Comment 1:

The work is a good, well performed, exercise of modeling. After the model calibration, the authors did some scenarios simulations to assess the effects of temperature increase and precipitation change. This should be the purpose when modeling climate changes effects.

Response:

Thank you very much for your appreciation on our work. We will revise the paper thoroughly according to your comments.

Comment 2:

Correctly the authors listed also the limitations of the work (chapter 4.3). At L572-577 they state that the simulation of climatic change was at least too abrupt. By sure when arriving at +5° the glaciers will not be the same than now. They already are reduced since the simulation period (2015). But furthermore, I would remark that the temperature increase due to the climate change is far from being linear. We currently measure mainly longer warm periods (sometimes with higher temperature maximums) and shorter cold periods, and this leads to an increased mean temperature. Simulating a linear increase is of course easier than introduce a climate (stochastic?) model, but the effects on hydrology are surely different. Remarkably on ice or snow melt, but also, for instance, on evapotranspiration estimates. A second deep source of uncertainties is due to lack of data over such a large basin. "The CMFD was made through fusion of ground-based observations with several gridded datasets from remote sensing and reanalysis" (He, J., Yang, K., Tang, W. et al. The first high-resolution meteorological forcing dataset for land process studies over China. Sci Data 7, 25 (2020). https://doi.org/10.1038/s41597-020-0369-y). The CMFD, like all large-scale datasets, is the product itself of a model that incorporates from sparse ground data (about 735 CMA stations over 9.5x106km^2) and remote sensing data combined by some algorithms and interpolated. As well known, eventually, the uncertainties of a cascade of models become rapidly great.

In my opinion these limitations severely reduce the usefulness of the work.

Response:

Many thanks for pointing out the major limitations of our study. We acknowledge that the current climate perturbation method is rather simple, but we believe that adopting GCM to analyze runoff change would also lead to significant uncertainties. For instance, according to Cui et al. (2023), the projected change in precipitation for the warming of 1.5℃ had a very large uncertainty, ranging from -13.68% to 7.20%, based on 22 CMIP6 models. The climate perturbation function has the special function on investigating the roles of particular precipitation or temperature perturbations in shaping the responses of specific hydrological processes, and was widely adopted in previous studies (e.g., He et al., 2021; Su et al., 2023; Rasouli et al., 2014). So we believe that our analysis is helpful for understanding the separate effect of changing temperature and precipitation on runoff, and the spatial pattern of runoff change.

We acknowledge that the data scarcity problem leads to large uncertainty in our results. Actually, as you said, all the existing datasets have large uncertainty on the Tibetan Plateau, because of the sparse ground data. We have tried to adopt multiple datasets to constrain the model and validate the simulations on multiple objectives. However, given the uncertainties exist in all the dataset, it is indeed hard to say whether this procedure could improve confidence of the results.

We will address this issue in the revised manuscript.

Comment 3:

L55 – the melting processes of frozen water are determined by the energy budget.

Response:

Many thanks for your correction. We will rephrase this sentence in the revised paper.

Comment 4:

L75 - I presume that you mean that the contribution of melt ranges from 0.86% to 40.59%, or it was estimated as 0.86% ± 40.59%. The use of a minus sign is not very clear due to the very wide range of values. Also at L45 and L77.

Response:

Many thanks for your careful reading. What we mean by the minus sign is the range, which is indeed misleading. We will change it to "~" in the revised paper.

Comment 5:

L140 – the drainage area is 2 x10^5 km²? The measure unity misses.

Response:

Many thanks for your careful reading. We will add the measurement unit in the revised paper.

Comment 6:

L165 – 1.875° at 30°N is a rectangle of about 180x208 km, 3.7x104 km². This means just a little more than five full pixels on a 2x10^5 km² basin.

Response:

Many thanks for your comment. We adopted the output of an isotope enabled General Circulation Model (iGCM) to drive the model, the spatial resolution of which is indeed coarse. However, our previous work (Nan et al., 2022) indicated that the bias of iGCM on the TP is highly related to elevation, and we have conducted bias correction according to the elevation of each REW. Although the bias correction procedure was still simple, it could provide a rather reasonable isotope input data,

Comment 7:

L180 – eight subzones. If I understand correctly the subzones should be 12 (6 surface x 2 subsurface)

Response:

We are sorry for not describing the model clearly. The six subzones in the surface layer are parallel to those in the subsurface layer. A subzone refers to either a zone in the surface layer or a zone in the subsurface layer, rather than the combination of two subzones in different layers. Consequently, there are eight subzones in each REW.

Comment 8:

L188 – does the model consider even the melt caused by (liquid) rainfall? It could be rather important mostly (but not only) in the changing rainfall scenarios.

Response:

Many thanks for your comment. We are sorry that we don't quite understand what you mean by "melt caused by liquid rainfall". If you mean the rainfall occurring in glacier covered areas, it was considered in the model but was regarded as rainfall runoff rather than meltwater.

Comment 9:

Table 3 – I presume that DDFG is the degree-day factor for ICE (glacier) melt.

Response:

Thanks for your correction.

Comment 10:

Table 3 – -4.28C is a rather cold temperature for melting threshold. Of course, this happens because of the daily average, but it is better to explain it.

Response:

Thanks for your comment. We will explain it in the revised manuscript.

Comment 11:

L245 and following. This could be the main problem of the work. The temperature increase due to the climate change is far from being linear. See my general comments on modeling limitations.

Response:

Many thanks for your pointing this out. We need to clarify that although the temperature scenarios were set linearly, we did not assume the process of temperature changing. We only analyze how runoff would change if the temperature is X°C higher than the current condition. The influence of gradual process of climate change on runoff has not been analyzed yet, which was indeed a limitation of this work.

Comment 12:

L258 - Did you combine also temperature and precipitation perturbations in a single simulation?

Response:

Thanks for your question. We did not combine temperature and precipitation perturbations in a single simulation, to focus on the separate effect of temperature and precipitation on runoff change.

Comment 13:

L269 – Figure 2. Streamflow discharge appears well simulated, NSE = 0.82 is more than satisfactory in such a long period. SCA is more confused, but still well acceptable, as the isotopes simulation. The average glacier mass balance comparison with observed values (L280) has no meaning. Even a linear mass loss could simulate those 11 points.

Response:

Many thanks for your comment. Although the 11 measurements of glacier mass balance are rather easy to simulate, the glacier calibration mainly aims to provide basic constraints for the amount of glacier meltwater. For instance, if the simulated glacier meltwater is twice the current simulation, we can expect that the sensitivity analysis result would be totally different.

Comment 14:
L316 – decreasing rate
Response:
Thanks for your correction.

Comment 15:
L333 – it is hard to believe that evaporation is not limited by water condition. Did you ever try to compare it with potential evaporation?
Response:
Many thanks for your comment. We calculated the evaporation and found it was much lower than potential evaporation (228mm/yr compared to 889mm/yr). It is actually inaccurate to say that the evaporation is not limited by water condition. It should be expressed as "the energy limitation played a more important role than water limitation on evaporation". This is mainly because the YTR basin is a relative wet region on the TP, and was also identified as an energy-limited area by Wang et al. (2022). We will change the expression in the revised manuscript.

Comment 16:
L362 – possibly in April the fraction of runoff due to snow melt increases. But SCA is going to decrease …
Response:
Many thanks for your comment. We also attribute the runoff increase to the increasing snow melt, and we will add it in the revised manuscript.

Comment 17:
L385-386 – please control the measure unit (km^3/yr and km^3/s).
Response:
Many thanks for your correction. We made a mistake here, and the measurement unit should be km^3/yr.

Comment 18:
L388 – the glacier surface is (almost) impermeable but runoff from bédières rather quickly falls to the bottom through crevasses, moulins, wells. So, melt runoff flows mostly on the bottom of the glacier.
Response:
Many thanks for your comment. Although glacier meltwater could fall to the bottom of glaciers, very little of them infiltrates in deep groundwater storage. Consequently, we assume glacier meltwater generates runoff quickly through the surface pathway (but not necessarily through glacier surface), similar to other glacio-hydrological modeling works (e.g., He et al., 2019; Gao et al., 2017).

Comment 19:
L498 – in my experience the melt component due to (liquid) rainfall can amount up to 15% of the total melt. In the REWs with larger GAR the increase of rainfall can lead to a greater runoff, if this component is considered in the model. Fig. 9d means that over a glacierized area a

precipitation increase corresponds to a runoff decrease. Projecting the interpolation line, we can suppose that for a 35% of GAR there are no runoff changes when precipitation increases to 120%. The 35% of glacierized area literally eats the rainfall increase over the whole basin. Rather surprising!

Response:

Many thanks for your comment. If we understand correctly, "the melt component due to rainfall" refers to the rainfall occurring in the glacier covered regions, which is regarded as rainfall overland runoff in the model. The meltwater in the model only refers to water melting from solid snow/glacier. In REWs with larger GAR, the contribution of rainfall in total runoff would be small, thus the runoff increasing in response to increasing precipitation would be accordingly small.

The inference that 35% GAR eats the rainfall increase over the whole basin is indeed surprising, but the deviation from data point to the regression line in Fig. 9d is rather large for high GAR, indicating that the confidence of regression line is likely low when GAR is large. This is because there are few REW samples with large GAR based on the current spatial discretization. The runoff change in response to precipitation increase depends not only the balance among precipitation, evaporation and glacier melt, but also the spatial scale. More works are needed to better understand this, and we will address this issue in the revised manuscript.

Comment 20:

L510 – the equation is useless, the correlation is high. But on fig. 10 also the "decreasing" REWs seems to have a correlation.

Response:

Many thanks for your comment. The seeming correlation between GAR and MAP is mainly because of the relatively narrow range under the dividing line. The distribution of "decreasing" REWs is actually rather dispersive.

Comment 21:

L513-517 – for "increasing" REWs the correlation between GAR, MAP and the increasing runoff is poorly understandable by the blue color intensity. Could you find a way to represent it with a number?

Response:

Many thanks for your comment. We will add a table presenting the GAR, MAP and runoff change in the Supplementary Information.

Comment 22:

L535 – glacier meltwater increases with temperature, but glaciers are shrinking and, soon or late, this leads to a runoff maximum followed by a decrease. It has already happened to many glaciers.

Response:

Many thanks for your comment. Our model also simulated the change of glacier area, and results indicated that the glacier covered area decreased by 10% during the simulation period. However, this was not stressed in the paper, because the glacier area shrinking was not validated by measurement data. This study adopted the climate perturbation method and did not consider the gradual climate change process, thus the turning trend of glacier melt runoff was not reflected. We will address this issue in the revised manuscript.

Comment 23:

L542-543 – and for the other regions the future will be the same, moved a little further.

Response:

Many thanks for your comment. We will add this in the revised manuscript.

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