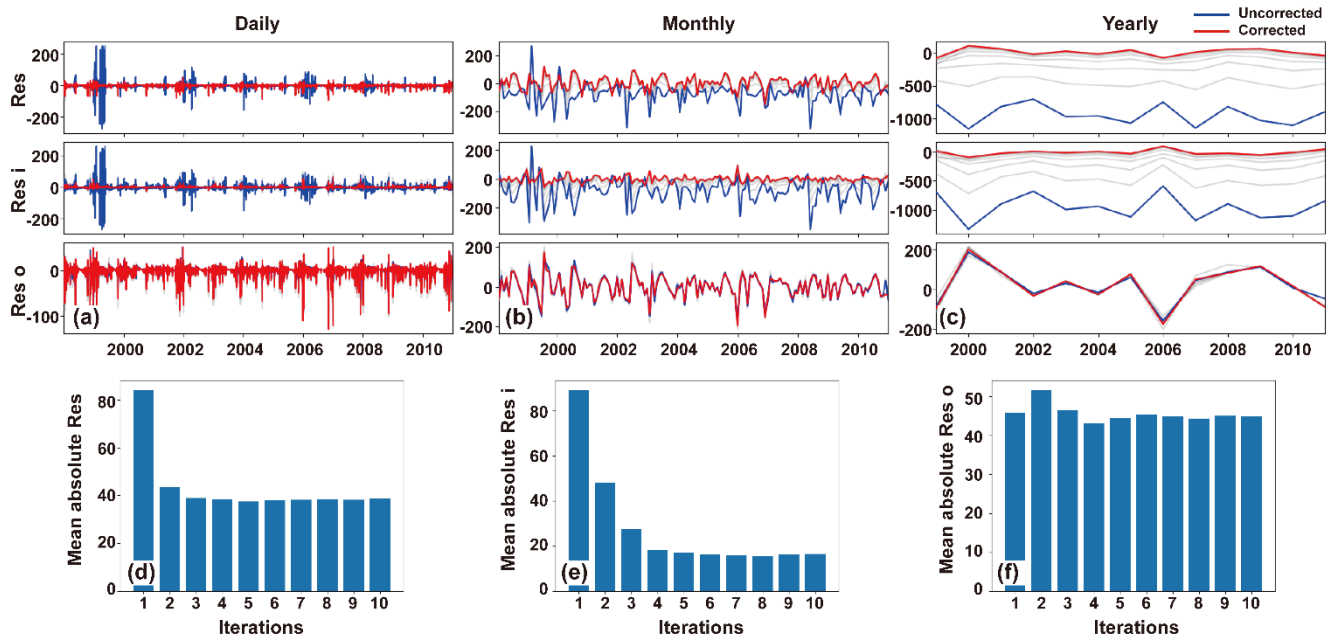



Figure S6. Same as Fig. 6, but for basin 14092750.

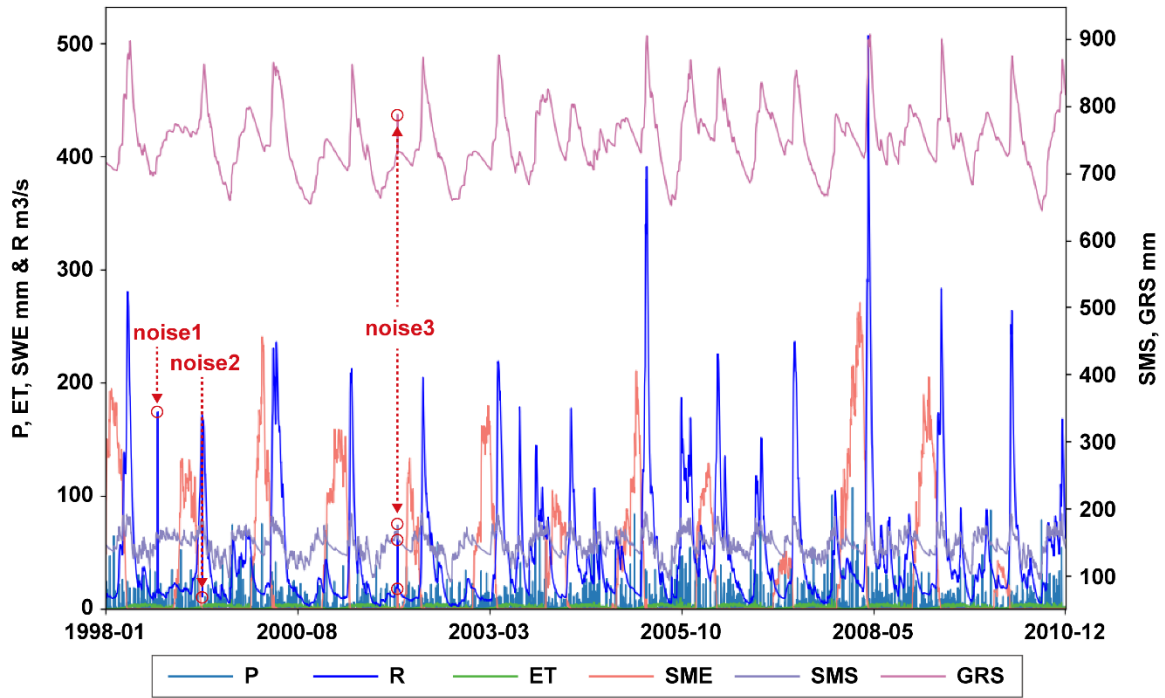



Figure S7. Noise sequence (NS1) generated by adding three single-point noises, corresponds to noise experiments 1-3.

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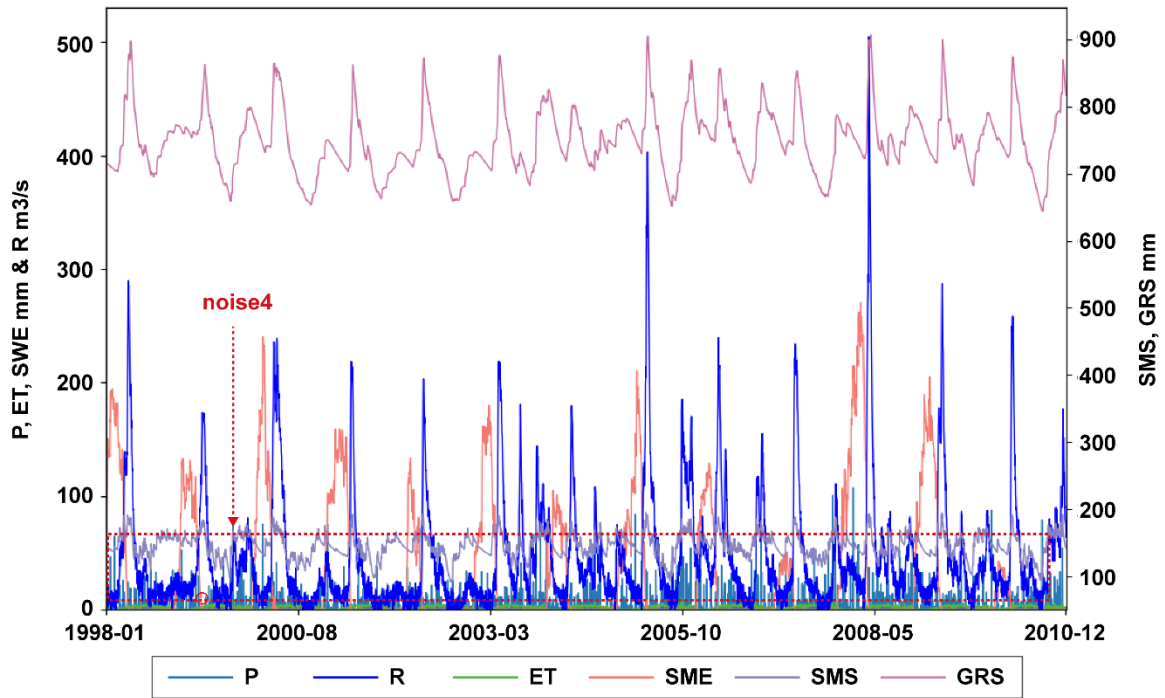
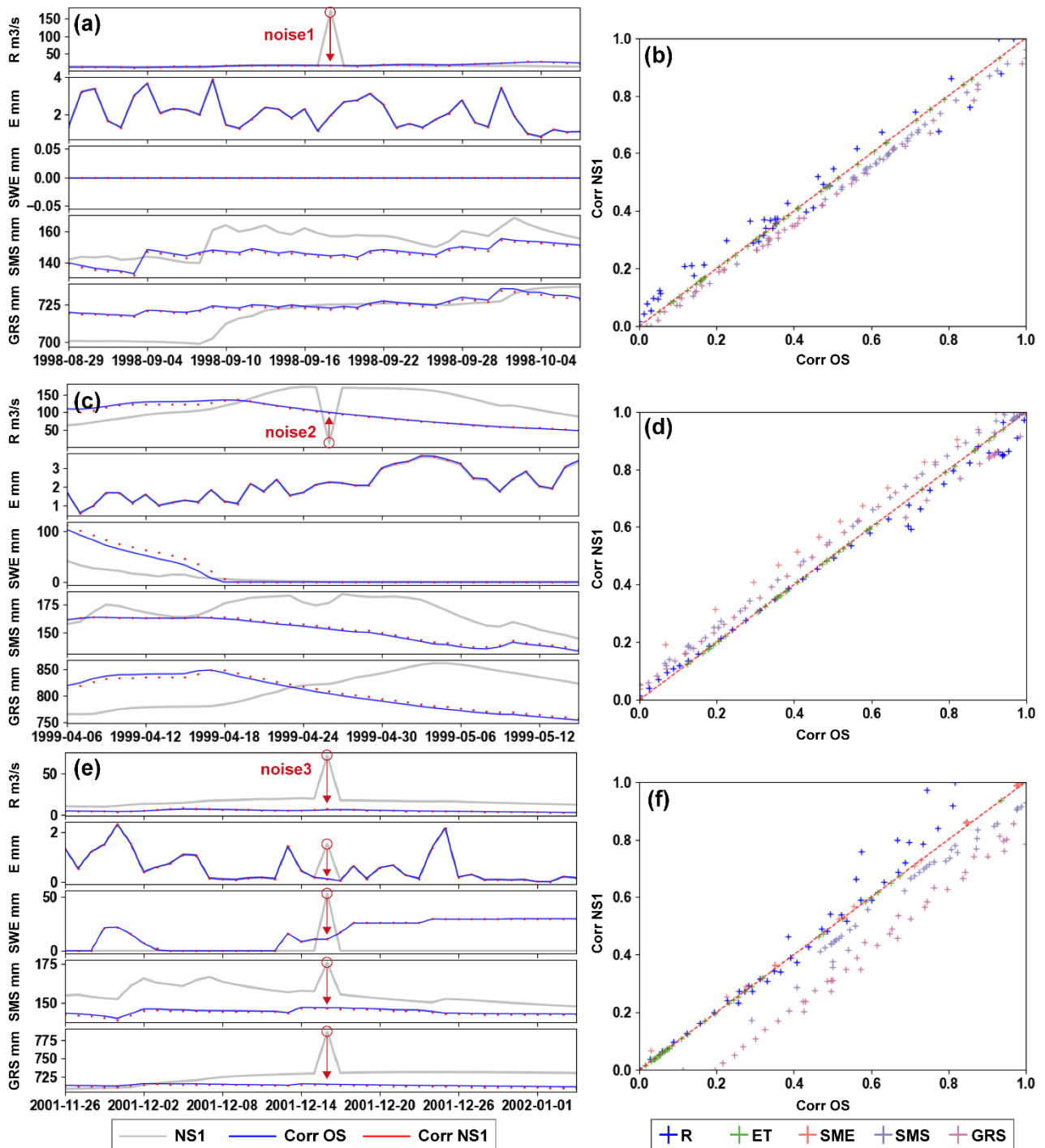


Figure S8. Noise sequence (NS2) generated by adding a Gaussian white noise sequence into the runoff, corresponds to noise experiment 4.

30   **Figure S9.** Correction results for multisource datasets around noises 1-3. Panels in the left column depict the time series of OS-based and NS1-based correction (Corr OS and Corr NS1), while panels in the right column compare them in terms of standardized values.

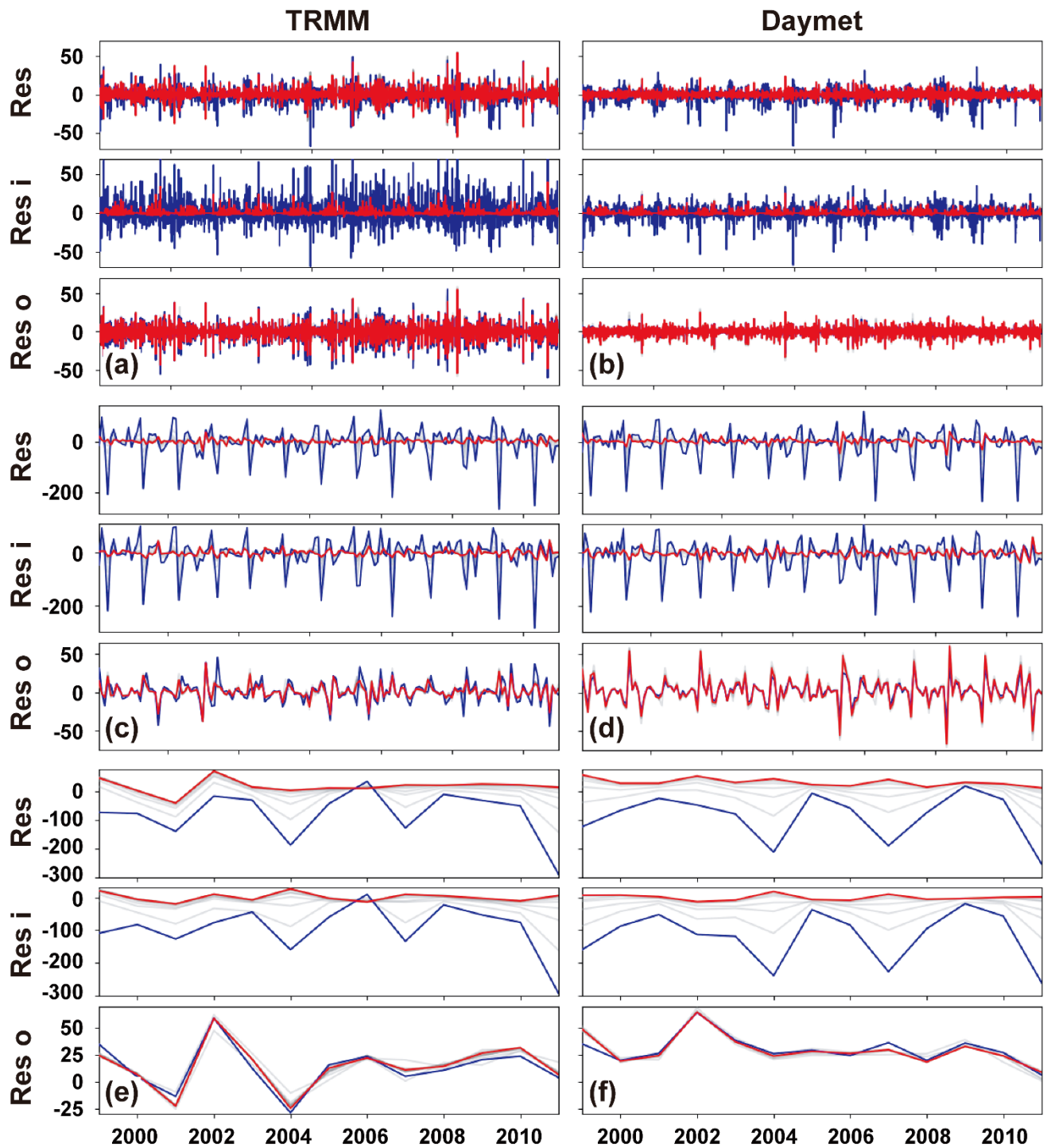



Figure S10. Comparison of correction results based on different forcing datasets (TRMM and Daymet) at basin 1013500. Time series of three types of residuals at daily (a-b), monthly (c-d), and yearly (e-f) timescales, respectively.

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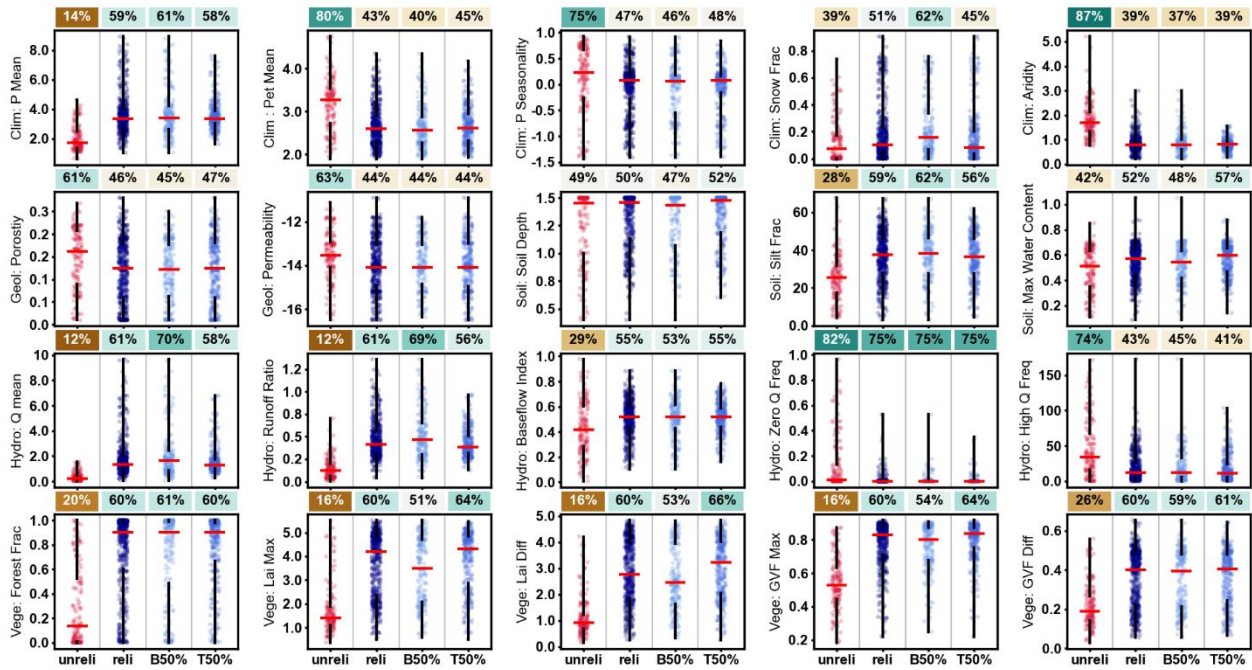
Figure S11. Grouping of basin characteristics based on model performance in runoff. Four groups labelled as "unreli", "reli", "B50%", and "T50%" represent basin groupings characterized by unreliable simulations, reliable simulations, below-average model performance, and above-average model performance, respectively. The cumulative probability of the median value for each group is labelled at the top of each panel.

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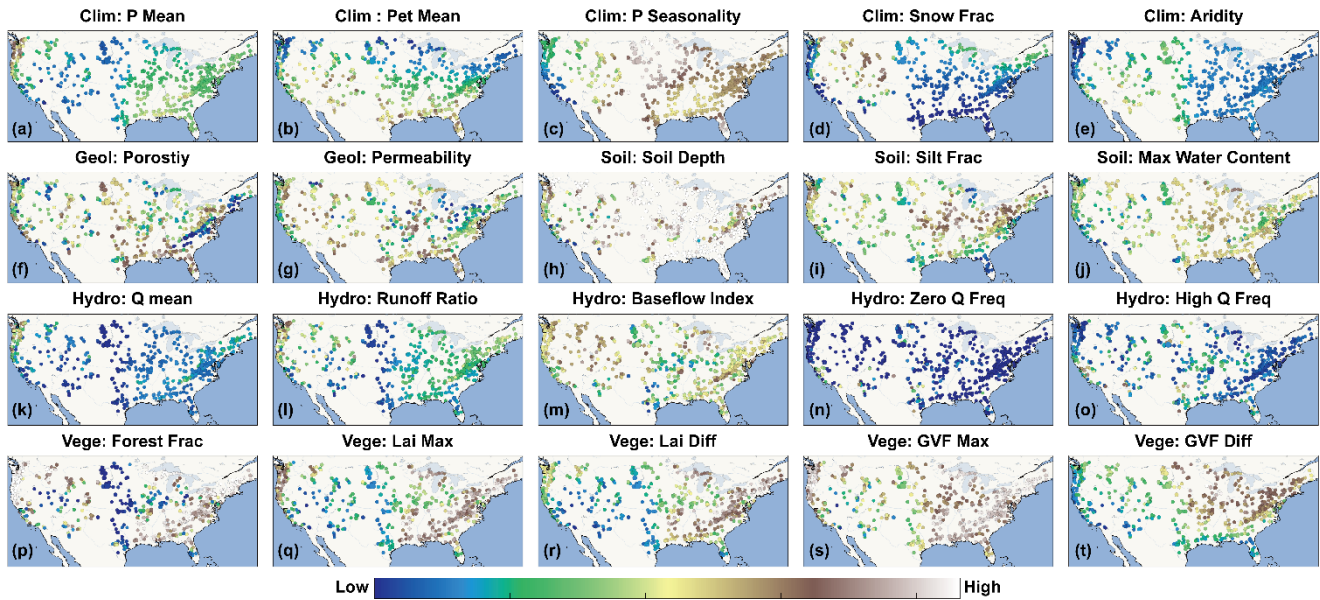
Figure S12. Spatial patterns of selected basin characteristics.