Dear editor and reviewers,

Thank you very much for your comments on our first round of revised manuscript. We have carefully addressed all the comments and suggestions provided by the reviewers in our second round of revised manuscript. This mainly includes the discussion of applicability of the designed conceptual model.

We provide point-to-point responses to the reviewers' comments below. The reviewers' comments and questions are in black font, while our responses are in blue font.

Anonymous Referee #1

The revision has been greatly improved. It is worthy of being published after minor revision.

Reply: Thank you for your time to review. We have carefully checked the full text.

Line 66, should be 'to understand'

Reply: Changed.

Line 258, '&' should be '%'?

Reply: Changed

Anonymous Referee #2

1. In the second paragraph of section 2.2, please provide examples or references of glacial lakes with different expansion mechanisms to support your hypothesis.

Reply: Thank you very much for the comment. We have cited related references to support our hypothesis, e.g. Carrivick and Tweed (2013), Mertes et al. (2017), Minowa et al. (2023). For example, supraglacial lakes often emerge on the debris-covered glaciers. As the glaciers melt, adjacent supraglacial lakes slowly coalesce and gradually expand. This expansion proceeds in all directions (Mertes et al., 2017; Watson et al., 2018). For the proglacial lakes, the expansion mainly proceeds backward by glacial retreat (Minowa et al., 2023; Wei et al., 2021). While for ice-dammed lakes, the evolution often appears horizontally with glacier retreat, as seen in the expansion of Merzbacher Lake in the Tianshan Mountains (Gu et al., 2023).

Carrivick, J. L., and Tweed, F. S.: Proglacial lakes: character, behaviour and geological importance, Quat. Sci. Rev.,78, 34–52, http://dx.doi.org/10.1016/j.quascirev.2013.07.028, 2013.

Gu, C., Li, S., Liu, M., Hu, K., and Wang, P.: Monitoring Glacier Lake Outburst Flood (GLOF) of Lake Merzbacher Using Dense Chinese High-Resolution Satellite Images. Remote Sens., 15, https://doi.org/10.3390/rs15071941, 2023.

Mertes, J. R., Thompson, S. S., Booth, A. D., Gulley, J. D., and Benn, D. I.: A conceptual model of supra-glacial lake formation on debris-covered glaciers based on GPR facies analysis. Earth Surf. Process. Landf., 42, 903–914, http://dx.doi.org/10.1002/esp.4068, 2017.

Minowa, M., Schaefer, M., and Skvarca, P.: Effects of topography on dynamics and mass loss of lake-terminating glaciers in southern Patagonia. J. Glaciol., 1–18, https://doi.org/10.1017/jog.2023.42, 2023.

Watson, C. S., Quincey, D. J., Carrivick, J. L., Smith, M. W., Rowan, A. V., and Richardson, R.: Heterogeneous water storage and thermal regime of supraglacial ponds on debris-covered glaciers, Earth Surf. Process. Landf., 43, 229–241, http://dx.doi.org/10.1002/esp.4236, 2018.

Wei, J., Liu, S., Wang, X., Zhang, Y., Jiang, Z., Wu, K., Zhang, Z., and Zhang, T.: Longbasaba Glacier recession and contribution to its proglacial lake volume between 1988 and 2018. J. Glaciol., 1–12, https://doi.org/10.1017/jog.2020.119, 2021.

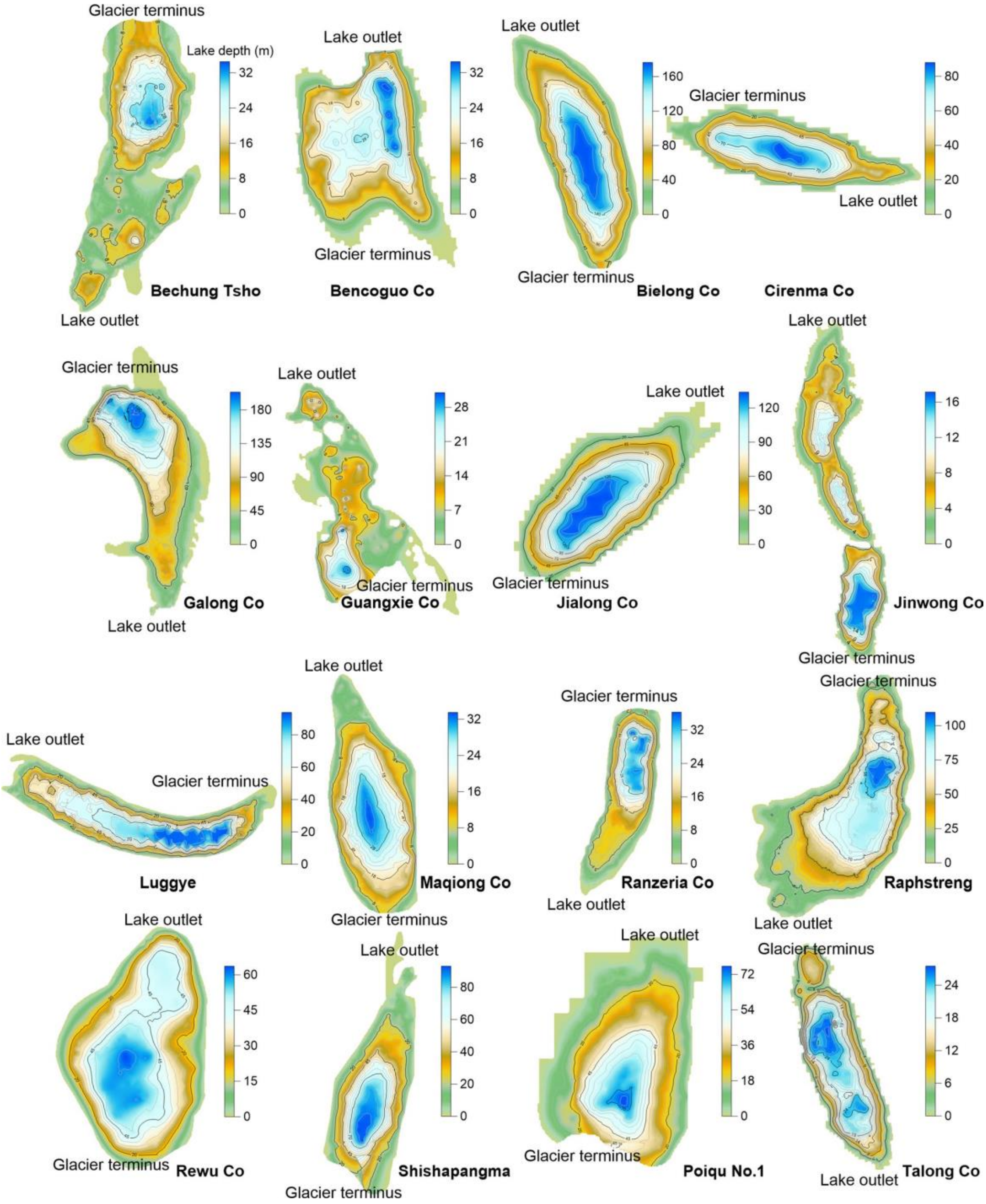
2. In line 152-154: "However, proglacial and ice-dammed lakes are different. Their expansions are focused toward the glacier's or valley's direction, and the maximum water depths are generally situated near the intersection with the glacier." Please provide specific examples of such glacial lakes in the form of references.

Reply: Thank you very much for the comment. We added an example of proglacial lake Longbasaba Lake as its expansion towards the direction of glacier retreat (Wei et al., 2021), and the deepest lake water located near the intersection with the glacier (Yao et al., 2012). We also added the Shisper Lake to be an example of ice-dammed lake, whose deepest lake water situated also near the intersection with the glacier (Singh et al., 2023).

3. In line 255: In the previous round of reviews, I suggested that the authors use the bathymetric data from 16 glacial lakes published by Zhang et al. (2023) (https://doi.org/10.1038/s41561-023-01150-1) for the validation of the proposed model. In this review, the authors failed to utilize more data even though they increased the number of validated glacial lakes from three to six. I would like to get an explanation from the authors.

Reply: Thank you very much for the comment. Currently, our modeling method is limited by several constraints. First, the designed conceptual model is more suitable for those glacial lakes with typically lengthy and elliptical-like shapes, and may be less applicable to very irregularly shaped glacial lakes. Second, the designed conceptual model is also more suitable for those glacial lakes with a cirque-valley glacier or a small/medium sized valley glacier flowing along a straight valley, ensuring idealized formation conditions for the glacial lake basin with minimal erosion and deposition from tributaries.

Under these two conditions, we cannot select all the 16 glacial lakes published by Zhang et al. (2023) to validate our model's credibility. And to balance the lake numbers and types, only the Dasuopuco, Poiqu NO.1 and Maqiongco were chosen in our study. Other glacial lakes such as Bielongco, Rewuco, and Ranzeriaco are also meet our conditions and are predictably well suited to our modeling method. Adding too many validated glacial lakes of the same type in the same region will not increase the applicability of our conceptual model.



Source: Zhang et al. (2023)

4. The six types of glacial lakes verified by the authors included four periglacial lakes and two proglacial lakes; the other three types were not verified. The validated glacial lakes are located only on the Tibetan Plateau. Although the authors' model theory is based on the statistics of global glacial lake bathymetry data, the validation part is really weak. Admittedly, the author's statement in Discussion 4.2, "Therefore, this modeling approach may be applicable to most glacial lakes in mountain glaciers." is not sufficiently persuasive. The scarcity of bathymetric data of glacial lakes is also taken into account, but the authors should have explained the

applicability of the model more scientifically and credibly through some literature or examples. For example, a comparison between the six validated glacial lakes used in this study and similar glacial lakes elsewhere in the world.

Reply: Thank you for the comment. In the revised manuscript, we have changed the assertion "Therefore, this modeling approach may be applicable to most glacial lakes in mountain glaciers" and highlighted the need of further validation on the global scale. Additionally, conducting comparisons between various glacial lakes worldwide is challenging due to the scarcity of published and accessible bathymetric data.

The adjusted statement is as below:

Our modeling theory is based on the observations of glacial lake bathymetric distribution characteristics worldwide, revealing a geometrical approximation law for glacial lake bathymetry. However, it is strictly limited by several constraints. Firstly, the designed conceptual model is more suitable for those glacial lakes with typically lengthy and elliptical-like shapes, and may be less applicable to very irregularly shaped glacial lakes, such as the ice-marginal and thermokarst lakes in the Greenland and Alaska region (Field et al., 2021; Coulombe et al., 2022). Secondly, he designed conceptual model is also more suitable for those glacial lakes with a cirque-valley glacier or a small/medium sized valley glacier flowing along a straight valley, ensuring idealized formation conditions for the glacial lake basin with minimal erosion and deposition from tributaries. Although the simulated results were only validated in the periglacial and proglacial lakes of the Himalayas and Nyainqentanglha due to limited observation data, the comparison results of the measured and modeled depth values at different locations of the six glacial lakes demonstrates the rationality and reliability of our conceptual models. Further validation is needed to assess the applicability of our conceptual model on a global scale. There is a significant limitation in the availability of glacial lake bathymetric distribution data, with most studies only providing key parameters such as total volume, maximum depth, and mean depth. Moreover, due to the challenges of field investigations, measurements of glacial lakes have predominantly focused on larger, hazardous, or particularly interesting peri- and proglacial lakes. This makes us unable to find any available bathymetric distribution data for extraglacial, supraglacial, and ice-dammed lakes, preventing validation of our conceptual model for these lake types.

5. Line 394: The authors should cite the latest research on the process chain modelling of glacial lake outburst flood, of which I am aware there are many articles published in several leader journals after 2020.

Reply: We added two related references in this section.

Duan, H., Yao, X., Zhang, Y., Jin, H., Wang, Q., Du, Z., Hu, J., Wang, B., and Wang, Q.: Lake volume and potential hazards of moraine-dammed glacial lakes–a case study of Bienong Co, southeastern Tibetan Plateau. Cryosphere, 17, 591–616, https://doi.org/10.5194/tc-17-591-2023, 2023.

Sattar, A., Allen, S., Mergili, M., Haeberli, W., Frey, H., Kulkarni, A. V., Haritashya, U. K., Huggel, C., Goswami, A., and Ramsankaran, R.: Modeling Potential Glacial Lake Outburst Flood Process Chains and Effects From Artificial Lake-Level Lowering at Gepang Gath Lake, Indian Himalaya. J. Geophy. Res. Earth Surf., 128, https://doi.org/10.1029/2022JF006826, 2023.

Referee #3 (Emmer, Adam)

Thank you for revising your work in line with my comments and suggestions. I appreciate that you increased the number of lakes used for the validation from 3 to 6. However, all of these lakes are classified as periglacial (n=4) or proglacial (n=2) and all are located in High Mountain Asia. Since you claim your approach is globally applicable (with the exception of polar regions), you may want to test it in various regions, not only in HMA. I'm also missing a validation for extraglacial lakes. Please consider further elaboration of your validation part to address this geographical and lake type imbalance that undermines otherwise solid study.

Reply: Thank you for acknowledging the significance of our study. In the revised manuscript, we have changed the assertion "Therefore, this modeling approach may be applicable to most glacial lakes in mountain glaciers" and highlighted the need of further validation on the global scale.

The adjusted statement is as below:

Our modeling theory is based on the observations of glacial lake bathymetric distribution characteristics worldwide, revealing a geometrical approximation law for glacial lake bathymetry. However, it is strictly limited by several constraints. Firstly, the designed conceptual model is more suitable for those glacial lakes with typically lengthy and elliptical-like shapes, and may be less applicable to very irregularly shaped glacial lakes, such as the ice-marginal and thermokarst lakes in the Greenland and Alaska region (Field et al., 2021; Coulombe et al., 2022). Secondly, the parent glaciers of glacial lakes can be a cirque-valley glacier or a small/medium sized valley glacier flowing along a straight valley, ensuring idealized formation conditions for the glacial lake basin with minimal erosion and deposition from tributaries. Although the simulated results were only validated in the periglacial and proglacial lakes of the Himalayas and Nyainqentanglha due to limited observation data, the comparison results of the measured and modeled depth values at different locations of the six glacial lakes demonstrates the rationality and reliability of our conceptual models. Further validation is needed to assess the applicability of our conceptual model on a global scale. There is a significant limitation in the availability of glacial lake bathymetric distribution data, with most studies only providing key parameters such as total volume, maximum depth, and mean depth. Moreover, due to the challenges of field investigations, measurements of glacial lakes have predominantly focused on larger, hazardous, or particularly interesting peri- and proglacial lakes. This makes us unable to find any available bathymetric distribution data for extraglacial, supraglacial, and ice-dammed lakes, preventing validation of our conceptual model for these lake types.