Reviewer 2#

The authors have done a very interesting work. The simulation of the depth distribution of glacial lakes has been less addressed in previous studies, but it is crucial for the simulations of outburst floods for vast glacial lakes without measured depth data. Therefore, the scientific value of this study is unquestionable. However, I have some questions about the study, and I hope the authors will provide reasonable answers.

Reply: Thank you for acknowledging the significance of our study. By considering both general and specific comments from three reviewers, we have undertaken a major revision of this manuscript to enhance the clarity of language and to improve the quality of figures. The original glacial lakes utilized to exhibit and validate model results were extended from three to six (Table 2). Our conceptual model for glacial lake bathymetric distribution exhibits high applicability and reliability across various types of glacial lakes, sizes, and geographic contexts. The results show a high consistency in the point-to-point comparisons of the measured and simulated water depths with a total volume difference of approximately ±10%.

Table 2. The crucial modeling parameters of the six selected glacial lakes.

Name	Lat°	Lon°	Region	Topological position	Survey year	Area (km^2)	Volume (10^6 m^3)	Mean water depth (m)	Maximum water depth (m)	Semi-long axis (m)	Semi-minor axis (m)
Jialongco	28.21	85.85	Central Himalaya	periglacial	2020	0.61	37.5	58.2	133	757	314
Cirenmaco	28.07	86.07	Central Himalaya	periglacial	2012	0.33	18.0	55	115	549	185
Poiqu NO.1	28.14	85.92	Central Himalaya	periglacial	2021	0.11	2.7	25.5	75.1	242	129
Maqiongco	30.49	93.36	Nyainqentanglha	periglacial	2021	0.23	3.2	15	33.5	493	168
Longbasaba Lake	27.95	88.08	Eastern Himalaya	proglacial	2009	1.17	64.0	48	102	1949	319
Dasuopuco	28.44	85.78	Central Himalaya	proglacial	2021	0.55	0.55	33.8	93	1362	247

Additionally, we have added a new discussion session on fitting empirical curves of volume (V) and area (A) of glacial lakes **(section 4.3, P17L329-350)**. Currently, many studies have attempted to fit V-A equations with regional or claimed global applicability for various types of glacial lakes (Cook et al., 2015; Qi et al., 2022). The most common classification method for glacial lakes is based on dam materials, such as moraine-dammed, bedrock-dammed, and landslide-dammed. However, this study reveals that the different types of glacial lakes have different ideal basin shapes that may be unfavorable to most already formed V-A empirical formulations, although some formulas have high R^2. For instance, most of the proglacial and periglacial lakes are generally dammed by moraine, involving in many fitting works of V-A relationships. Unreasonably, the incompletely developed basins of proglacial lakes and the fully developed basins of periglacial lakes are often described by same empirical formulas, disregarding the distinct basin development stages between them. This aspect has overlooked in the previous studies. In our fitted curves of V-A relationships for various types of glacial lakes (Fig. 4), the V-A relationship for proglacial lakes is robust, indicating global applicability. However, the V-A relationships for periglacial and extraglacial lakes exhibit many outliers, suggesting a stronger influence from exogenous materials. The V-A relationships of these glacial lakes decoupled with their glaciers at least require parameters related to the glacier characteristics and time of detachment for further description.

No single classification method can adequately capture the refined characteristics of glacial lakes. Even lakes classified as the same type may differ in terms of parent glaciers, bedrock properties, or dam materials. In the modeling of glacial lake bathymetric distribution, accurately estimating the total volume and maximum water depth of glacial lakes is crucial. Therefore, future studies should not only focus on whether the empirical formula is generalizability or global applicability, but also develop more detailed classification criteria for glacial lakes, comprehensively considering dam materials, topological positions, glacier properties, area intervals, geographic location, and other relevant factors. This will facilitate a well-fitting of regional empirical relationships of V-A and D-A for various types of glacial lakes, thereby reducing the dispersion between data points.

Below are our point-to-point responses. Reviewers' comments and questions are in black font, while our response in blue font.

1 In the abstract it is stated that there are 10 standard conceptual models, 4 in Section 2.3, 5 in Figure 3a, and 4 standard curves in Figure 3b, so how many standard conceptual models are there in this study as defined by the authors?

Reply: (Section2.3, P6L138-141) Thank you for the question. We have clarified in the revised manuscript. For periglacial, extraglacial, and supraglacial lakes, we identified four standard conceptual models (SCMs) for each glacial lake types: the hemisphere structured by the elliptical side (V = 2/3AD); the hemisphere structured by the upward-opening parabolic side (V = 1/2AD); the cone structured by the straight side (V = 1/3AD); and the cone structured by the rightward-opening parabolic side (V = 1/5AD). **(P6L146-157)** The SCMs for the proglacial lakes were determined to be half of the aforementioned four conceptual models, namely the semi-hemisphere structured by the elliptical side (V = 1/3AD); the semi-hemisphere structured by the upward-opening parabolic side (V = 1/4AD); semi–cone structured by the straight side (V = 1/6AD); and the semi-cone structured by the rightward-opening parabolic side (V = 1/10AD). We designed two SCMs for the ice-dammed lake (Fig. 3a): the semi–cone structured by the straight side and the triangular cone (V = 1/3AD). Ultimately, a total of 9 different SCMs were designed to express the idealized geometric shapes of glacial lake basin.

2 The authors classified glacial lakes as supraglacial, proglacial, periglacial, extraglacial, and ice-dammed types based on the topological positions between the glacial lakes and their parent glaciers. Of the three glacial lakes for in model validation, Cirenmaco and Jalongco are defined as periglacial lakes. The authors are requested to describe the specific topological relations of the five glacial lakes with their parent glaciers or to indicate the references in the article.

Reply: (Section 2.2, P5L113-118) Thank you for the comment. The topological relations of the five types of glacial lakes with their parent glaciers have added in the revised manuscript: "Glacial lakes were classified into five types based on their topological positions with glaciers: (1) proglacial lake, located in contact with glacier terminus; (2) periglacial lake, decoupled from its glaciers but situated at glacial moraines; (3) extraglacial lake, located far from glacier terminus and often with a landslide dam or without any dams; (4) supraglacial lake, found on the surface of glaciers; (5) ice-dammed lake, formed when glacier surges block downstream valleys or meltwater fills depressions between retreating tributary and main glaciers." We have also cited appropriate references below.

Citations:

Petrov, M. A., Sabitov, T. Y., Tomashevskaya, I. G., Glazirin, G. E., Chernomorets, S. S., Savernyuk, E. A., Tutubalina, O. V., Petrakov, D. A., Sokolov, L. S., Dokukin, M. D., Mountrakis, G., Ruiz-Villanueva, V., and Stoffel, M.: Glacial lake inventory and lake outburst potential in Uzbekistan, Sci. Total Environ., 592, 228–242, http://dx.doi.org/10.1016/j.scitotenv.2017.03.068, 2017.

Rick, B., McGrath, D., Armstrong, W. and McCoy, S.W. Dam type and lake location characterize ice-marginal lake area change in Alaska and NW Canada between 1984 and 2019, Cryosphere, 16, 297–314. https://doi.org/10.5194/tc-16-297-2022, 2022.

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.

3 The general curve generated must pass through points A and C, and the C is the maximum depth of a glacial lake. So how do we get the maximum depth of a glacial lake for a lake that has no actual bathymetry? Is it by an empirical formula? In your study, what is this empirical formula?

Reply: (Section 2.3, P8L164) We have compiled an inventory of glacial lake bathymetry worldwide, including the necessary attributions of lake area and maximum water depth. The fitted empirical curves were exhibited in Figure 2. For a specific glacial lake, the maximum depth of glacial lake can be calculated using these empirical formulas.

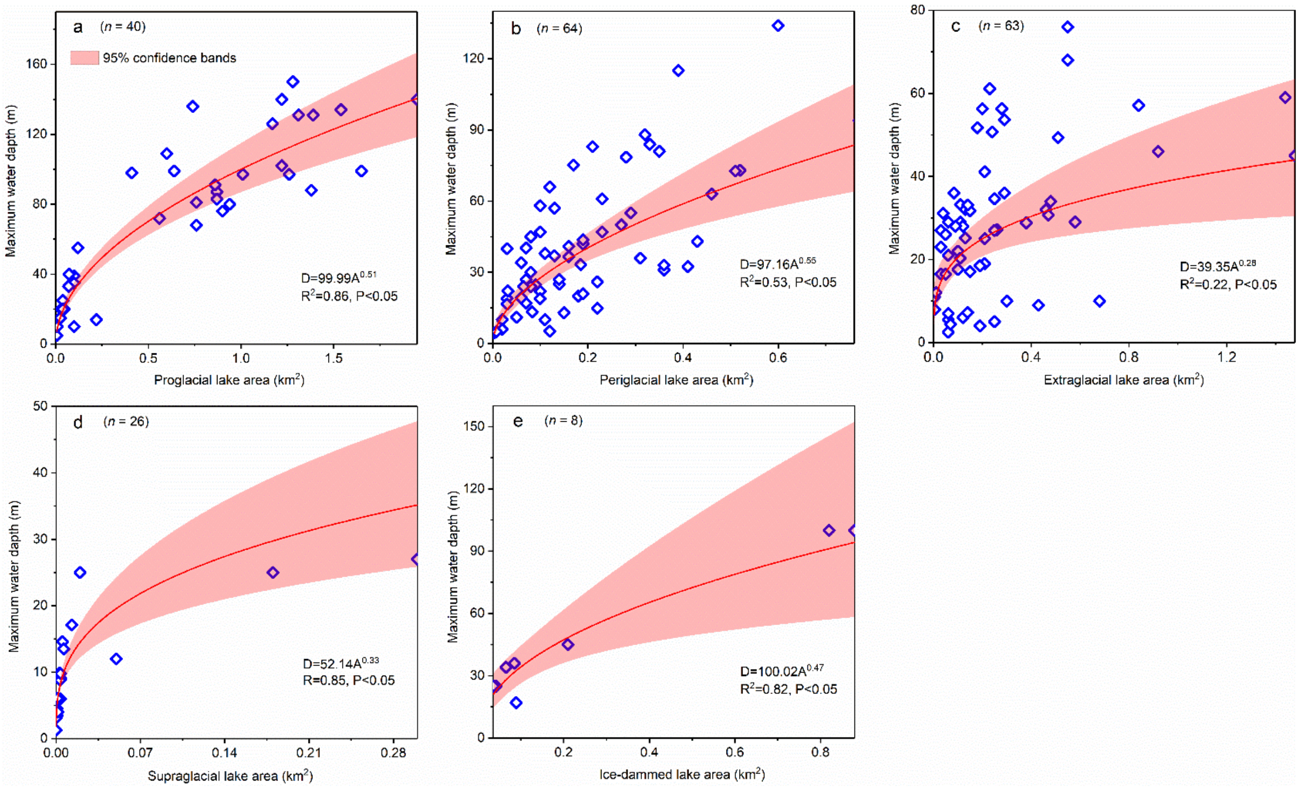

Figure 2. Relationships between maximum water depth and the area of glacial lakes were compiled in the present study for the following lake types: (a) proglacial lake, (b) periglacial lake, (c) extraglacial lake, (d) supraglacial lake, and (e) ice-dammed lake.

4 In figure 4, how can we obtain the different standard conceptual models in five lake types?

Reply: (Section 2.3, P9L173) See our reply to specific comment 1. For periglacial, extraglacial, and supraglacial lakes, we have identified four standard conceptual models (SCMs) for each glacial lake types; for proglacial lakes, we have determined four SCMs which is half of the aforementioned four conceptual models; for ice-dammed lake, we have developed two SCMs. We have updated the Figure 4 (see below).

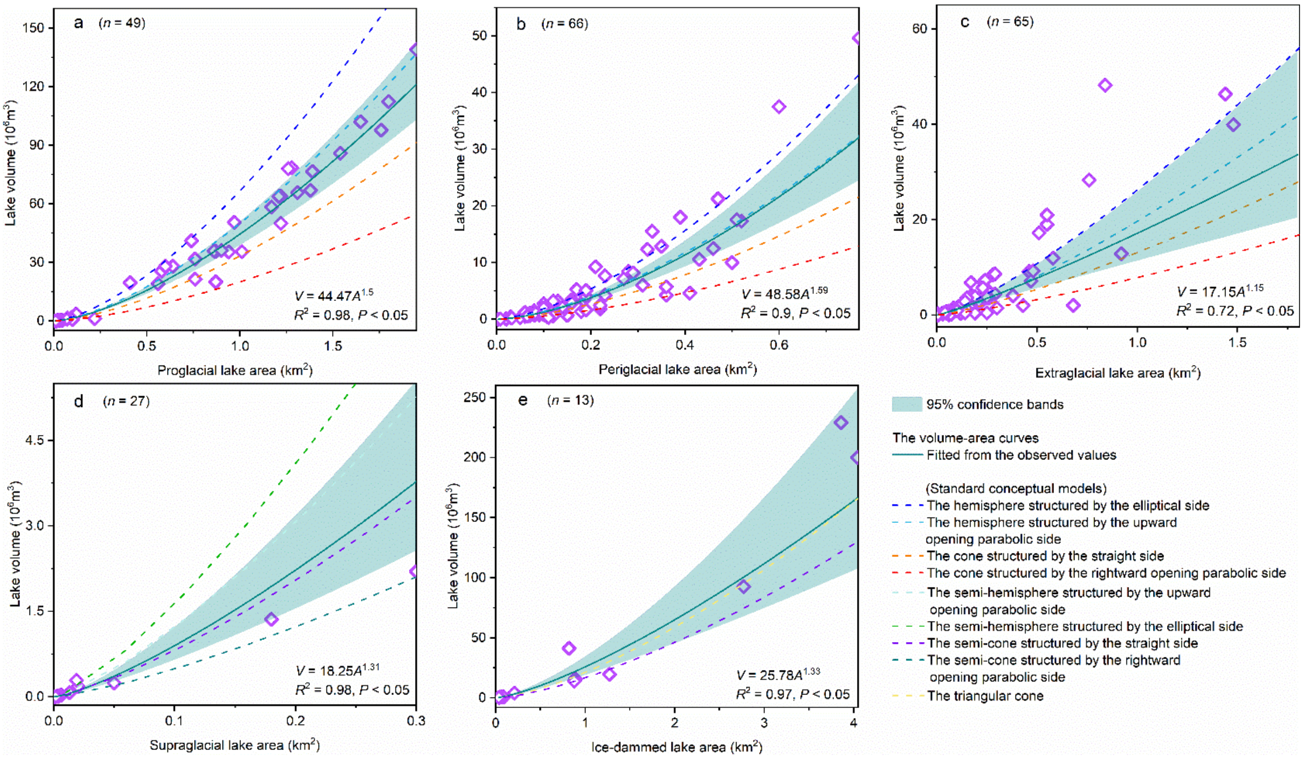

Figure 4. Relationships between the volume (V) and area (A) of glacial lakes were compiled in the present study for the following lake types: (a) proglacial lake, (b) periglacial lake, (c) extraglacial lake, (d) supraglacial lake, and (e) ice-dammed lake. The dotted lines indicate the volume curves of different standard conceptual models, which were fitted by Eq. (3).

5 Zhang et al., (2023) published bathymetric data for 16 glacial lakes on the Tibetan Plateau (https://doi.org/10.1038/s41561-023-01150-1). Could you apply your conceptual model to more glacial lakes for validation?

Reply: (Section 2.6, P12L246) Thank you for the constructive comments. The original glacial lakes utilized to exhibit and validate results were extended from three to six (Table 2). The Poiqu NO.1, Maqiongco, and Dasuopuco glacial lakes have added for validation.

Table 2. The crucial modeling parameters of the six selected glacial lakes.

Name	Lat°	Lon°	Region	Topological position	Survey year	Area (km^2)	Volume (10^6 m^3)	Mean water depth (m)	Maximum water depth (m)	Semi-long axis (m)	Semi-minor axis (m)
Jialongco	28.21	85.85	Central Himalaya	periglacial	2020	0.61	37.5	58.2	133	757	314
Cirenmaco	28.07	86.07	Central Himalaya	periglacial	2012	0.33	18.0	55	115	549	185
Poiqu NO.1	28.14	85.92	Central Himalaya	periglacial	2021	0.11	2.7	25.5	75.1	242	129
Maqiongco	30.49	93.36	Nyainqentanglha	periglacial	2021	0.23	3.2	15	33.5	493	168
Longbasaba Lake	27.95	88.08	Eastern Himalaya	proglacial	2009	1.17	64.0	48	102	1949	319
Dasuopuco	28.44	85.78	Central Himalaya	proglacial	2021	0.55	0.55	33.8	93	1362	247

6 In figure 6, the order of Figure b and Figure c in the title should be switched.

Reply: (Section 2.6, P13L248) See our updated figure below:

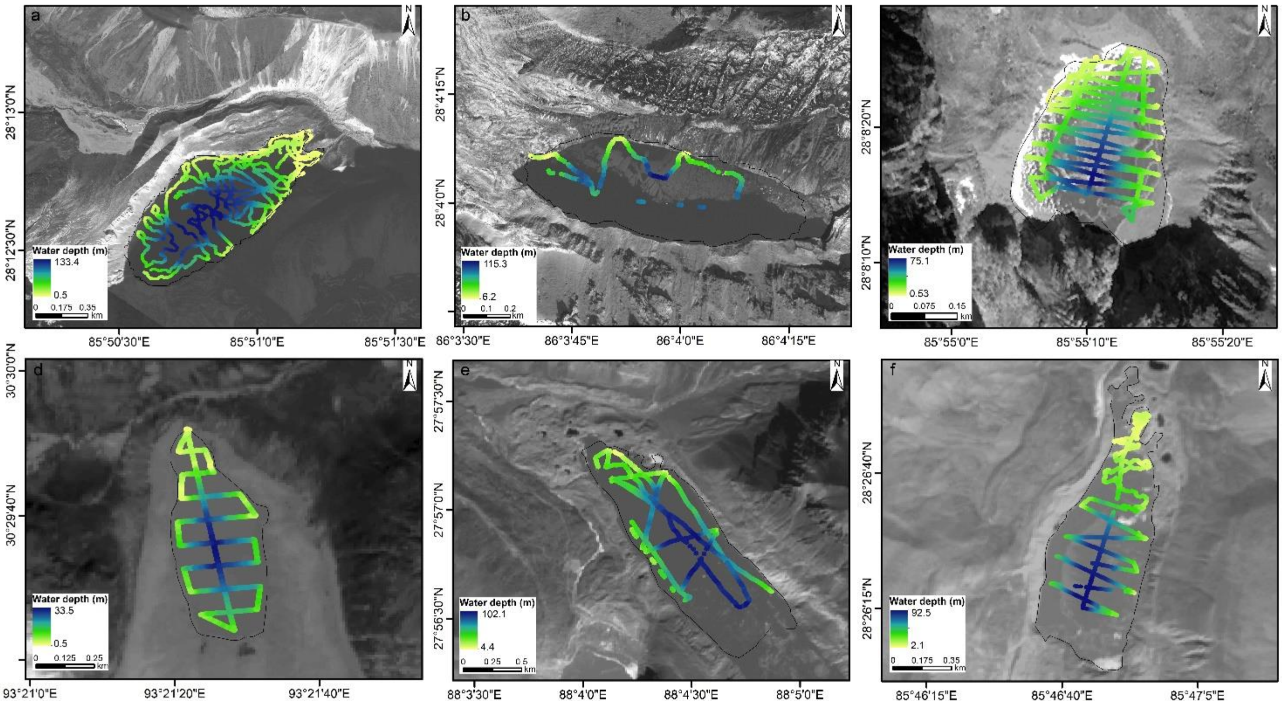

Figure 6. The water depth observed along the bathymetric routes for (a) Jialongco, (b) Cirenmaco, (c) Poiqu NO.1, (d) Maqiongco, (e) Longbasaba Lake, and (f) Dasuopuco.

7 In figure 7, the display of the standard conceptual model and the general conceptual model in the figure on the left lacks the necessary legends, such as what does the fill color represent? What is the color of the lines of each standard conceptual model? and the dashed line representing the general conceptual model is not visible in Figure 7b.

Reply: In fact, these colors do not have any specific significance. They are simply used to enhance the visual appeal of the figures and to emphasize the transition of general curves between the standard curves in the X-O-Z quadrant. **(Section 3, P15L280)** See our updated figure below:

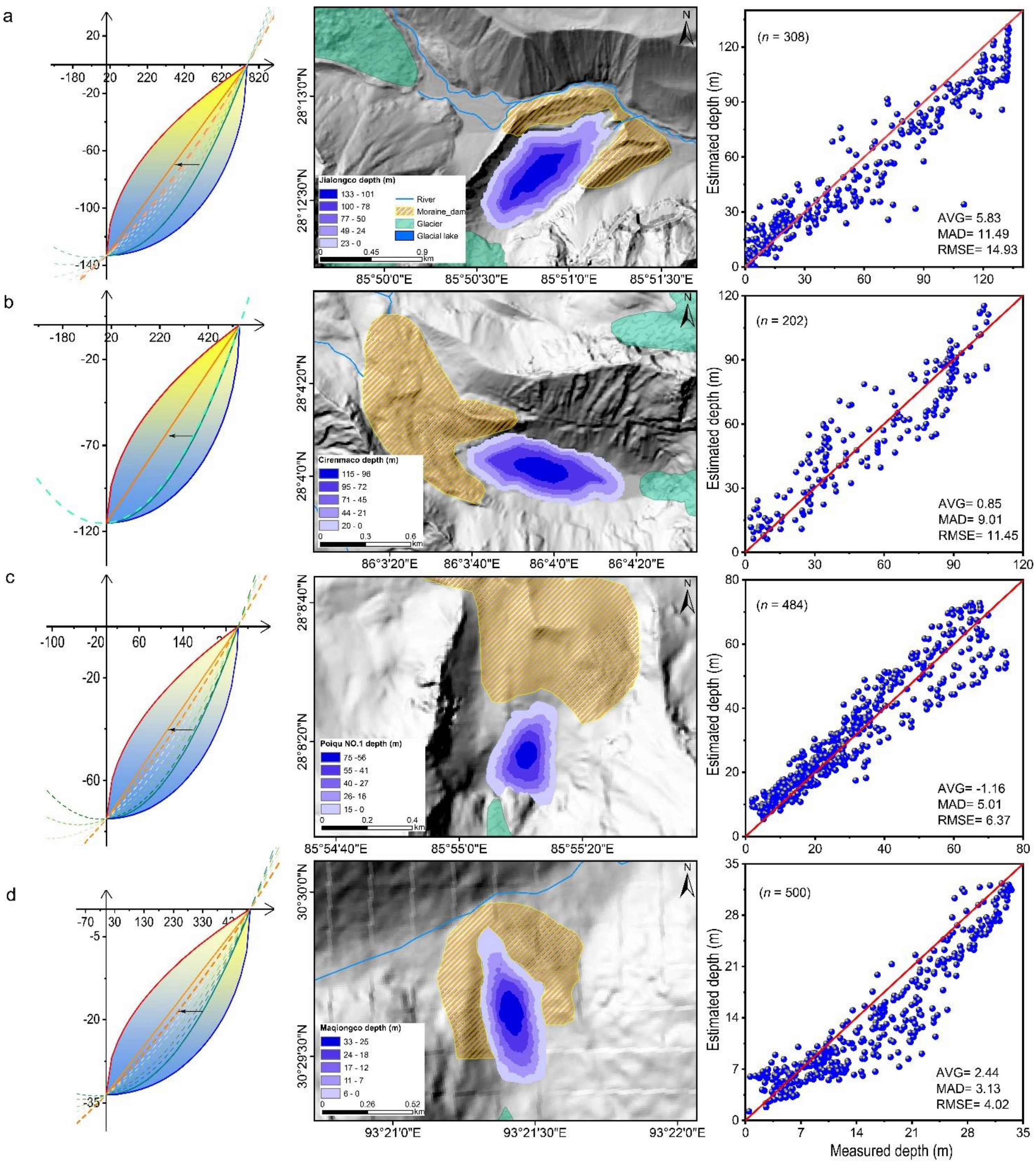

Figure 7. Modeled glacial lake bathymetric distributions of the four selected periglacial lakes. (a) Jialongco, (b) Cirenmaco, (c) Poiqu NO.1, and (d) Maqiongco. The average deviation (AVG), mean absolute deviation (MAD), and root mean square error (RMSE) were selected to depict the consistency between the simulated and measured individual water depths along the boat routes. The movements of the general curves from one standard curve to another are also indicated.

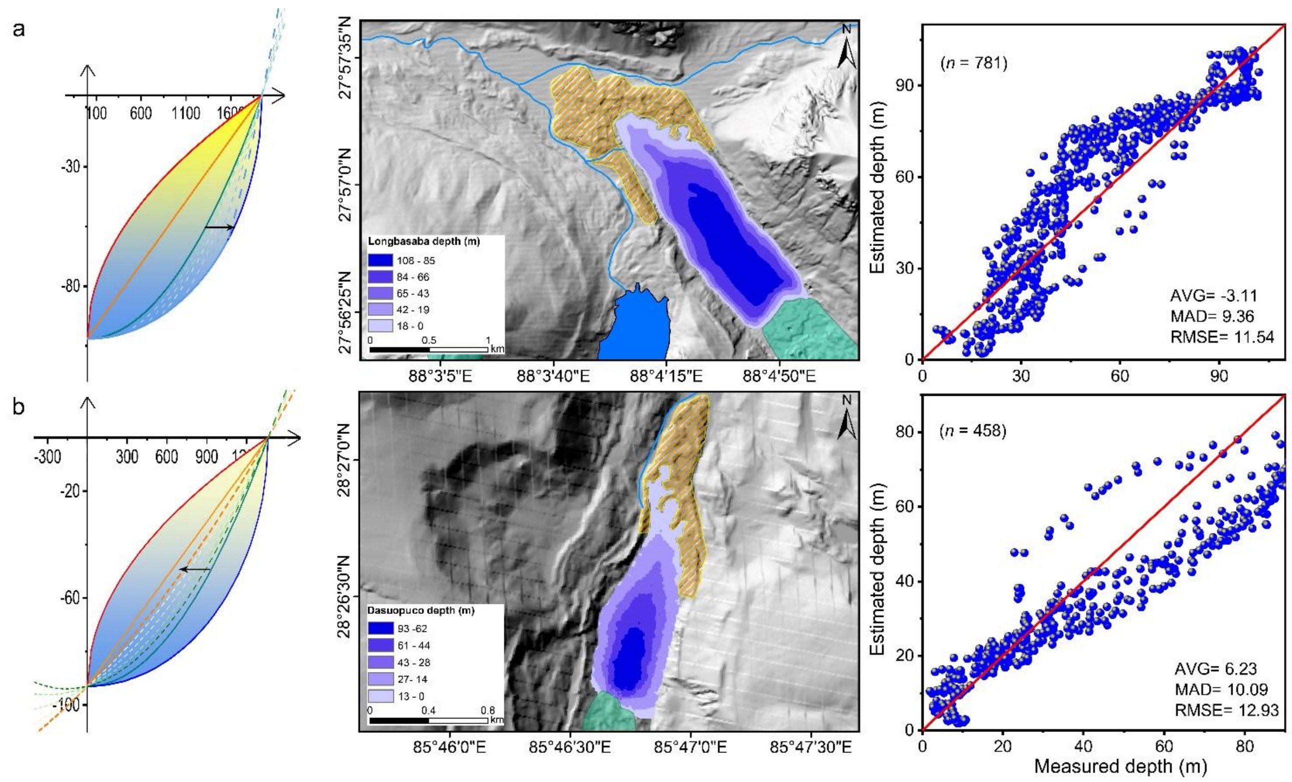

Figure 8. Modeled glacial lake bathymetric distributions of the two selected proglacial lakes. (a) Longbasaba Lake, and (b) Dasuopuco. The average deviation (AVG), mean absolute deviation (MAD), and root mean square error (RMSE) were selected to depict the consistency between the simulated and measured individual water depths along the boat routes. The movements of the general curves from one standard curve to another are also indicated.

8 The expressions in lines 157-160 are not easy to understand. What means "the SCMs of proglacial lakes to be half of the preceding four SCMs"? How is one half divided? "We ultimately designed two SCMs: the semi–cone structured by the straight side and the triangular cone (V = 1/3A·D)." Are these two SCMs applied to the previously mentioned proglacial lakes and ice-dammed lakes, respectively? I think the description here should be improved to make it easier to understand.

Reply: (Section 2.3, P6L148-153) The new description is as follows:

We considered the SCMs of proglacial lakes to be half of the preceding four SCMs, namely the semi-hemisphere structured by the elliptical side ($V = 1/3AD$); the semi-hemisphere structured by the upward-opening parabolic side ($V = 1/4AD$); semi–cone structured by the straight side ($V = 1/6AD$); and the semi-cone structured by the rightward-opening parabolic side ($V = 1/10AD$). We designed two SCMs for the ice-dammed lake (Fig. 3a): the semi–cone structured by the straight side and the triangular cone ($V = 1/3A \cdot D$).

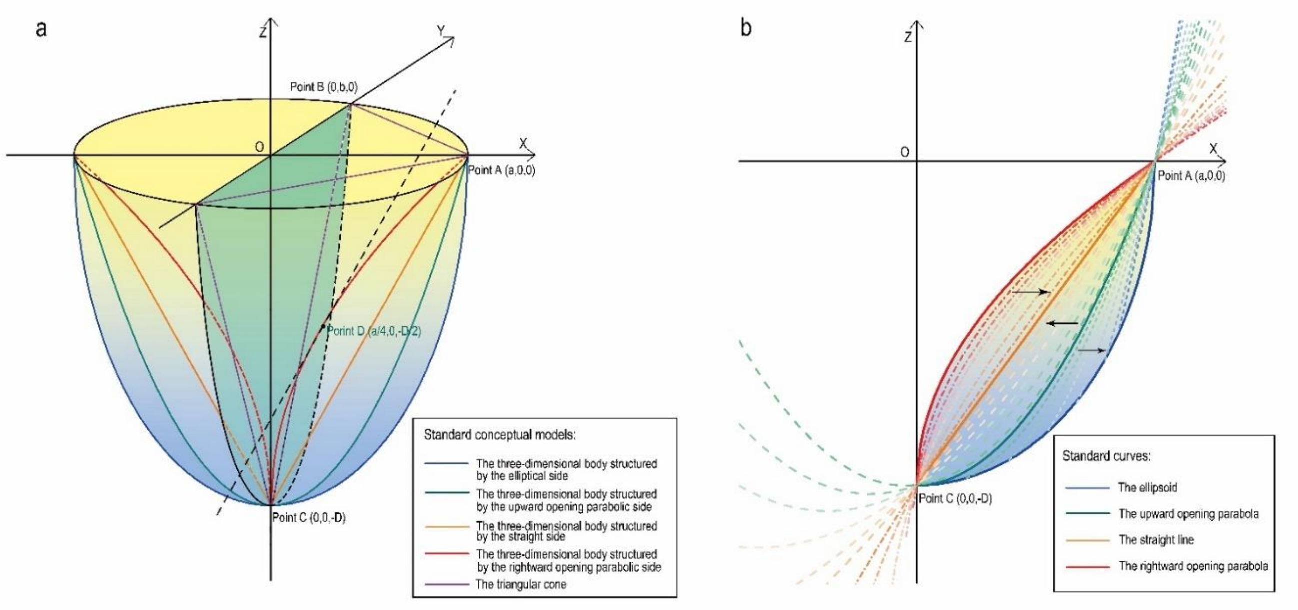

Figure 3. (a) Schematic diagram illustrates the shapes of the SCMs, namely the hemisphere structured by the elliptical side/upward-opening parabolic side, the cone structured by the straight side/rightward-opening parabolic side, the triangular cone, as well as their shapes when symmetrically divided matching the SCMs of the proglacial lake. Here, A is the semi-long axis, B is the elliptical surface's semi-short axis, and D is the maximum water depth. (b) Convergences of the general curves towards the standard curves in the X–O–Z quadrant in different orientations.