Referee 5

The authors present a study aiming at the ground thermo-hydrological changes in a plateau lake. Overall, the topic is interesting and the authors provide detailed model construction and data analysis. This study is of great significance for the water level changes and water resource utilization of plateau lakes under climate change. But, I still have some concerns before considering for acceptance. Thus, this manuscript is subject to major revision.

We are grateful to Referee 5 for the review we received and for the positive perception on the significance of the study. We present below our detailed answers to each of the discussed points.

1. There are several questions regarding the modeling process of the lake water balance:

(1)In analyzing the lake water balance, the water input is considered to include direct precipitation, land surface and subsurface runoff, and glacier runoff. Does subsurface runoff include the recharge from permafrost/frozen soil thawing?

Yes, recharge from permafrost is included. In the model, when frozen water in the ground melts, it becomes available for subsurface runoff if the liquid water content exceeds the field capacity. This is true for places with permafrost and with seasonally frozen ground. To clarify this point we added the following line to Sect. 3.2.4. (model setup and validation):

"Because the model couples thermal and hydrological fluxes, all of these changes in the soil water content can be driven by precipitation input, evaporation but also water phase change in the ground such as ice melt."

And in the model construction (Line 191), the important part of the subsurface runoff was ignored.

Our intention was to merge surface and subsurface runoff in a variable that we called $Runoff_{Land}$ but we see it leads to misinterpretation. So now, to solve this problem, we split both terms in the equation:

"$\Delta zLake = Precipitation_{Lake} + Runoff_{LandSurf} + Runoff_{LandSub} + Runoff_{Glacier} – Evaporation_{Lake}$"

Additionally, considering that the lake is located in a closed basin of surface water systems, the water output is only considered to be evaporation. However, does the lake have any water exchange with underground aquifers?

We are aware of the possibility of water flow between the lake and a surrounding aquifer. We believe that attempting to close the hydrological budget of such a catchment, that present glaciers, snowfall, rainfall permafrost, seasonally frozen ground and a lake is very challenging. Therefore, as modelers, we have to choose the processes we want to represent, based on the scientific questions we want to tackle and based on our ability to quantify these processes. For this reason, as we explained in Sect. 3.2.1. (Conceptual hydrological model for the catchment) we cannot quantify such a flow and we had no choice but to ignore it in our calculations. Yet because we know it can impact our results, we include an extensive paragraph on the topic in the discussion. To clarify this point, we modified it. It now reads:

"Additionally, our approach ignores potential water fluxes between the lake and a surrounding aquifer. This can be a possible reason for this mismatch. In the context of a decreasing lake level, an aquifer surrounding the lake can create an additional water inflow when the lake level passes below the piezometric level of the aquifer (Yechieli et al., 1995). We suggest that such an inflow could mitigate the lake level decrease and thus explain the missing water in our reconstruction (Fig. 6B). It could also explain the gradual stabilization of the lake level that our model does not reproduce. This flow is not part of our conceptual hydrological framework even though it likely exists in reality, especially since there is no permafrost near the lake (as we simulate it here), allowing for the existence of such an aquifer (Walvoord and Kurylyk, 2016). Groundwater has been identified as a potential contributor to lake level rise in other regions of the QTP (Lei et al., 2022). In the long run, lake-aquifer systems commonly follow oscillations of the net atmospheric flux of water (Precipitation – Evaporation) and of the runoff that forces its mass balance (Watras et al., 2014). During these oscillations, the lake can "pump" water from the aquifer or feed it depending on the relative difference of piezometric level between them (Almendinger, 1990; Liefert et al., 2018). Yet, this potential effect is difficult to account for and its magnitude remains unclear. Therefore, the reasons for the mismatch between observed and simulated lake levels could also be connected to other aspects of our methodology such as bias in the climatic forcing data and other shortcomings arising from the lack of field data, or hydrological processes, as developed in Sect. 5.1.1. and 5.1.2."

(2)This study focuses on the impact of ground thermal processes on hydrological processes. From the conceptual diagram in Figure 2, it can be seen that this study considers the process of glacier melting, but does not take into account the process of permafrost/frozen soil thawing, which is also sensitive to temperature.

We regret a misunderstanding here, as stated above, our model couples heat and water flows, therefore the relevant processes to account for potential hydrological impacts of thermal changes in permafrost and/or seasonally frozen ground are represented in our approach. See further details on this point below.

On the one hand, permafrost/frozen soil thawing can provide water,

Our model accounts for this effect. As stated earlier, when frozen water in the ground melts, it becomes available for subsurface runoff if the liquid water content exceeds the field capacity, regardless if this happens in permafrost or in seasonally frozen ground.

Seasonally frozen ground is fully thawed in summer, therefore its ice stock is fully depleted each year according to a seasonal pattern. In this condition, it cannot represent a long term water stock that ground warming would empty year after year to fill the lake. This is different in the case of permafrost. In a catchment with important permafrost disappearance and active layer deepening over the years, permafrost could indeed represent a long term water input to the lake. Yet, as presented in Sect. 4.2., Active Layer deepening is only observed for 44% of the warm permafrost simulations, which represents in the end only 8% of the total land area (44% of 19%, Table 1). Additionally, this AL deepening trend is rather weak (5.2.1.). Therefore, even under the assumption that the thawing permafrost layer is ice saturated, the water release from this process would be several orders of magnitude below the flows affecting the lake balance, as we quantify them in Sect. 4.1.2.

In the case of disappearing permafrost, the AL already neighbors or exceeds 2m at the beginning of the simulations in 1980 (0 to 2 m is the hydrologically active ground layer in our setup), therefore we do not derive any significant flow from this process.

And on the other hand, it can change soil permeability and the connectivity between lakes and groundwater.

Since our model couples heat and water flows and account for phase changes, it therefore provides a relevant and consistent representation of cryohydrological changes in the ground as demonstrated in Sect. 5.3.1. and Fig. 11. As such, parameters such as hydraulic conductivity, which is used to calculate the subsurface runoff, accounts for changes of the thermal regime. We here quote an example from Sect. 3.2.3. (The CryoGrid community model (version 1.0)).

"Additionally, to represent the obstruction of connected porosity by ice formation, the hydraulic conductivity is reduced by a factor dependent on the local ice content, following Dall'Amico et al. (2011)."

Regarding lake-aquifer interactions, we developed our take on this question earlier in our answer to referee's point 1.(1). Additionally, we want to point out that there is no permafrost near the lake and that large stores of liquid groundwater are unlikely in higher elevations areas of the catchment.

Thus, can the water flows between the lake and potential aquifers be ignored, especially in the context of increasing temperatures and significant melting of frozen soil? Would this portion of the error be significant?

See the answer to 1.(1).

(3)The study conducted a one-dimensional vertical simulation of water and heat processes. Is the impact of lateral water and heat transfer ignored?

Indeed, as described in Sect. 3.2.4., there are neither heat nor water fluxes between the land simulations. In this study we tackle complex questions involving numerous physical processes (surface energy fluxes, infiltration, heat conduction, phase change, soil suction…), we therefore have to make compromises regarding the processes we represent. Regarding lateral heat fluxes, we want to point out that they are most likely insignificant in the near surface, especially when compared to the vertical heat fluxes.

Additionally, because we want to capture the important spatial variability of the climate in a high mountain catchment (spanning vertically over 2400 m), we chose to work with downscaled and clustered climatic data (100 x 100 m resolution). This setup limits our ability to represent lateral water fluxes between the simulation units and we see it as a necessary compromise to carry out our approach and preserve its strengths. Indeed, a different framework with larger and interconnected response units would allow to derive these water fluxes but would not allow to map the cryological types of ground as we did it. Yet, we show that each cryological type of ground has a very specific behavior.

Therefore, we think it is important to evaluate our work in the frame of the processes we want to investigate and against what is doable today with other approaches. In this regard, we are confident that our approach is part of the state of the art and one of the most complete effort to include the variety of coupled

climatological, surface and subsurface processes characterizing the climate, hydrology and ground thermal regime of high-mountain catchments in Tibet at a small scale with a high spatial resolution (Sect. 5.3.1.). Yet we are aware of the limitations brought by the lack of water routing. To clarify this point, we rephrased the part of the Discussion (Sect. 5.1.2. Modeling strategy) tackling this point. It now reads:

"A limitation in our study is that lateral water flows between land simulation units is ignored. By giving access to the timing of water transport across the catchment, water routing would allow to investigate temporal hydrological patterns at a monthly or seasonal scale. Because we work at annual and decadal time scales, this limitation has limited consequences on our results. The main consequence is to ignore potential storage effects on the land that would delay the arrival of runoff to the lake. We suggest that it is possible that this limitation partly explains the limited match between computed and required runoff at the annual time scale (Fig. 5). Yet, our subdivision of the catchment based on the different cryological states of the ground allows us to work with hydrological units that are smaller than the catchment and thus present shorter hydrological response time to precipitation."

Additionally, all 368 simulations are independent and use the same parameterization. Considering the large range of 2400 km2, the same vertical distribution of soil condition in different elevations, mountain hillslopes - valleys, and under different land uses and vegetation cover, may introduce significant errors.

Indeed, because of the absence of specific datasets for the basin or even borehole observations, all the simulations use the same setup. To clarify this methodological choices and explain how we adapted to data scarcity, we now added the following consideration in the Discussion in Sect. 5.1.1. (Data usage within the conceptual framework and data scarcity):

"Additionally, in absence of borehole data that would allow us to anchor our parameters into observations, we rely on gridded values designed for hydrological and/or land surface modeling (Sect. 3.2.4. and Appendix A). Because these values might be less reliable than field observations, we chose to average them over the catchment to derive some more robust values."

Regarding the potential impact of vegetation, we present below a photo to show the type of land cover we found on the field that supports our approach. As we precise it in Sect. 5.1.2.:

"…since vegetation is extremely scarce in the Paiku catchment, which is largely dominated by barren lands, we suggest that this would not significantly affect our results. However, this limitation should be explored in future field and modeling studies."

Figure R5.1 Ground photo in the Paiku catchment (Credit: Fanny Brun).

We are aware that the limitations of the model approach can influence our results and we acknowledge it in the discussion, in Sect. 5.1.1.:

"Altogether, this scarcity of field observations is likely to bring significant uncertainties to our analysis. Future efforts should focus on acquiring additional data or developing validation methods based on remotely sensed observations."

2. The research topic mentioned "implications for lake level changes", so what are the specific trend and influence factors of lake water level changes? What is the reason for the transformation from rapid lake shrinkage to relative stable stage in recent years? What are the impacts on the lake level from water and heat changes? The authors could further summarize the answers to these questions to help readers more intuitively understand the impact of water and heat processes on lake water level changes.

We understand the reviewer's point and, in combination with comment number 3, we significantly modified the structure of the Discussion. Within this new structure, the Discussion now has a Sect. 5.4. called *Implication for lake level changes* that gathers our findings on the question. We reproduce it below:

" 5.4 Implications for lake level changes

At the scale of the Paiku catchment and in regard of lake level variations, the results we present highlight that:

- ***The sum of the direct precipitation in the lake, the land runoff and the glacier runoff are not enough to compensate for the lake evaporation over the study period, hence driving the observed lake level decrease.***
- ***Long-term hydrological trends in the catchment are led by trends in climate; and precipitation increase, jointly with glacier melt, provides enough water to drive a concomitant increase of runoff and evaporation.***
- ***Ground thermal changes increase the distribution of liquid vs. frozen water in the ground and the duration of seasonal thaw, correlations suggest that these modifications increase evaporation. The warming of the ground is also related to the increase of subsurface runoff towards the lake.***
- ***Ground warming and permafrost thawing promote subsurface runoff over time, contributing to an increase in the runoff/evaporation ratio of the catchment.***
- ***Over the 40 years we studied, the presence of permafrost seems to promote evaporation at the expense of runoff. Yet this trend appears to be climate-dependent and the cryological state of the ground might shift the runoff/evaporation distribution in the other direction under colder and wetter climates.***

At the scale of the QTP, these results have several implications. First, a better understanding of the recent and future lake level variations will come with a better knowledge of spatial patterns and temporal trends in precipitation. Second, climate changes are modifying the ground thermal regime of Tibetan catchments. Ground warming may lead to active layer deepening, permafrost disappearance and/or changes in the seasonal freeze/thaw cycles, affecting evaporation, runoff volumes and pathways and overall, changing the hydrological functioning of Tibetan catchments (and the waterflow provided to the lakes). Finally, the effect of permafrost on the distribution between evaporation and runoff seems to be dependent on the climate settings and the permafrost coverage of the catchment. Further studies should investigate this phenomenon and how it might contribute to explaining the contrasting lake level evolutions across the QTP."

3. The paper structure can be improved, not only just presenting simulation results, but also highlighting specific targeted questions. For example, in the discussion section, the key points of the study are not highlighted, and only the various aspects of the results including data, model, permafrost changes, ground temperature, evaporation, and runoff changes, are listed. What is the main focus of this study? How are water and heat related and how do they affect lake water level changes? I think the structure of the discussion section could be more focused.

We understand the reviewer's concern and see how the many changes we have already made to the discussion have probably weakened its structure. To correct this point and answer the reviewer's comment, we have now fully restructured the Discussion as follows:

5. Discussion

5.1. Limitation and potential of the approach

5.1.1. Data usage within the conceptual framework and data scarcity

5.1.2. Modeling strategy

5.2. Trends in the catchment and across the QTP

5.2.1. Lake hydrological budget and level variations

5.2.2. Permafrost and ground temperature trends

5.2.3. Evaporation and runoff trends

5.3. Cryo-hydrological couplings at catchment scale and implication for lake level variations

5.3.1. Interdependence of thermal and hydrological variables

5.3.2. Influence of the ground thermal regime on the distribution between runoff and evaporation

5.4. Implications for lake level changes over the QTP

Here, some detailed comments are listed:

(1)Line6: "Therefore, climate-driven modifications of the ground thermal regime may contribute to lake level variations, yet this hypothesis has been relatively overlooked until now.". Previous studies have already conducted a lot of relevant research. The most important thing is that this study did not effectively reveal how the ground thermal regime affects the lake water level. The author should further revise the manuscript.

To account for the reviewer's comment and keep the abstract short, we modified it as follows:

"Consequently, climate-induced changes in the ground thermal regime may contribute to variations in lake levels, but the validity of this hypothesis has yet to be established."

(2)Line58: "Whereas the northern and central QTP have recorded lake expansion, the southern parts of the plateau have experienced lake shrinkage". What is the cause of lake shrinkage? After all, most lakes on the Qinghai-Tibet Plateau experience water level increases, while the lake in this study experienced water level decreases. Therefore, it is worthwhile for the author to further summarize existing research findings and take their influence into account when explaining lake shrinkage in their writing.

We now added the following paragraph to the introduction :

"Shrinking lakes have received less attention in the literature than rising lakes because they are fewer. For this reason the drivers of this shrinkage are still unclear. Qiao et al. (2019) reported that recent lake shrinkage over the QTP could be driven by local precipitation decrease and/or evaporation increase (in relation to air temperature increase). Zhang et al. (2020a) suggests that the divergent trends in lake level variations across the QTP could be linked to the contrasting evolution of moisture transport between the north and south of the plateau. On longer timescales, lake shrinkage over the QTP during the Holocene seems to be related to variations in the intensity of the Asian monsoon (Chen et al., 2013). Overall, such a complex pattern of rising and shrinking lakes challenges our understanding of the hydrological changes occurring in these high Asian watersheds."

(3)Line115: " We show the interplay in the water and energy fluxes occurring between the atmosphere, the surface and the subsurface and discuss their impact on the hydrology of the catchment and their implication regarding lake level variations.". What are the factors that affect lake level changes, and how can the interaction between lakes and groundwater be considered?

This line closes the Introduction and thus aims at giving an overview of the rest of study. The lake budget and its positive and negative terms are presented in Sect. 4.1.2. and Discussed in Sect. 5.2.1., including a discussion paragraph on lake-groundwater interactions (see answer to Reviewer's point 1.(1)).

(4)Line149: "Because it is hydrologically closed, the lake mainly loses water through evaporation". The basin is hydrologically closed in surface water system does not mean that the underground is also closed. Whether there is water exchange between lakes and the underground, and whether there is seepage of lake water?

As stated above, lake-aquifer interactions are ignored by our approach. This is described in the methodology (Sect. 3.2.1.), discussed in the Discussion (Sect. 5.2.1.) and our argument to do so are described in the answer to Reviewer's point 1.(1).

(5)Line277: "see section 3.2.2". The full form (section) and abbreviation (sect.) of the same word should be consistent throughout the text.

Done. All references to a given section are now written "Sect.".

(6)Line288: "infiltration according to Richards equation only occurs in the top and bottom soil units". Does this study only consider the infiltration to the depth of 2m, and is the result reliable?

As mentioned in the response to Reviewer's point 1.(3), no observations/boreholes data are available for the catchment. Therefore, the only dataset available for modeling are large scale gridded datasets that we decide to average for the sake of simplicity and robustness. As stated in the study (Sect. 3.2.4. Model setup and validation):

"In absence of direct observation of the soil stratigraphy within the catchment, the soil column was designed to agree with field observations in the region (Yuan et al., 2020; Wang et al., 2009; Hu et al., 2020; Luo et al., 2020; Yang et al., 2014b; Wang et al., 2008), to be consistent with similar modeling approaches

across Tibet (Chen et al., 2018; Song et al., 2020) and to be consistent with input datasets (Shangguan et al., 2017, 2013)."

(7)Line431: "(Sect. 4.1.1.)". The format should be consistent: "4.1.1." or "4.1.1"

Done. All references to a given section now have a numbering finishing with a dot.

(8)Line432: " This pattern of a too strong decrease followed by an increase is consistent with the comparison between simulated and required runoff presented on Fig. 5D. ". Lake water level variation is a key focus of this study, while there are significant errors in simulating lake water levels. What is the source of these errors?

We understand that, when looking at lake levels, the difference may look significant but we believe that this take on our results exacerbates the mismatch. Indeed, when we look at it rather in terms of lake hydrological budget over the 40 years, the missing water input to the lake (from land and glaciers) that leads us to overestimate the lake decrease only corresponds to a 5% error on the total water input (Sect. 4.1.2., Fig. Fig. 6A, red line). In the framework of a study that attempts to couple glacier mass change, land thermo-hydrological changes and lake level changes altogether, with very limited available data, we find the agreement acceptable.

Following our approach, this mismatch can arise from bias (i) in the forcing data (and mainly in the precipitation) used for the land and lake simulations, (ii) in the glacier mass balance estimate and/or (iii) in the quantification of hydrological processes for the land or for the lake (evaporation, runoff). For all these variables, we believe that we provide the best possible estimates because we use all the available data that could possibly contribute to correct and validate them.

Especially after 2005, there is a trend difference that may require further improvement in the simulation process. Could the rapid decrease in lake water level during the early stages of the simulation be related to the ignorance of the water source provided by the melting of frozen soil?

There are two aspects of our methodology that can limit our ability to accurately match the observed lake level trends. Firstly, our estimates of glacier mass changes correspond to two time averages, one for the 1980-2000 period and one for the 2000-2020 period. Therefore our values of glacier runoff are very smooth and a different distribution of the same amount of water towards the lake over the 40 years (i.e. more before 2010 and less after) could limit the discrepancy between the observed and simulated lake levels.

Secondly, the absence of water routing also limits the realism of the lake level variations. The routing could induce delays or storage effects on the land runoff towards the lake that would change the year to year variation of the lake level. Discussions on the absence of water routing in our study are developed in the Discussion (Sect. 5.1.2.) and higher in this response.

Thanks to the reviewer's comment, we now see that these different elements on the mismatch between the simulated and observed lake levels were not gathered in one paragraph but scattered in the Discussion. Therefore, we modified the first paragraph of Sect. 5.2.1. (Lake hydrological budget and level variations) to include these considerations:

"The reason for the overall mismatch of 1.06 m can arise from bias (i) in the forcing data (and mainly in the precipitation) used for the land and lake simulations, (ii) in the glacier mass balance estimate and/or (iii) in the quantification of hydrological processes for the land or for the lake (evaporation, runoff). On top of these potential biases, the difference in trends for the end of the simulation time can be influenced by (i) our estimates of glacier mass changes, which are made of two time averages (one for the 1980-2000 period and one for the 2000-2020 period) and therefore produce very smoothed glacier runoff values that cannot capture variations at the scale of the decade of less and (ii) the absence of water routing that prevent us from accounting for delays of storage effects on the water supply from the land to the lake."

(9)Line442: "Disappearing permafrost". This study simulated the areas where permafrost will disappear. What are the characteristics of these places, including topographic factors, precipitation and temperature factors, or other reasons that cause these areas to disappear earlier than other place under the same warming conditions? This is of significance for studying the distribution of permafrost.

As it is visible on Fig. 7A and in Tab. 1, elevation (and the climate variability it creates) is the main factor affecting the distribution of disappearing permafrost. Indeed, the mean elevation of disappearing permafrost is 200 m lower than the one of warm permafrost and 600 lower than the one of cold permafrost (Tab. 1). As such, it always occurs at the boundary between permafrost and permafrost free areas (i.e., the lowest possible place). As stated in Sect. 4.2. (Ground thermal results):

"Permafrost disappearance (grey zones in Fig. 7D) mainly happens for low-lying permafrost of the south and the center of the catchment. It occurs for the most part on the outer slopes of the permafrost regions and at the bottom of steep glacial valleys."

Otherwise, regarding the information we make available, we remind that for each cryological type of ground, including disappearing permafrost, we provide in the study:

- **In Tab. 1: % of catchment area, elevation, slope**
- **In Tab. 2: Precipitation input, runoff, evaporation**
- **in Fig. 7A: spatial extent and distribution within the catchment**
- **in Fig. 7B: yearly mean annual temperature at 2m deep**

Specifically for disappearing permafrost we also provide:

- **in Fig. 11D: the relationship between ground warming and subsurface runoff**

(10)Line461: What is the mean of MAGT in Figure 7.

MAGT stands for *Mean Annual Ground Temperature*, we modified the caption of Fig. 7 so that it now explains this acronym.

(11)Line494: "we distinguished ALT for locations experiencing an average evaporation lower or higher than 150 mm per year during the simulations". Line 509 shows an average evaporation of 180 mm per year, how was the value of 150 mm per year determined?

The choice of this value is based on the relationship between evaporation and AL deepening as it can be seen on Fig. 11. This value marks a threshold among warm permafrost simulations, between those with a clear deepening trend and the others. We now clarified this point by adding to this paragraph the sentence:

"This threshold value of 150 mm per year is based on further investigations on the relationships between evaporation and ALT provided in Sect. 5.3.1."

(12)Line495: "evaporation below 150 mm per year record an active layer deepening trend". In areas with low evaporation, the active layer thickens, while in areas with high evaporation, which should have more heat and more melting, the active layer becomes shallower. What is the reason for this?

This point is discussed in Sect. 5.2.2.:

"Active layer (AL) evolution is contrasting throughout the catchment and a deepening signal is only visible for the locations with limited evaporation (<150 mm per year). Given the strong drive of summer climate on ALT, this overall lack of a deepening trend highlights how evaporation can act as an energy intake at the surface (Yang et al., 2014a), limiting the surface and subsurface heat fluxes and thus AL deepening. In this regard, our results fall in line with the conclusions of Fisher et al. (2016)…"

(13)Line519: "We also present the catchment average of the runoff / (runoff + evaporation) ratio (Fig. 9C), which is equivalent to runoff / (rain + snow – snow sublimation) given the negligible contribution of soil storage variations. ". As glaciers and permafrost melt, does the soil water storage change? Line 538 suggests an increase in unfrozen water content in the soil, is this assumption valid?

Firstly, because there is no water routing in our approach, glacier runoff cannot increase soil water storage. Glacier runoff is directly accounted as a water flux towards the lake. Secondly, as we explained it in detail in the response to reviewer's point 1.(2), liquid water input from active layer deepening or disappearing permafrost is negligible compared to any other water flux in the catchment and does not have the power to impact soil water storage. Finally, line 538 goes together with Fig. 9D, which shows the annual proportion of liquid / total water averaged for the whole catchment. Therefore it is a ratio which does not indicate an increase in the absolute quantity of water in the soil per year but rather an increase in the time the water spends unfrozen in the ground compared to frozen. To clarify this point we rephrased this line to:

"The graph shows that the proportion of liquid water in the total water content increases at around +1.41% per decade ($p=1\times10^{-4}$), indicating that water spends more and more time in the ground in a liquid form, being thus increasingly available for hydrological processes such as evaporation or runoff."

(14)Line 540: "Figure 9. Hydrological results. A: Annual evaporation averaged over the whole catchment. ". Over the whole catchment, is this correct? Land area only?

We thank the reviewer for pointing out this unprecise formulation. The results indeed concern the land area of the catchment. We added the mention (landed area only) in the caption to clarify this point.

(15)Line547: "4.4. Sensitivity test on evaporation and runoff". This study adds a simulation result comparison by adding one scenario that cannot be referred to as sensitivity analysis.

To be precise, the wording "sensitivity analysis" is nowhere to be found in our study. We initially referred to a "sensitivity test" because we believe that a test is a smaller thing than an analysis. Yet, to cut short discussions revolving around the usage of a single word, Sect. 4.4. is now called "Sensitivity of evaporation and runoff". We also added the following lines to this section:

"We conducted a simple sensitivity test on the climatic conditions (i.e. not a full-scale sensitivity test)."

(16)Line556: "Figure 10C aggregates...". Figure or Fig. needs to be consistent.

Based on this comment, we now apply consistently the following rule:

- **Figure captions are written "Figure"**
- **Mentions to figures are written "Fig."**

(17)Line584: "Table 2. Distribution of between runoff and evaporation for the 2 scenarios ". The table caption should be corrected.

We removed "of".

(18)Line633: "Gao et al., n.d.". Format correction and corresponding reference format.

Reference updated.

(19)Line674: "Such an inflow could mitigate the lake level decrease and thus explain the missing water in our reconstruction (Fig. 6B). It could also explain the gradual stabilization of the lake level that our model does not reproduce.". This explanation is too speculative.

We did not come up with this hypothesis. It is based on the literature review we did to document this section of the discussion. Yet, to account for the reviewer's comment, we added some more cautious wording. The full paragraph now reads as follow:

"In the context of a decreasing lake level, an aquifer surrounding the lake can create an additional water inflow when the lake level passes below the piezometric level of the aquifer (Yechieli et al., 1995). We suggest that such an inflow could mitigate the lake level decrease and thus explain the missing water in our reconstruction (Fig. 6B). It could also explain the gradual stabilization of the lake level that our model does not reproduce. […] In the long run, lake-aquifer systems commonly follow oscillations of the net atmospheric flux of water (Precipitation – Evaporation) and of the runoff that forces its mass balance (Watras et al., 2014). During these oscillations, the lake can "pump" water from the aquifer or feed it depending on the relative difference of piezometric level between them (Almendinger, 1990; Liefert et al., 2018)."

(20)Line 782: "Given the strong drive of summer climate on Active Layer Thickness (ALT), ". The previous text has already provided the abbreviation.

We replaced "Active Layer Thickness (ALT)" by "ALT".

(21)Line834: "5.3. Evaporation vs runoff and sensitivity to climate conditions". From the view of title, is it similar content with 5.2.2 Evaporation and runoff changes?

Titles of the Discussion have been significantly modified to follow comment 3 from the reviewer. We believe the new ones provide a clearer understanding of the content of each subsection.

(22)Line883: "hence driving the observed lake level decrease.". Is the reason for the lake water level decline really due to high evaporation? So why do most lakes on the Tibetan Plateau still experience rising water levels against the backdrop of rising temperatures?

We state here the results of our quantification of the lake hydrological budget (Sect. 4.1.2.). According to our reconstruction, and despite the increasing trend in precipitation over the catchment, evaporation exceeds the sum of direct precipitation in the lake and land and glacier runoff. Unfortunately our catchment scale study does not allow us to derive firm conclusions for the rest of the Tibetan plateau. Each catchment

has indeed its own characteristics, and from one catchment to another many factors can vary such as elevation, climate (and in particular precipitation and temperature), glacier coverage, lake/land area ratio, evaporation… As stated earlier, much is still to be understood about the spatial distribution of rising and shrinking lakes over the QTP. Yet, thanks to our results linking climate, permafrost coverage and the partition between evaporation and runoff (Sect. 4.4.) we believe our study indicates a worthy direction for future investigations on the topic.

(23)Line891: "Ground warming and permafrost thawing promote subsurface runoff over time, contributing to an increase in the runoff/evaporation ratio of the catchment.". The impact on runoff is greater than evaporation, why does the lake level decrease? As mentioned earlier, it is due to increased evaporation under climate warming, which leads to a decrease in lake water level.

Indeed, we report trends on land runoff and land runoff/evaporation ratio showing that more and more water reaches the lake over time. This likely explains the gradual stabilization of the lake level decrease. Yet, these trends are not enough to overturn the dominance of lake evaporation over all the input variables of the lake budget.

(24)The authors should carefully check the format of cited references and the reference lists. Such as the abbreviation of Journal of Geophysical Research: Atmospheres, IEEE Geoscience and Remote Sensing Letters, Vadose Zone Journal... in the reference list.

Our reference list is formatted with a bibliography software. We have updated the reference list which should now fit the formatting of HESS.

References

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