Dear editors and reviewers:

On behalf of my co-authors, thank you very much for your attention to our paper "Regional difference in runoff regimes and changes in the Yarlung Zangbo river basin". My co-authors and I think that all the comments are valuable and very helpful for us to improve the manuscript. We have carefully revised the manuscript according to the reviewers' comments.

We hope this manuscript will satisfy the requirement of the Hydrology and Earth System Sciences.

Best regards

He Sun

REVIEWER COMMENTS:

Reviewer #1: This paper offers an hydrological modeling of the Yarlung Zangbo River (also named upper Brahmaputra), and five sub-basins, over a long period of time, by using the VIC- Glacier model forced by the ERA5 reanalysis data.

This work is a good contribution to the knowledge of hydro-systems in the Tibetan Plateau, in particular regarding the question of partitioning the rainfall and glacial melt contributions.

The scientific approach is good, with a rigorus description of input data and results. Sources of uncertainties are also described in the results section, which is good.

Number and quality of tables and figure is good, despite the accuray of legends needs to be improved.

Scientific significance: Fair

Scientific quality: Good

Presentation quality: Fair

Reply:

Thanks for the comments. At the same time, we have carefully addressed the reviewer's comments point-by-point in the revision.

Specific comments:

My main remark stands on the description of the calibration process, and in particular the time periods. Degree-Day factor (DDF) and 6 parameters of the VIC model are calibrated. Please provide more information and syntetic explaination of the process. What are the intial ranges of tested parameters? What are the method/tool employed for the optimization process? Please add a table with this info.

Reply:

Thanks for the comments. We have provided more information about the calibration and validation processes, and a Table is also added in the revised version.

"Two categories of model parameters need to be calibrated for the VIC-Glacier model: (1) the degree day factor (DDF) related to glacier runoff simulation; and (2) the parameters of the VIC model related to runoff simulation in non-glacierized regions, mostly including the depth of the first and second soil layers (D1 and D2), the infiltration shape parameter (B_inf), and three base flow parameters, including the maximum velocity of baseflow (Dsmax), fraction of Dsmax where non-linear baseflow begins (Ds), and fraction of maximum soil moisture where non-linear baseflow occurs (Ws).

The VIC-Glacier hydrological model is calibrated by a systematic two-step approach. Observed streamflow, observed glacier mass balance, satellite-based glacier area and snow cover fraction estimates are applied to calibrate and validate the model in this study. The Nash-Sutcliffe efficiency (NSE), relative bias (RB, %), and correlation coefficient (CC), are applied to assess the performance of the hydrological model. The trial-and-error method is used for the optimization process in order to achieve the least bias between simulations and observations against the corresponding criteria.

First, initial values of DDF parameters (6.5–11.0 $mm°C^{-1}$ day^{-1}) in the glacier model related to glacier and snowmelt are adopted from Sun and Su (2020). The glacier model is calibrated to match the glacier area observation from RGI V6 for 2000s−2010s, and validated by observed mass balance data from Gurenhekou and Parlung No.94 glacier

sites. Based on the good performance of glacier area simulation (with RB of mostly < 7%), the final DDF are adjusted across six sub-basins (Table 1).

Second, the VIC-related model parameters (mostly B_inf and D2) are calibrated and validated with streamflow observations at eight hydrological stations across the six sub-basins. The B_inf which defines the shape of the variable infiltration capacity curve has a common range of 0–0.4 (Liang et al., 1996; Shi et al., 2008). The D2 mainly determines the moisture storage capacity in the VIC model, which has a range of 0.5–1.0 (Liang et al., 1996; Shi et al., 2008). The final values of the B_inf and D2 are usually calibrated at basin scales to match observed streamflow. The VIC-Glacier model captures well the magnitudes and patterns of observed runoff at daily, monthly, and seasonal scales, with NSEs of 0.83 to 0.96 and RBs of less than 5.0% for the calibration period of 1971–2000 and NSEs of 0.78 to 0.92 and RBs of -8% to 2% for the validation period of 2001–2015 across the sub-basins. After the careful calibration and validation, in this study, the final values of D1, D2 and B_inf for each grid cell are set to 0.1 m, 0.8–1.5.0 m, and 0.2 across six sub-basins (Table 1), respectively. The three base flow parameters (Dsmax, Ds, Ws) and the first layer depth (D1) is adopted from Sun and Su (2020) without further calibration."

Table 1. Characteristics of the VIC-Glacier model parameters.

		LZ	LZ-YC	RKZ	LS	YC-NX	NX-BXK
DDF ($mm°C^{-1}$ day^{-1})	Initial range	6.5–11.0	6.5–11.0	6.5–11.0	6.5–11.0	6.5–11.0	6.5–11.0
	Final value	10.97	10.97	10.97	9.2	6.8	6.5
D1(m)	Initial range	0.05–0.10	0.05–0.10	0.05–0.10	0.05–0.10	0.05–0.10	0.05–0.10
	Final value	0.1	0.1	0.1	0.1	0.1	0.1
D2(m)	Initial range	0.5–1	0.5–1	0.5–1	0.5–1	0.5–1	0.5–1
	Final value	0.7	0.7	0.9	0.7	1	1
B_inf	Initial range	0–0.4	0–0.4	0–0.4	0–0.4	0–0.4	0–0.4
	Final value	0.2	0.2	0.2	0.2	0.2	0.2
Ds	Initial range	0.001–1	0.001–1	0.001–1	0.001–1	0.001–1	0.001–1
	Final value	0.3	0.3	0.3	0.3	0.3	0.3
Ws	Initial range	0.1–1	0.1–1	0.1–1	0.1–1	0.1–1	0.1–1
	Final value	0.9	0.9	0.9	0.9	0.9	0.9
Dsmax (mm/day)	Initial range	5–20	5–20	5–20	5–20	5–20	5–20
	Final value	10	10	10	10	10	10

References:

Liang, X., Lettenmaier, D. P., and Wood, E. F.: One-dimensional statistical dynamic representation of subgrid spatial variability of precipitation in the two-layer variable infiltration capacity model, J. Geophys. Res. Atmos., 101, 21403-21422, https://doi.org/10.1029/96jd01448, 1996.

Shi, X. G., Wood, A. W., and Lettenmaier, D. P. How Essential is Hydrologic Model Calibration to Seasonal Streamflow Forecasting? Journal of Hydrometeorology, 9(6), 1350–1363, https://doi.org/10.1175/2008JHM1001.1,2008.

Also, regarding the periods of time: Is the whole analysis performed over the calibration period? Is there any calibration/validation periods? Please make this clear.

Reply:

Thanks for the comments.

"To adjust the model internal stores of energy and water from the initial condition to an equilibrium state, the VIC-Glacier model is run for the years 1961–1970 as spin-up, and the years of 1971–2020 for simulation in this study. In addition, 1971–2000 is selected as the calibration period and 2001–2015 the validation period for the VIC-Glacier model based on the observed monthly streamflow for 1971–2015. The VIC-Glacier model captures well the magnitudes and patterns of observed runoff at daily, monthly, and seasonal scales, with NSEs of 0.83 to 0.96 and RBs of less than 5.0% for the calibration period of 1971–2000 and NSEs of 0.78 to 0.92 and RBs of -8% to 2% for the validation period of 2001–2015 across the sub-basins (Figure 1)." These have been clearly indicated in the revision (lines 213–248).

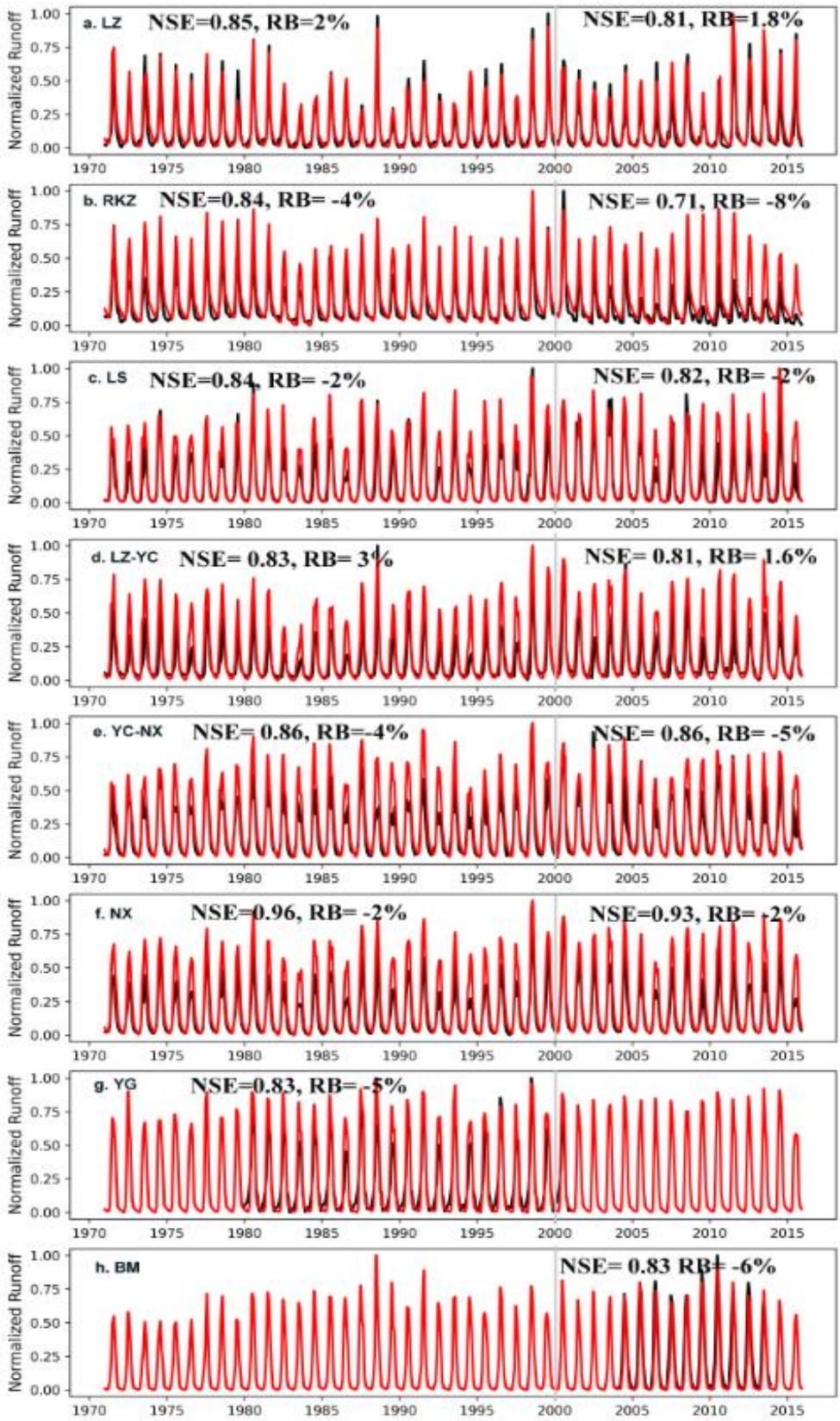

Figure 1. Monthly time series of observed and simulated runoff at eight hydrological stations in sub-basins of the YZ for 1971–2015 (1981–2000 for YG and 2004–2013 for BM).

In table 2: several period of time are quoted. What are they used for? Glaciar coverage and observed runoff are not availaible over the same period, so which period is used for the calibration process? A real clarification of this is needed.

Reply:

Sorry, we may not clear for this point in the submission version.

"In this study, we simulated streamflow in the YZ basin for 1971–2020 by the VIC-Glacier model. The VIC-Glacier hydrological model is calibrated and validated by observed streamflow, observed glacier mass balance, satellite-based glacier area and snow cover fraction estimates.

First, glacier coverage from the first Glacier Inventory of China for 1970s−1990s is the input for glacier model, and the simulated glacier area and volume are updated every year for 1971–2020 in the model by the volume-area scaling approach. Then, the glacier model is calibrated to match the glacier area observation from RGI V6 for 2000s−2010s, and is validated by observed mass balance data from Gurenhekou and Parlung No.94 glacier sites for the overlap period between observations and simulations during 1971–2020.

Second, the VIC-related model is calibrated by observed streamflow in the calibration period (1971–2000), and is validated by observed streamflow in the validation period (2001–2015) and the Moderate Resolution Imaging Spectroradiometer (MODIS) snow cover fraction estimates for the overlap period."

We have made these points clear in the Section 3.2 "Model Calibration and Validation" in the revised text.

Technical corrections:

l68: 0.3-0.4°C: over wich period?

Reply:

We have replaced it by "Like elsewhere on TP, a rapid ongoing temperature rise (0.3–0.4°C per decade) since the mid-1960s may influence runoff processes and water resources availability in the YZ basin"

l83: at a rate of 48.2m yr−1: over which period?

Reply:

The glacier length has decreased at a rate of 48.2m yr−1 during the 1970s–2000s.

l106: which may be due to

Reply:

We have replaced it by "which may be due to variations in forcing inputs for hydrological model simulations"

l150: annual precipitation increases from upstream (283 mm) to downstream (1465 mm): what do you mean?

Reply:

It is the spatial pattern of mean annual precipitation in the YZ basin. "Mean annual precipitation increases from upstream (283 mm) to downstream YZ basin (1465 mm)."

l155 snow cover fraction (SCF) = annual mean or winter maximum coverage?

Reply:

We have replaced it by "The mean annual snow cover fraction (SCF) ranges from 7%

(RKZ) to 32% (NX-BXK), with an average of 19% in the YZ basin."

l186 (eq 1): give the reference/source for this equation

Reply:

We have added the reference.

Zhang, L., Su, F., Yang, D., Hao, Z., and Tong, K.: Discharge regime and simulation for the upstream of major rivers over Tibetan Plateau, J. Geophys. Res. Atmos., 118, 8500-8518, https://doi.org/10.1002/jgrd.50665, 2013.

l211: please give calibration period and validation period

Reply:

"To adjust the model internal stores of energy and water from the initial condition to an equilibrium state, the VIC-Glacier model is run for the years 1961–1970 as spin-up, and the years of 1971–2020 for simulation in this study. In addition, 1971–2000 is selected as the calibration period and 2001–2015 the validation period for the VIC-Glacier model based on the observed monthly streamflow for 1971–2015."

l231: what is figure S2?

Reply:

Figure S2 is in the supporting information. "Figure S2. Monthly time series of observed and simulated runoff at eight hydrological stations in sub-basins of the YZ for 1971–2015 (1981–2000 for YG and 2004–2013 for BM)."

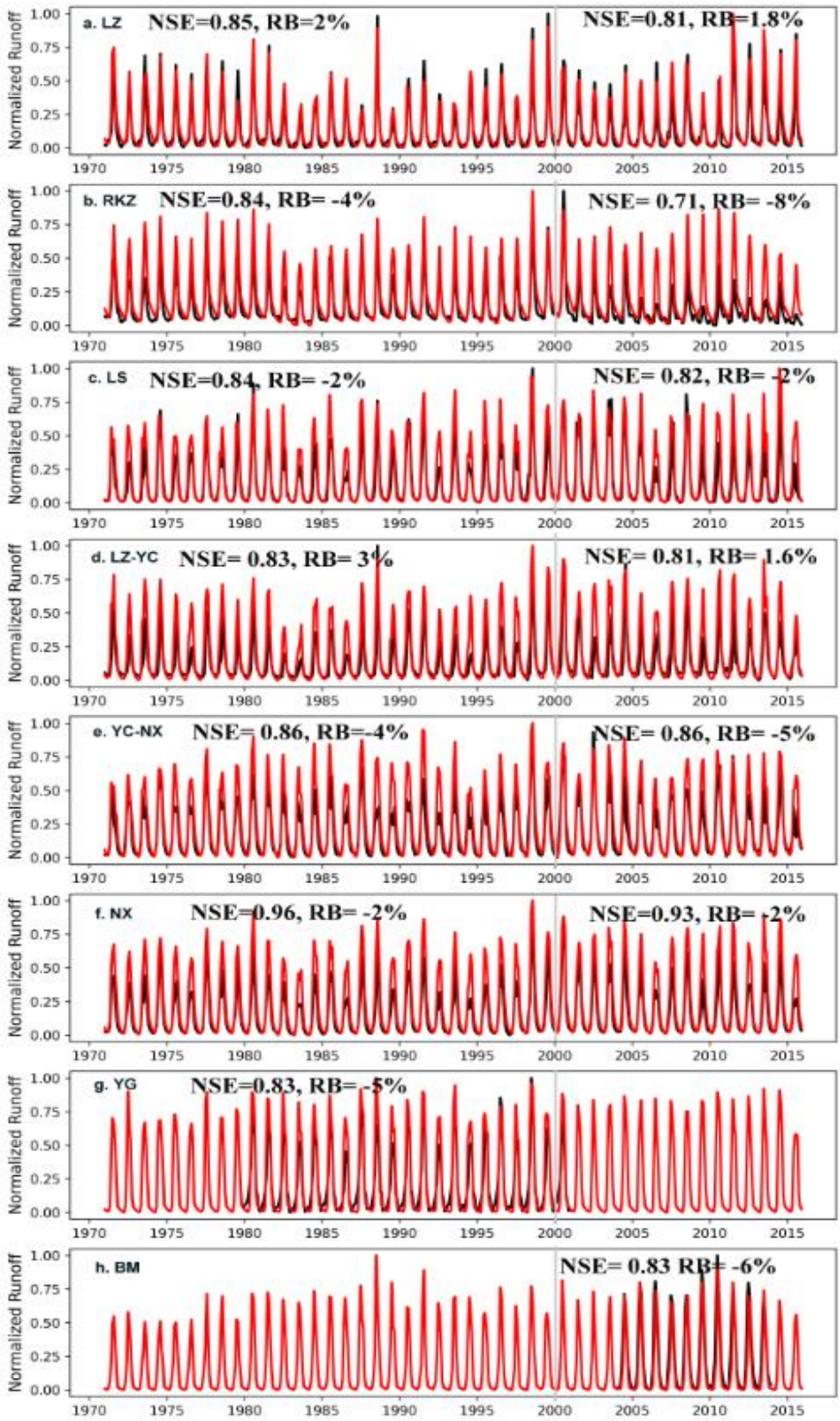

Figure S2. Monthly time series of observed and simulated runoff at eight hydrological stations in sub-basins of the YZ for 1971–2015 (1981–2000 for YG and 2004–2013 for BM).

l244: Snow cover is considered on average over the basin?

Reply:

Yes. It is considered on average across the sub-basins.

l452: Zhang et al 2013 applyed the same model?

Reply:

Yes. Zhang et al. (2013) established the VIC-Glacier modeling framework over the entire TP and evaluated the model performance over the source regions of the Yellow (UYE), Yangtze (UYA), Mekong (UM), Salween (US), Brahmaputra (UB), and Indus (UI) Rivers.

Figure 2: please quote data source in the legend

Reply:

Figure 2. Annual time series of observed and simulated glacier mass balance at (a) Gurenhekou for 2005–2009 and (b) Parlung No.94 for 2006–2018 (http://www.tpdc.ac.cn), and (c) mean annual glacier coverage (%) from the RGI V6.0 during 2000−2010 from the VIC-Glacier model simulation and satellite-based observations over the entire YZ basin and its sub-basins.

”

Figure 3: 1971-1980 is the whole calibration period of the model?

Reply:

The model is calibrated by observed monthly streamflow. 1971–2000 is selected as the calibration period and 2001–2015 the validation period for the VIC-Glacier model based on the observed monthly streamflow for 1971–2015. In addition, we also

compare the model performance in daily simulation for a short period (1971–1980) in the figure 3.

Figure 5: 'The asterisk indicates 95% significance confidence level.': not clear. why is there a confidence interval for correlation coeficient? Please clarify

Reply:

Sorry, we may not clear for this point. “The asterisk indicates 95% significance confidence level ($p<0.05$)” is the significance test for correlation coefficient.

Figure 6: please quote data source in the legend. please clarify '95% significance confidence level'

Reply:

Figure 6. Monthly time series of snow cover fraction (%) from the VIC-Glacier model simulation and satellite-based MODIS observations over the entire YZ basin and its four sub-basins for 2001–2019. The asterisk indicates 95% significance confidence level ($p<0.05$).

table 1: please give reference/product for the precipitation and temperature data and for DFF, SCA and SCF values. Are they results from the calibration process?

Reply:

“The precipitation and temperature data are from Sun et al., 2022. The value DDF is resulted from the calibration process. The snow cover area and snow cover fraction data are from the MODIS 10CM, https://nsidc.org/data.” We have made it clear in the Table 1.