Supplementary

1. Temporal Variations of Precipitation and Surface Air Temperature

The annual growing season precipitation and surface air temperature from GLDAS NOAH model were analyzed based on the linear regression model. Results showed that precipitation was decreasing with the rate of 3 mm/year, while surface air temperature was increasing with the rate of 0.03 °C/year. This indicated that the YZR basin experienced a warmer and drier process since the new millennium.

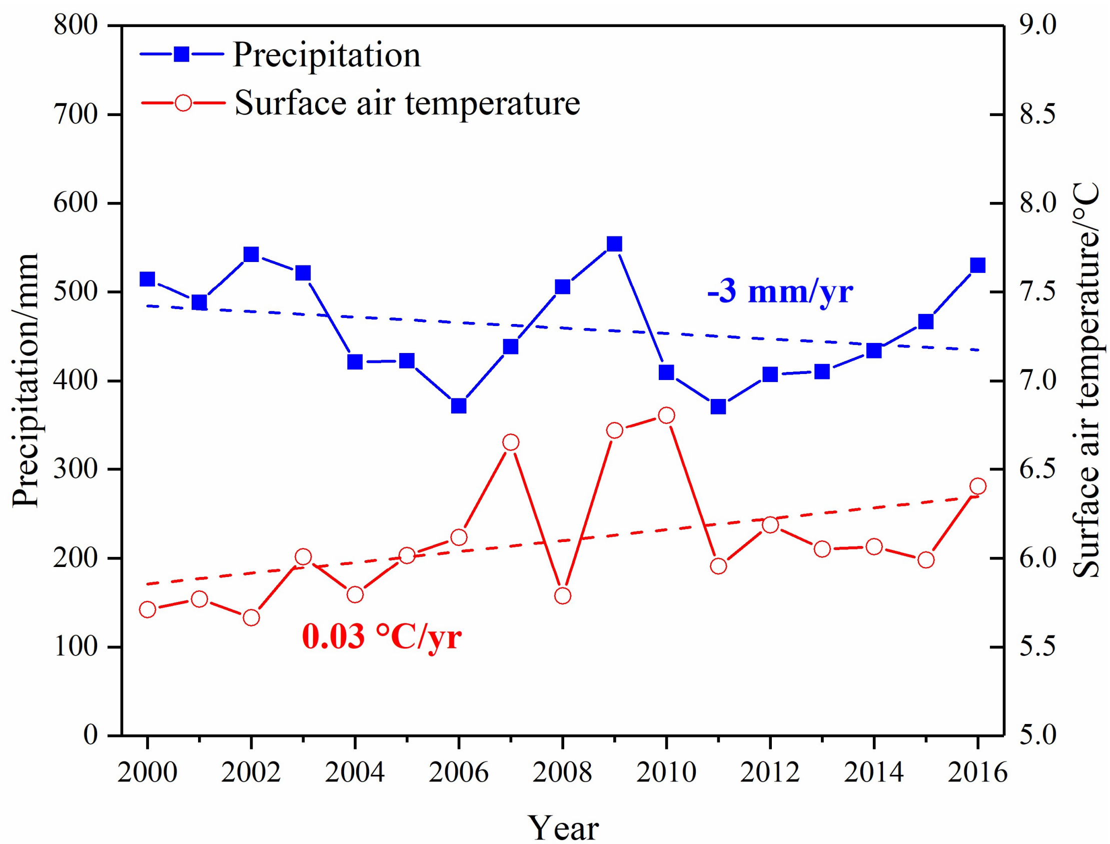


Figure S1. Temporal variations of the annual precipitation and surface air temperature during the growing season in the YZR basin since 2000.

2. Performance Evaluation of the GLDAS NOAH Data

At the river basin scale, GLDAS NOAH monthly precipitation and surface air temperature data both manifested the similar cyclical fluctuating pattern as that for the observed data from 2000 to 2016 (Figure S2). The *NSE*, *MB*, and *RMSE* between the GLDAS NOAH and in situ monthly precipitation during the study period were 0.309, 25.892 mm and 40.535 mm, respectively. *NSE*, *MB*, and *RMSE* between GLDAS NOAH and in situ monthly surface air temperature were 0.663, −3.05 ℃ and 3.797 ℃, respectively. Correlation analysis of the GLDAS NOAH and in situ data (Figure S3) demonstrated that GLDAS NOAH monthly precipitation and surface air temperature both showed high consistency with those of the in situ measurements, and the correlation coefficient (R) were 0.949 and 0.959, respectively. The above analysis showed that GLDAS NOAH could well represent temporal characteristics of precipitation and surface air temperature in the YZR basin.

The observed monthly precipitation and surface air temperature data at four meteorological stations (Bomi, Lhasa, Damxung, and Shigatse) and the corresponding gridded data extracted from the GLDAS NOAH outputs were utilized to calculate *R*, *NSE*, *MB*, and *RMSE* respectively. The results were shown in Table S1. As for precipitation, it could be found that GLDAS NOAH data showed high consistency with in situ data of all stations (R > 0.90, NSE > 0.60), except the Bomi station, indicating that GLDAS NOAH data can well represent precipitation fluctuation and changing tendency. The GLDAS NOAH precipitation performance of Bomi station was the worst among four stations, implied by its lowest *R* and *NSE* (R = 0.688 and NSE = 0.240) as well as its highest *RMSE* ($RMSE$ = 50.655 mm). This can be partly attributed to the dramatic topographic variations around the Bomi station ranging from 3100 m to 5000 m, whereas the elevation of the gauging station was 1300 m, which may insufficiently represent the regional precipitation within the GLADS NOAH grid area of approximately 625 km^2 (0.25° × 0.25°). Regarding the performance of surface air temperature, GLDAS NOAH data showed a higher agreement with in situ data compared with that of precipitation, reflecting in the higher consistency (R > 0.940 and NSE > 0.800) and lower bias ($|MB|$ < 1.050 ℃, $RMSE$ <2.800 ℃) except Damxung station. Though the *NSE* of Damxung station (NSE = 0.629) was the lowest, it still implied rather qualified simulation.

The above analysis from river basin scale to in-site scale both showed that precipitation and surface air temperature from GLDAS NOAH dataset exhibited reasonable applicability in the YZR basin by capturing relatively well variation patterns, although there was the overestimation of precipitation and underestimation of temperature to some extent. The following section in discussion will show the reasons in detail.

The performance of GLDAS NOAH surface air temperature is overall better than that of precipitation at both river basin scale and in situ scale. It can be partly attributed to the relative smoother spatial distribution and less spatial discrepancy of surface air temperature, which can make surface air temperature more representative. In addition, the performance of Bomi station is the worst in four selected stations representing different sub-areas in the YZR basin. Bomi station is located in the typical precipitation transition zone and is characterized by rather complicated terrain, with many lakes, mountains, and glaciers, which may amplify uncertainties when using point in situ data from the gauging station to examine regional averaged simulation results within the grid. Last but not least, although the GLDAS NOAH overestimates and underestimates the precipitation and temperature respectively, such inconsistency is not the key issue in this study because of the following two reasons. First, the observed data were at the point scale, while GLDAS NOAH data represented the average performance at the pixel scale, approximately an area of 25 km × 25 km. With the high divergence of underlying factors over the YZR basin, it is rather hard for the scarce observed data to represent the pixel average features. Second, this study focused on spatio-temporal variation trends rather than absolute magnitudes. That is, the systematic overestimation or underestimation could be reasonably eliminated on a tendency or relationship analysis if the variation patterns of the GLDAS NOAH data fitted well with those of the in situ data.

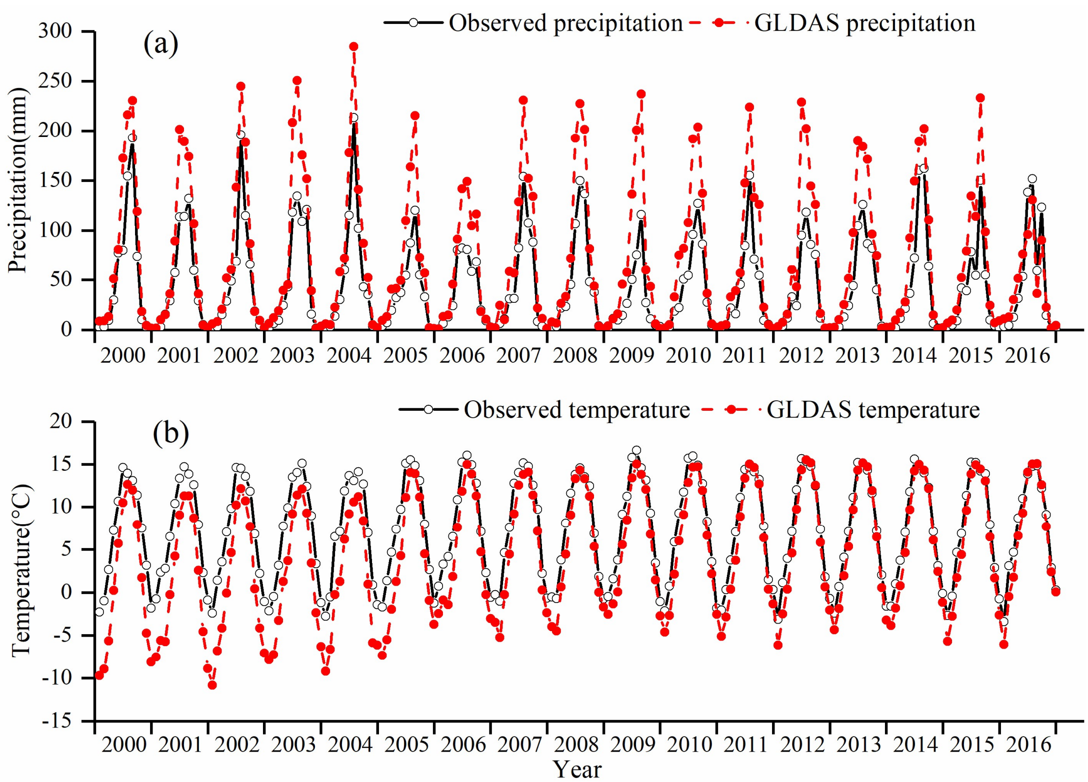
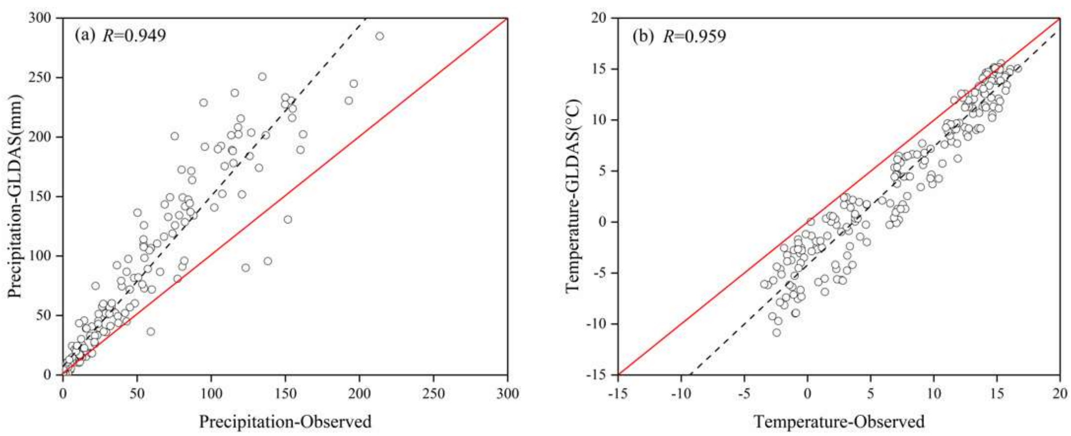


Figure S2. GLDAS NOAH and observed precipitation (**a**) and air temperature (**b**) variations.



(**a**) (**b**)

Figure S3. The correlation coefficient between GLDAS NOAH and in situ precipitation (**a**) and surface air temperature (**b**).

Table S1. Statistical indicators of precipitation (Pre) and surface air temperature (Tem) between GLDAS NOAH and in situ data.

Station	***R***		***NSE***		***MB***		***RMSE***	
	Pre	**Tem**	**Pre**	**Tem**	**Pre**	**Tem**	**Pre**	**Tem**
Bomi	0.688	0.960	0.240	0.818	5.807	1.041	50.655	2.466
Lhasa	0.908	0.958	0.580	0.801	17.899	1.024	36.878	2.707
Damxung	0.917	0.969	0.726	0.629	14.223	-3.612	26.531	4.170
Shigtase	0.903	0.947	0.601	0.931	18.253	-0.129	36.462	2.667