Dear editors and reviewers,

We sincerely appreciate your constructive comments and suggestions to improve this manuscript. We have revised the manuscript and addressed these comments point by point. We hope that this revised manuscript fulfills the editor's and reviewers' high standards for the *Hydrology and Earth System Sciences*.

The reviewers' comments are shown in black, our responses are highlighted in blue, and the revised text in the manuscript is highlighted in orange.

We look forward to your feedback.

Yours sincerely,

Yao Li

This manuscript presents a promising and innovative framework for reconstructing lake bathymetry by leveraging topographic continuity and widely available Digital Elevation Models (DEMs). The study addresses a critical need for cost-effective alternatives to traditional surveys, and the validation effort involving 12 lakes on the Tibetan Plateau represents a substantial and valuable contribution to the field. While the work is well-structured and tackles a clearly defined problem, the manuscript would benefit from the following refinements to further strengthen its theoretical grounding and clarify its methodological contributions.

Response: We sincerely appreciate the reviewer's positive feedback. We have carefully revised and improved the manuscript based on your comments. The key revisions include strengthening the theoretical grounding and adding a sensitivity experiment on the buffer distance. Please find our detailed responses to each comment below.

1. The manuscript's conceptual framing could be significantly strengthened by realigning the "lake recession" terminology with the well-documented hydrological expansion of lakes on the Tibetan Plateau.

Response 1: Thank you for this important suggestion. We agree that the term "lake recession" in the manuscript could be misinterpreted as describing an observed hydrological trend, whereas many lakes on the Tibetan Plateau have shown well-documented expansion in recent decades. However, the concept of "lake recession" was not originally proposed in our study, and we therefore retain this terminology. To avoid confusion, we have added further clarification in the manuscript to explicitly state that "lake recession" is used here only as a physical simulation within the modeling procedure and does not imply a real, long-term lake-level recession: "lake level recession (used here solely as a physical simulation within the reconstruction procedure, rather than implying an observed lake-level trend)" (Lines 76–77)

2. Reframing the method's success as leveraging "historical exposure" captured in older DEMs (e.g., SRTM 2000) prior to inundation would better articulate the physical mechanism driving the accurate results.

Response 2: Thanks for this insightful suggestion. We agree that the performance of the proposed method is fundamentally linked to the physical information preserved in historical DEMs acquired before lake inundation.

Specifically, NASADEM captured large portions of lake margins and shallow basins before the widespread hydrological expansion observed in recent decades on the

Tibetan Plateau. These historically exposed terrains provide critical geomorphic constraints that can be leveraged to infer present-day submerged topography.

In response to your suggestion, we have revised the manuscript to include the following text: "Consequently, the DEM preserves geomorphic information from historically exposed shorelines and shallow lake margins, providing critical physical constraints for reconstructing present-day underwater topography and enabling more comprehensive lake depth estimation." (Lines 87–91)

3. In order to enhance the study's robustness, it would be beneficial to elaborate on the rationale for selecting the 12 validation lakes. For instance, classifying these lakes by geomorphological origin (e.g., tectonic, glacial) and discussing the algorithm's consistency across these types would greatly increase the paper's utility for the broader research community.

Response 3: Thanks for this helpful suggestion. In the revised manuscript, we have expanded the justification for selecting the 12 validation lakes and clarified their representativeness. Specifically, these lakes were chosen for the following reasons:

(1) High-quality in situ bathymetry datasets (echo-sounder surveys) are available for them from the National Tibetan Plateau/Third Pole Environment Data Center, enabling point-wise and volume-based validation.

(2) They are evenly distributed across the Tibetan Plateau and span a wide range of lake characteristics (area, elevation, depth, shoreline complexity), which is essential for testing model robustness.

Following your suggestion, we attempted to classify the lakes used in this study in a more detailed manner based on their geomorphological origin. First, the formation of all 12 lakes is closely related to geological processes on the Tibetan Plateau, and Buruo Co has been identified as a proglacial lake (Xu et al., 2019). Building on this, we further explored differences in lake types from a structural–tectonic perspective. For lakes whose long axes are approximately parallel to major fault trends (i.e., (c) Dongcuo, (f) Longmucuo, (h) Mapang Yongcuo, and (k) Siling Co), all except Dongcuo showed good performance in bathymetry estimation (r = 0.86, 0.78, and 0.83). This result may indirectly suggest that our method performs better when underwater morphology is strongly coupled with surrounding topography.

Nevertheless, given the limited sample size in this study, drawing definitive conclusions about the relationship between our method's performance and deeper tectonic controls could undermine the rigor of the manuscript. Therefore, we provide Fig. S4 in the

Supplementary for readers' reference rather than discussing it in detail in the main text. In future work, we will carefully follow this suggestion and, using a substantially larger sample set, investigate how geomorphological origin influences the performance of topography-based bathymetric methods to derive more robust and broadly applicable conclusions.

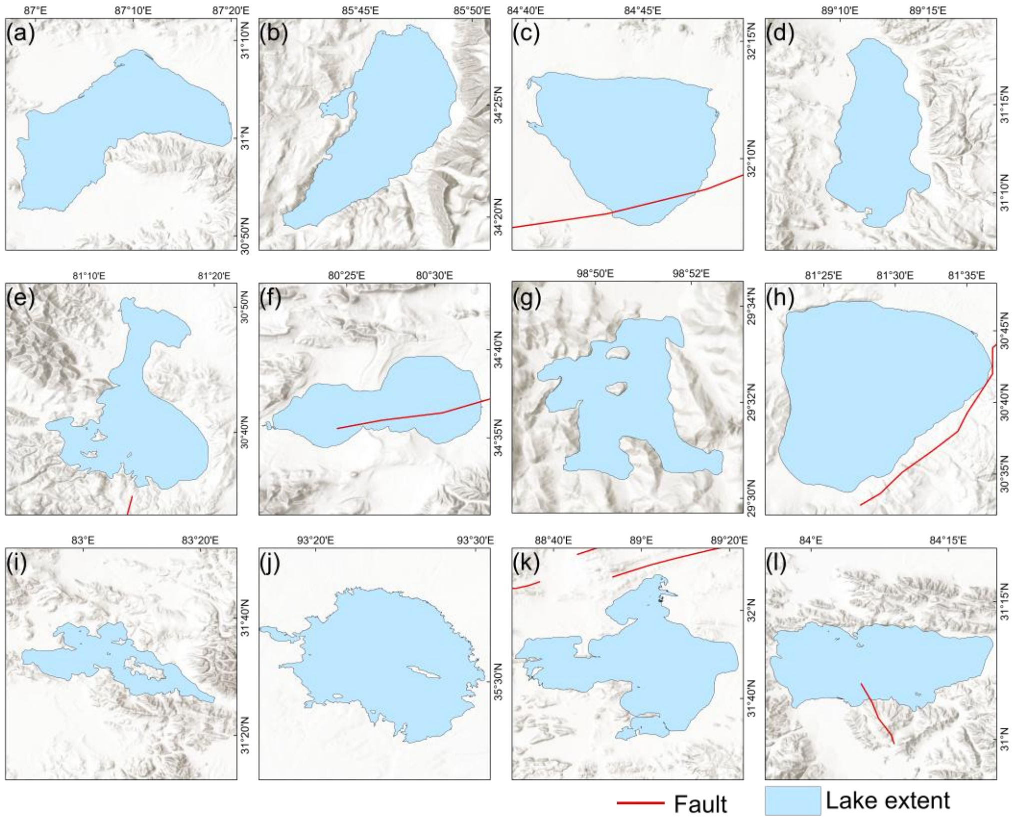

Figure S4. Spatial relationships between major faults (red lines) and the long-axis orientations of the 12 validation lakes. Fault data are derived from Gao et al. (2023).

References

Xu, T., Zhu, L. P., Lü, X. M., Ma, Q. F., Wang, J. B., Ju, J. T., and Huang, L.: Mid- to late-Holocene paleoenvironmental changes and glacier fluctuations reconstructed from the sediments of proglacial lake Buruo Co, northern Tibetan Plateau, *Palaeogeogr. Palaeoclimatol. Palaeoecol.*, 517, 74–85, https://doi.org/10.1016/j.palaeo.2018.12.023, 2019.

Gao, Z.: Seismotectonic map and seismic hazard zonation map of Pan-Third Pole region (1960–2021), National Tibetan Plateau / Third Pole Environment Data Center, https://doi.org/10.11888/SolidEar.tpdc.300783, 2023.

4. It is suggested to include a sensitivity analysis regarding the width of the "dynamic exposed area" used for slope calculation in Discussions.

Response 4: Thank you for this helpful suggestion. In our method, the shoreline slope is estimated from the buffer area (i.e., the "dynamic exposed area") around the lake boundary. Specifically, we adopt a multi-level buffering strategy with a maximum buffer of 600 m and nested buffers at 100 m intervals; a terrain transition point adaptively determines the final buffer extent, and a default buffer of 600 m is used when no transition point is detected.

To evaluate the robustness of the modeled bathymetry to this parameter, we performed a sensitivity analysis by varying the maximum buffer width. We have revised Section 4.2 to discuss the impact of different buffer size: "We further assessed how bathymetry accuracy responds to the distance of the dynamic exposed area used to calculate shoreline slope by testing maximum buffer widths of 300, 600, and 900 m (Fig. 11). The median NRMSEs are similar across the three settings (16.65%, 18.00%, and 18.14%, respectively), indicating that overall performance is not strongly sensitive to buffer width within the tested range. However, error dispersion increases with buffer size, with the 900 m setting exhibiting the largest interquartile range (IQR = 7.72) and a more pronounced upper tail, suggesting that overly wide buffers may incorporate broader-scale topographic signals unrelated to the representative nearshore slope (e.g., terraces or distant hillslopes), thereby degrading performance for some lakes. In contrast, the 600 m setting yields the smallest IQR (6.19) and the most consistent results across lakes; it is therefore adopted as the default in this study. Notably, because our workflow determines an adaptive buffer extent using the multi-level buffering scheme described in Section 2.2.1, the specified value represents the maximum buffer distance and is not necessarily reached for all lakes. In some cases, the optimal buffer is identified at a smaller distance, so the maximum value is not applied." (Lines 473–485).

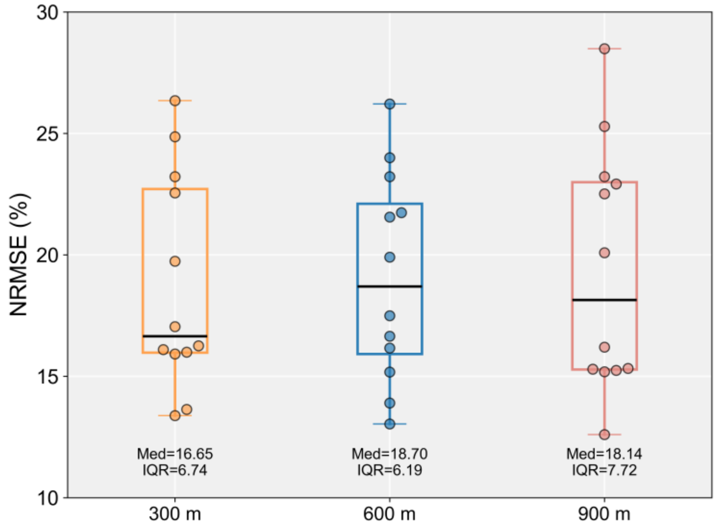

Figure 11. Boxplots of NRMSE (%) from buffer distance sensitivity experiments (300, 600, and 900 m). Box ranges represent the upper and lower quartiles, and whiskers extend to 1.5 times the interquartile range.

5. For the proposed Method, it would be better to suggest a recommended threshold for this exposed zone would provide valuable guidance for users applying this method to lakes with varying bank steepness.

Response 5: Thank you for this suggestion. In our workflow, the "exposed zone" (dynamic exposed area) used for shoreline-slope estimation is defined through a multi-level buffering strategy (100 m intervals) with an upper bound, and the final buffer extent is adaptively determined by a terrain transition point; if no transition point is detected, a default maximum buffer is used.

Based on the sensitivity experiment (maximum buffer = 300/600/900 m), the median NRMSE varies slightly across settings (16.65%, 18.00%, and 18.14%), indicating limited sensitivity within this range. Notably, the 600 m setting yields the smallest interquartile range (IQR = 6.19), reflecting the most consistent performance across lakes. In contrast, a larger maximum buffer (900 m) increases dispersion (IQR = 7.72) and may introduce broader-scale terrain signals unrelated to the representative nearshore slope.

Therefore, we recommend setting the maximum exposed-zone width to ~600 m (≈15–20 pixels for 30 m DEMs) as a default upper bound, together with the built-in adaptive selection. For lakes with steeper banks, we further suggest using a smaller upper bound (e.g., 300–600 m) to avoid mixing distant hillslopes/terraces into the slope fit; for gentle banks, 600 m remains appropriate, and a larger upper bound (e.g., 900 m) should only be used when the nearshore terrain is very flat or when the transition point cannot be identified robustly. As a practical criterion for "bank steepness", users may adopt the mean shoreline slope threshold of ~5° (already used in our parameterization).

We have revised Section 4.2, and users can also refer to the performance of different buffer distances to select an appropriate delineation threshold.

6. The error analysis would be more impactful if it moved beyond listing discrepancies to offering a geomorphological diagnosis of the results. Explicitly linking performance variations (e.g., in Dongcuo and Ngangla Ringco) to factors such as signal-to-noise ratios or structural decoupling would add significant depth to the findings.

Response 6: Thank you for this insightful suggestion. We agree that a geomorphological diagnosis provides more actionable interpretation than a simple error listing. Accordingly, we revised Section 3.1 to explicitly connect performance variations to the signal-to-noise ratio of shoreline-derived slope information, and potential structural decoupling between shoreline topography and lakebed morphology:

"To quantitatively evaluate the accuracy of the simulated bathymetry, we randomly generated 2,500 validation points within each lake boundary and compared simulated depths against in situ measurements. As shown in Fig. 7, the simulated depths exhibit good agreement with observations, with an average *r* value of 0.72 and an average NRMSE value of 19.09%. Because the method assumes that nearshore topography contains informative signatures of underwater slope structure, its performance depends on the signal-to-noise ratio (SNR) of shoreline-derived slope information and the degree of structural coupling between shoreline morphology and lakebed geometry within a basin.

According to Table 2, the method underestimated maximum water depth for several lakes, including Angzicuo, Buruocuo, Longmucuo, Ngangla Ringco, and Taro Co. Among them, Ngangla Ringco (Fig. 7i) shows the weakest agreement. Inspection of the three-dimensional bathymetry (Fig. 6i) reveals an abrupt deepening in the southern part of the lake, indicating a localized bathymetric anomaly and partial shoreline–lakebed decoupling. Such features are difficult to infer from shoreline terrain alone, posing a challenge for approaches that rely primarily on nearshore topographic constraints. In contrast, simulated depths were overestimated for Dongcuo and Mapang Yongcuo. In particular, Dongcuo, with a surface area of 106.80 km² and a maximum depth of 3.99 m, exhibits relatively poor simulation performance despite its shallow depth. This likely reflects the limited depth range and the heightened influence of measurement noise and subtle topographic gradients, which can reduce the robustness of shoreline-derived slope signals and amplify relative errors.

Across all lakes, MAE is strongly correlated with lake depth ($r = 0.94$). For deep lakes such as Buruocuo and Taro Co, where maximum water depths exceed 100 m, MAE values reached 17.33 m and 21.15 m, respectively. This pattern suggests that shoreline–lakebed coupling tends to weaken with increasing depth, consistent with a reduced ability of shoreline-derived constraints to represent deep-basin morphology. Nevertheless, the model maintains acceptable accuracy across a wide range of lake sizes, depths, and morphologies, demonstrating its general applicability for regional-scale bathymetric estimation." (Lines 337–359).

7. The discussion in Section 4.2 regarding the performance of NASADEM versus ALOS PALSAR offers an opportunity for deeper insight. Highlighting the temporal advantage of the older NASADEM (acquired during low stands) rather than focusing solely on spatial resolution would provide a compelling explanation for its superior performance.

Response 7: Thanks for your insightful suggestion. We agree that the performance difference between NASADEM and ALOS PALSAR should not be interpreted solely in terms of spatial resolution. We have revised Section 4.2 to explicitly emphasize the temporal (acquisition-epoch) advantage of NASADEM. Specifically, NASADEM (improved SRTM DEM) was acquired earlier and can preserve more exposed nearshore terrain under relatively lower lake stands, providing more reliable shoreline gradients for our recession-based bathymetry inference. Because our method relies on the water mask and shoreline slope derived from the input DEM, a DEM acquired during lower water levels can better constrain the shore-to-lake transition and reduce error propagation toward the lake center. This temporal factor offers a compelling explanation for why NASADEM outperforms the higher-resolution ALOS PALSAR within our framework.

In response to your suggestion, we revised the manuscript to include the following text: "Beyond spatial resolution, the DEM acquisition time is also critical for our method. Because the algorithm infers underwater elevations from shoreline gradients and a DEM-derived water mask, DEMs acquired at lower lake levels can preserve more exposed nearshore topography. This additional geomorphic information strengthens constraints on shoreline-slope estimation and the subsequent recession simulation. In this regard, the earlier acquisition time of NASADEM may partly explain its better performance compared to ALOS PALSAR, despite the latter's finer spatial resolution." (Lines 444–448).

8. Abstract: A minor adjustment to punctuation in the phrase "Bathymetry data and lake volume two key physical parameters" is recommended.

Response 8: Thank you for your suggestion. The punctuation has been corrected as recommended: "Bathymetry data and lake volume, two key physical parameters of lakes" (Line 25).

9. Section 1: To correct the typo in the header "Introdution".

Response 9: Thanks. We have corrected this typo.