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Runoff component quantification and future streamflow projection in a large mountainous basin based on a multidata-constrained cryospheric–hydrological model

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1 Supplementary Tables and Figures

2 **Table S1** Calibrated parameters of the THREW model in this study.

No.	Symbol	Unit	Description	Range
1	kv	–	Fraction of potential transpiration rate over potential evaporation	0~0.8
2	nt	–	Manning roughness coefficient for hillslope	0~0.2
3	GaIFL	–	Spatial heterogeneous coefficient of infiltration capacity	0~0.7
4	GaEFL	–	Spatial heterogeneous coefficient of exfiltration capacity	0~0.7
5	GaETL	–	Spatial heterogeneous coefficient of evapotranspiration capacity	0~0.7
6	WM	m	Tension water storage capacity	0~2
7	B	–	Shape coefficient for calculating the saturation excess streamflow area	0~1
8	Gatr	–	Coefficient representing spatial heterogeneity of exchange term between t-zone and r-zone	0~10
9	KKA	–	Coefficient to calculate subsurface runoff in $R_g = KKD \cdot S \cdot K_S^S (\frac{y^S}{Z})^{KKA}$, where S is the topographic slope, K_S^S is the saturated hydraulic conductivity, y^S is the depth of saturated groundwater, Z is the total soil depth	0~6
10	KKD	–	See description for *KKA*	0~0.5
11	C_1	–	Coefficient to calculate the runoff concentration process using Muskingum method: $O_2 = C_1 \cdot I_1 + C_2 \cdot I_2 + C_3 \cdot O_1 + C_4 \cdot Q_{lat}$, where I_1 and O_1 is the inflow and outflow at prior step, I_2 and O_2 is the inflow and outflow at current step, Q_{lat} is lateral flow of the river channel, $C_3 = 1 - C_1 - C_2$,$C_4 = C_1 + C_2$	0~1
12	C_2	–	See description for C_1	0~1
13	LL	–	cover area in $SCA = A \cdot (\frac{SWE}{WMAX})^{LL}$	0~1
14	T_0	℃	Temperature threshold above which snow and glacier melt	–5~5
15	T_1	℃	Temperature threshold for separating rainfall and snowfall	–5~5
16	DDF_s	mm ℃$^{-1}$ day^{-1}	Degree day factor for snowmelt	0~10
17	DDF_g	mm ℃$^{-1}$ day^{-1}	Degree day factor for glacier melt	0~10
18	SHmax	–	Threshold for snow sublimation ratio	0~1
19	SHsd	mm	Reference depth of snow sublimation	1.1~20

3 **Table S2** The optimal value of the THREW model parameters by various calibration variants,

No.	Parameter	D	DG	DS	DSG	ALL			
		Whole basin				Nuxia	Yangcun	Nugesha	Lazi
1	kv	0.634	0.568	0.653	0.228	0.699	0.748	0.767	0.492
2	nt	0.072	0.014	0.031	0.050	0.076	0.014	0.198	0.043
3	GaIFL	0.169	0.174	0.138	0.328	0.618	0.288	0.311	0.005
4	GaEFL	0.402	0.483	0.391	0.537	0.438	0.396	0.115	0.594
5	GaETL	0.272	0.206	0.116	0.050	0.543	0.449	0.023	0.559
6	WM	1.458	0.669	1.842	0.656	1.118	0.804	1.749	0.706
7	B	0.866	0.510	0.351	0.726	0.284	0.535	0.466	0.956
8	Gatr	3.120	2.566	4.213	2.536	5.649	4.007	7.280	8.136
9	KKA	2.167	5.523	3.070	4.966	5.734	5.282	5.916	5.200

10	KKD	0.269	0.249	0.122	0.180	0.307	0.137	0.463	0.368
11	C_1	0.006	0.550	0.121	0.032	0.149	0.127	0.238	0.017
12	C_2	0.784	0.448	0.664	0.833	0.777	0.728	0.463	0.230
13	LL	0.796	0.467	0.724	0.870	0.821	0.756	0.666	0.555
14	T_0	–2.337	–2.745	–4.856	–3.142	–3.451	–4.850	–4.889	–4.659
15	T_1	2.240	2.267	–0.144	0.384	–2.192	1.693	–2.672	4.527
16	DDF_s	4.188	7.725	7.901	8.383	4.799	8.760	8.440	3.903
17	DDF_g	5.875	4.515	6.458	3.971	2.708	2.614	4.259	3.101
18	SHmax	0.332	0.527	0.796	0.797	0.797	0.799	0.786	0.799
19	SHsd	9.991	11.913	1.224	1.104	1.186	1.366	1.126	1.147

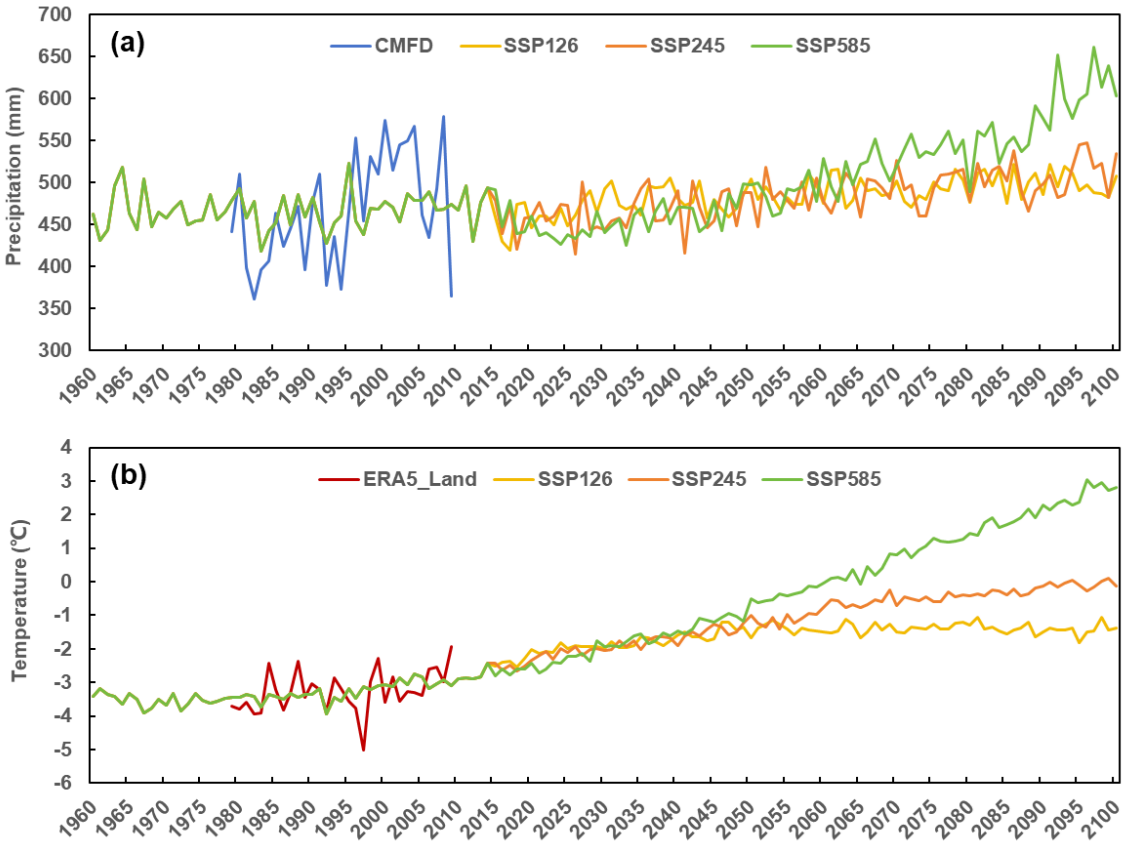

Figure S1 Average annual precipitation (a) and temperature (b) of 10 bias-corrected CMIP6 GCMs during 1960–2100 in the YTR basin.

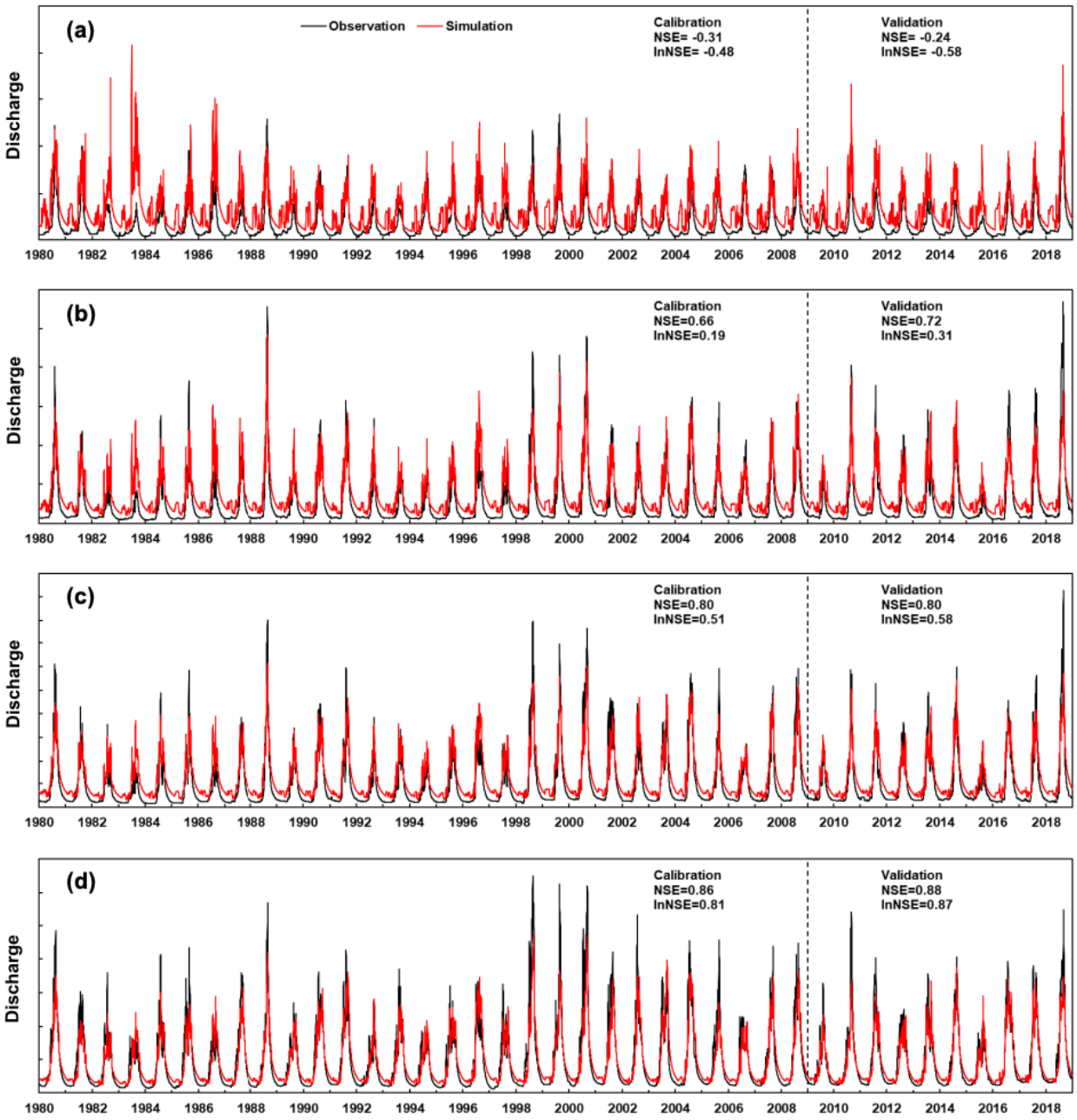

Figure S2 Annual discharge processes of observation and simulation at four stations in the YTR basin during 1980–2018 by calibration variant "DSG". (a)–(d) for Lazi, Nugesha, Yangcun, Nuxia station, respectively.

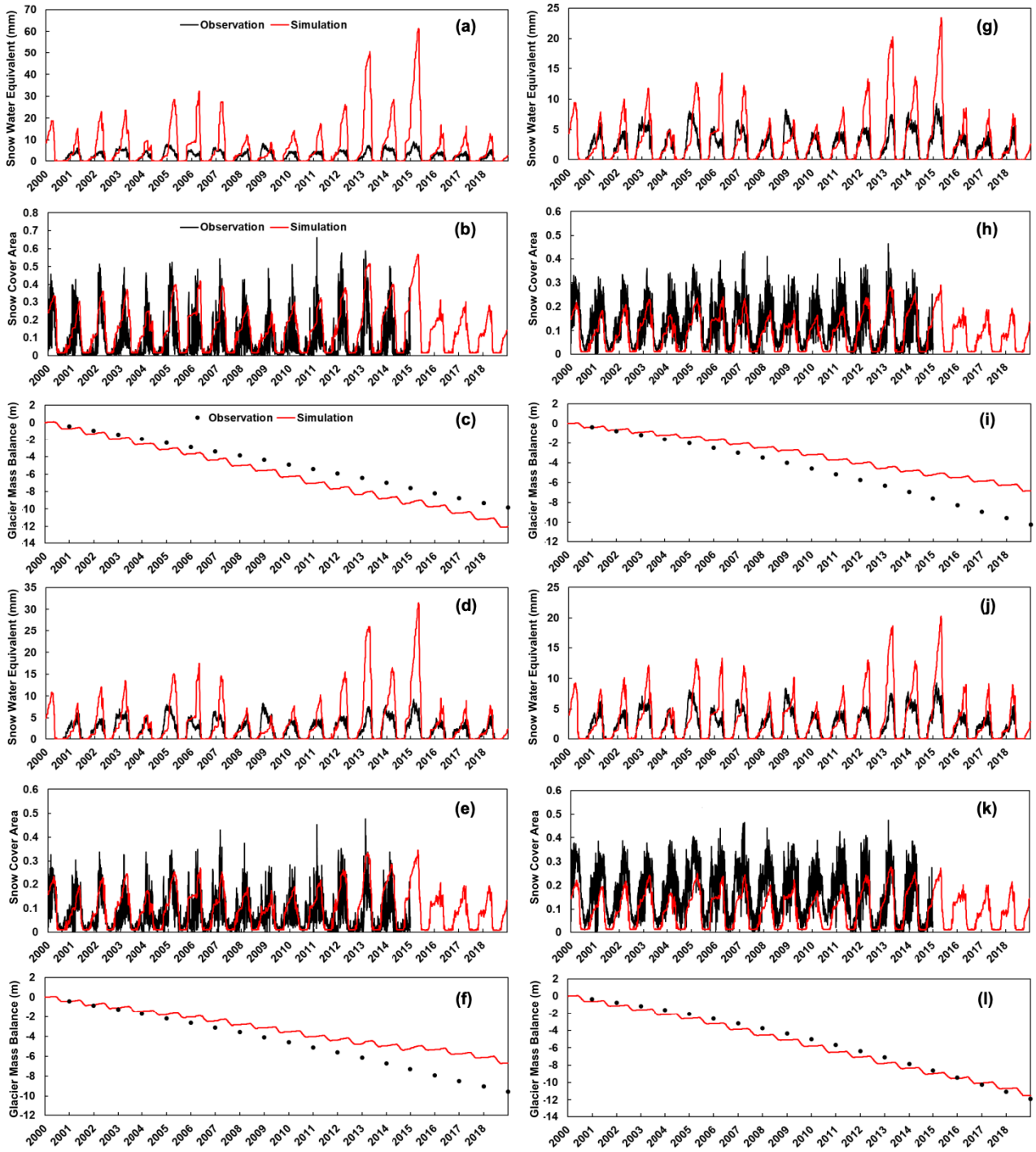

Figure S3 Annual processes of SWE, SCA and GMB of observation and simulation in various regions of the YTR basin during 2000–2018 by calibration variant "DSG". (a–c), (d–f), (g–i) and (j–l) for the region to Lazi, Nugesha, Yangcun, Nuxia station, respectively.