# 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 |

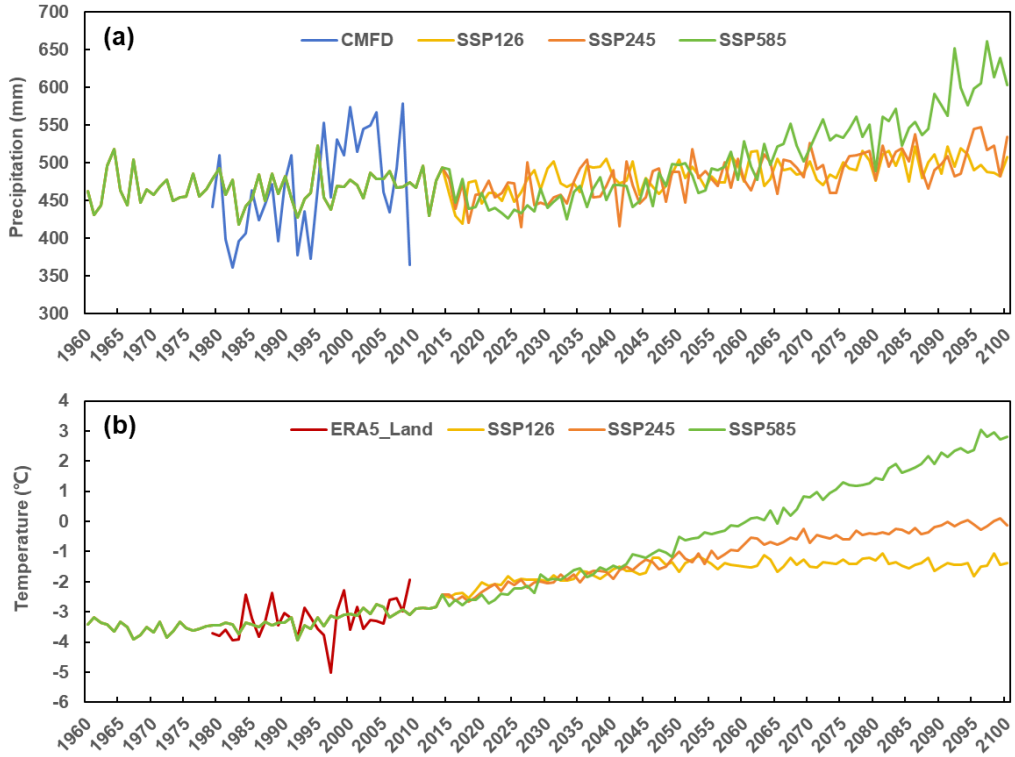


**Figure S1** Average annual precipitation (a) and temperature (b) of 10 bias-corrected CMIP6 GCMs during 1960–2100 in the YTR basin.