Editor

Dear editor,

Based on the comments of two reviewers, we have made significant modifications to this study, mainly to extend the original simulation of GLOF propagation downstream based on the hypothetical dam failure to a process chain simulation of GLOFs triggered by material movements. Three model were used to simulated the GLOFs process chain, RAMMS model was used for simulation of potential mass movement, BASEMENT model was used to simulate the displacement wave in the lake, Heller-Hager model was used as a calibration for BASEMENT's results, and BASEMENT model was also adopted to simulate the dynamic breaching process of moraine dam, the propagation of flood wave and the inundation in downstream. We described the details of the GLOF process chain's simulation in the methodological section of the manuscript. Based on your hints, we have responded to both reviewers' comments in point-by-point detail. Thank you for your tips and help, again.

Best wishes!

Review#1

Dear reviewer,

We sincerely thank you for your valuable comments on this study. After three months of work, we completed the first major revision of this manuscript according to your comments. The revised version is quite different from the initial version due to the addition of the simulation for glacial lake outburst floods (GLOFs) process chain. We first simulated the movement of triggers using the RAMMS model, GLOFs begin with ice avalanches or landslides. Secondly, we simulated and visualized the wave's propagation in the lake based on the output of the RAMMS model using the BASEMENT model. And then, the overtopping flow and erosion of the moraine dam was simulated using the BASEMENT model. Finally, the hydraulic behavior of GLOFs in the downstream region was also simulated using the BASENMENT model.

In addition, we made some modifications in the **Discussion** section according to your and other reviewer's comments. To batter illustrate the potential danger and the typicality of Bienong Co, we moved the description of outburst potential characteristics of Bienong Co from the original **Discussion** section to the **Study area** section in this revision. Furthermore, we removed the content to developing an updated area-volume relationship for glacial lakes based on published bathymetry data due to the scarcity of samples. However, the peculiarity of Bienong Co was still clarified by comparing with glacial lakes with in-site measurement. Lastly, we made some clarifications of the shortcomings and uncertainties in the simulation of GLOFs.

Note: In this response, the black text is the reviewer's comments, and the blue text is our response where name of section is in boldface and the content in our revised manuscript is in italic font.

This study aims at estimating lake volume and modelling potential GLOF from the Lake Bienong, SE Tibet Plateau. In general, I'm convinced that such studies are needed and are logical step following region-wide GLOF susceptibility assessments. The outcomes might be of interest for research community as well as DRR practitioners.

The authors of this study employ broadly used data (Landsat images, ALSO PALSAR DEM, …) and methods (bathymetric surveying, empirical equations for deriving breach parameters, MIKE11 modelling tool) in new geographical context. As such, this study brings only limited novelty in terms of methodological development and to some extent only replicates the workflows of previous GLOF modelling studies of different lakes. I would maybe expect more novelty in leading journals such as the Cryosphere. Below I provide my comments to individual parts of this study:

The section about lake evolution actually presents no evolution and can be omitted or summarized in one sentence in the Introduction or Study area section in my opinion.

Reply: According to your suggestion, we present this part in **Study area** section. The description is "*The elevation of water surface in 2021 was 4745 m covering an area of 1.15 ± 0.05 km^2 that has experienced less significant changes. Mulang Glacier had an area of 8.29 ± 0.22 km^2 and mean surface slope of ~18.28˚, which has also remained largely unchanged area over the last 45 years. However, the glacier ablation zone experienced a thinning process of 6.5 m/a.*".

The authors defined 4 moraine dam breach (GLOF) scenarios which are then modelled in the MIKE11 and MIKE21 software. However, the moraine dam breach is not the beginning of the process chain, but a consequence of certain triggering event. Considering that this is detailed case study of only one lake, I would expect the authors to analyze the whole process chain in as much detail as possible, i.e. starting with detailed quantitative analysis of potential GLOF trigger which would help to define and justify dam breach scenarios.

However, this is not met in the current version of the manuscript. My major concern is that the breach scenarios are defined subjectively and are not linked to possible GLOF trigger identified in Section 5.1. What is described in Section 5.1. gives mainly qualitative overview of potential GLOF trigger. This is perhaps true for many lakes in the region, but there is no link to considered breach depth scenarios. And this is the major drawback of this study in my opinion.

Reply: By referring to the triggers of the collapsed glacial lakes on the Tibetan Plateau, we assumed two different types of triggers for potential GLOFs of Bienong Co, i.e., ice avalanches and landslides. Ice avalanches come from the tongue of the Mulang Glacier (the mother glacier of Bienong Co), and we assumed three different magnitudes. Landslides come from moraines on both sides of Bienong Co, and we assumed landslide movements at two different locations with different release depths. In this study, ice avalanches and landslides differ in the impulse to the glacial lake and the propagation of displacement waves in the lake caused by the different locations. The description in the manuscription is "*Based on a survey of the environment surrounding Bienong Co, ice avalanches from Mulang Glacier and two locations of lateral moraine landslide were selected as potential triggers for GLOFs. Wang et al., (2012) defined the volume of dangerous glacier as the volume from the location of abrupt changing slope to the glacier termini or the volume of glacier snout where ice cracks are well developed. We adopted the latter, i.e., the crevasse-developed ice body of Mulang Glacier shown in MapWorld image with a surface area of 0.19 km^2 was selected as the potentially ice avalanche source of Bienong Co (Fig. 1a). For the convenience of subsequent description, we name it Scenario A. The elevation difference between the top of the dangerous ice body and the lake surface was measured to be about 155 - 208 m based on ALOS PALSAR DEM. We divided the dangerous ice body into three parts according to elevation range to simulate subsequence processes from ice* *avalanches of different magnitudes (ice avalanche 1, 2 and 3 in Fig. 1b). Scenario A1 was defined as a low-magnitude trigger, ice body at elevation below 4,844 m yields a release area of 0.05 km^2 with the maximum and average elevation differences of 99 m and 75.8 m from the lake surface. Scenario A2 was defined as a moderate-magnitude trigger, ice body at elevation below 4,889 m yields a release area of 0.11 km^2 with the maximum and average elevation differences of 144 m and 102.7 m from the lake surface. Scenario A3 was defined as an extreme-magnitude trigger, the total ice body of crevasse with an area of 0.19 km^2 was set as a release area, with the average elevation difference between glacier surface and lake surface of 131 m. In the above three cases, we assumed that the release depths of ice avalanches are the average elevation differences from the glacier surface to the lake surface, i.e., the glacier is supported by flat bedrock located at the height of the lake water table.*

Lateral moraine landslide as a GLOFs trigger is not common on the Tibetan Plateau, but the GLOF of Jinwu Co in 2020 was caused by a lateral moraine landslide, therefore it was taken as a trigger of the potential GLOF for Bienong Co. Two areas of lateral moraine within the slope range of 30° - 45° were selected as potential landslide sites, one is located on the left bank (in this study, the left and right sides are defined in a downstream-oriented manner) of Bienong Co, near the moraine dam with an area of 0.015 km^2, we named it Scenario B (Fig. 1c). Another is located on the right bank, near the mother glacier with an area of 0.024 km^2, we named it Scenario C (Fig. 1d). Two sites are at different distances from the moraine dam and we set three different release depths of 2 m (Scenario B1 and C1), 5 m (Scenario B2 and C2), and 10 m (Scenario B3 and C3) for each release area as low-, moderate- and extreme-magnitude trigger. Therefore, a total of two different types, three different locations and nine different magnitudes of materials were designed to enter the lake as potential triggers for GLOFs in this study. The above design fully considers the impact of triggers on Bienong Co under different magnitudes, and the results are used as the input for the subsequent disaster chain simulation.

In this study, ice avalanches and lateral moraine landslides of Bienong Co were modeled using the Avalanche module of Rapid Mass Movement Simulation RAMMS model, which has been successfully used for simulating triggers of GLOFs. RAMMS adopts the Voellmy-Salm finite volume method to solve the depth-averaged equations governing mass flow in two dimensions. Based on the basic inputs of DEM, the initial release area and depth, the calculation domain, and the friction parameters μ (the velocity-independent dry Coulomb) and ξ (velocity-dependent turbulent friction terms), the outputs of runout distances, flow height and flow velocity can be calculated. And time series of material entering the glacial lake can serve as the input condition for subsequent simulations. For this study case, the initial release area was determined by combining MapWorld image of the spatial resolution of 0.5 m (https://www.tianditu.gov.cn/) and ALOS PALSAR DEM with a spatial resolution of 12.5 m (https://asf.alaska.edu/data-sets/derived-data-sets/alos-palsar-rtc/alos-palsar-radiometric-terrain-correction/). Values of μ=0.12, ξ=1,000 m s^{-2}, and ρ=1,000 kg m^{-3} for ice avalanche and ρ=2,000 kg m^{-3} for landslide were used, which agree with values used in previous GLOF-producing avalanche models.”

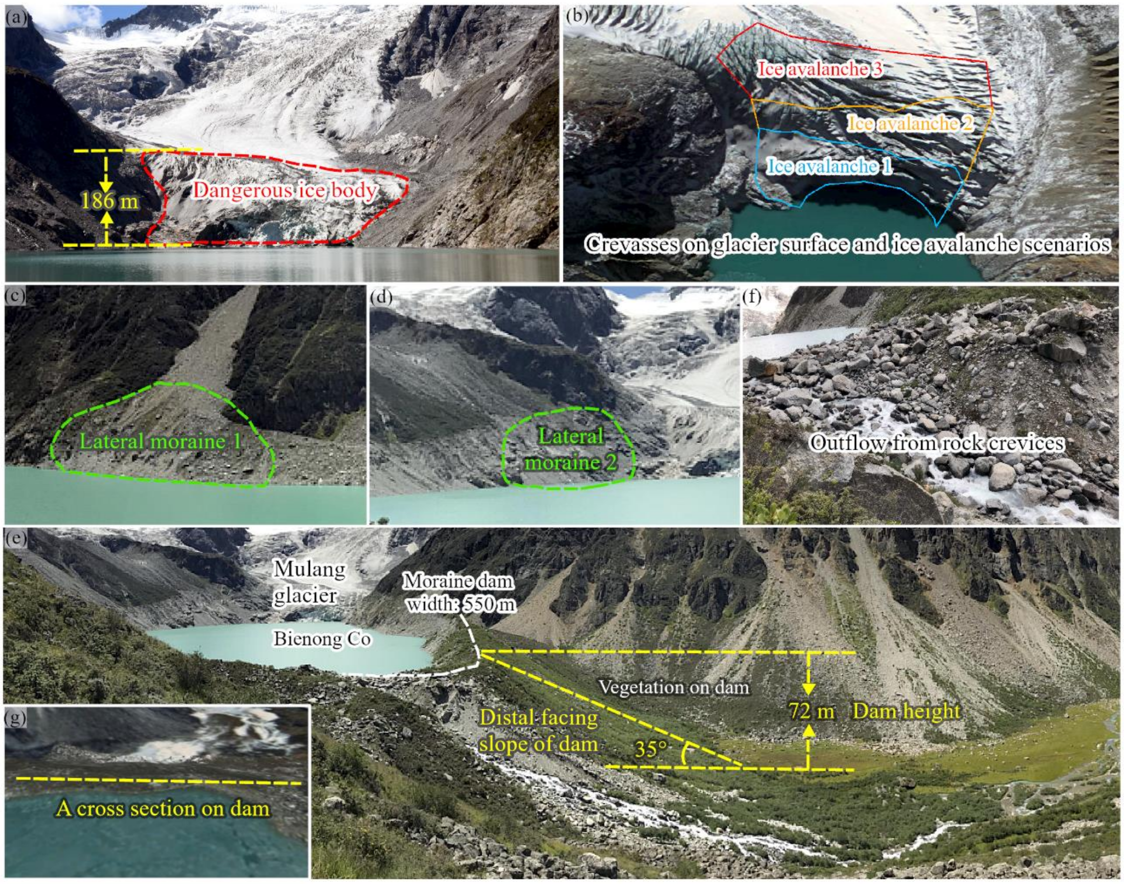


Figure 1. The hazards assessment of Bienong Co. (a) The connection condition of Mulang Glacier and Bienong Co, (b) the crevasses on glacier surface and the assumed ice avalanche scenarios of Mulang Glacier, (c) and (d) the assumed lateral moraine location, (e) and (f) the moraine dam of Bienong Co, and (g) a cross section on the moraine dam for statistic. Fig (b) and (g) is based on the MapWorld image, other pictures were taken by Xiaojun Yao and Qi Wang on Aug 27, 2020.

For instance, I wonder what would need to be the magnitude of triggering slope movement to initiate 72 m deep breach? Is there any evidence that such slope movement could occur in the lake's surrounding? Landslide zones identified in Figure 11 don't seem to be releasing large mass volumes into the lake. Ideally, the initial slope movement, displacement wave propagation in the lake as well as dam breaching would be modelled, not only the GLOF. Critical questions regarding potential GLOF trigger are: Is there any evidence of mass movements entering the lake in the past? Have you observed any evidence from your analysis of remote sensing images and DEMs? Is there any evidence of potential future mass movements (displaced blocks, surface ruptures, opening crevasses, etc.)? Any evidence from your field work? Did any strong earthquake hit the region in the past? Did the lake experience any precipitation / temperature extremes? Do you expect them to change in the future? Considering the scope of the study (case study of one lake), individual trigger should be identified, quantified and treated more in depth in my opinion, feeding the definition of dam breach (GLOF) scenarios.

Reply: In the initial version, the GLOFs was based on the assumed break depth of moraine dam. We assumed an initiate 72 m deep breach of the moraine dam referring the study of Sattar et al. (2021) for the Lower Barun Glacial Lake, in which, the extreme-magnitude GLOFs of Lower Barun Glacial Lake was assumed that breach incision occurs until it reaches the base of the moraine (i.e., 104 m). Based on your suggestions, we identify and quantify the triggers of GLOFs from a more in-depth perspective in this revision. The Mulang Glacier is directly connected to Bienong Co, and the slope of the glacier tongue is steep and crevices are developed. Although, no ice avalanche was observed in our field investigation, we found that collapse occurred at the glacier tongue by comparing the MapWorld image (earlier than 2020, but the exact date is not clear) (Fig 2-left) with the photos taken during the 2020 field survey (Fig 2-right). Earthquake-triggered glacial lake outburst floods are not common in Tibet, China, therefore we ignore this causative factor in this revision. Furthermore, due to the lack of reliable meteorological observations around the lake, there is no way to know whether the glacial lake has experienced extreme precipitation/temperature conditions. However, studies have shown that Jinwu Co, 24 km away from Bienong Co, experienced several days of continuous rainfall associated with the South Asian monsoon immediately prior to the outburst, which contributed to the formation of lateral moraine landslides on the one hand, and increased runoff at the spillway on the other hand. Based on your suggestions, we have simulated the initial slope movement, the propagation of displacement waves, the dam failure, and the downstream flooding behavior in this revision. The initial slope movement originated with the terminus of Mulang Glacier and the landslides of the moraines on both sides. The specific definition of scenarios for ice avalanche and landslide was described in the previous reply.

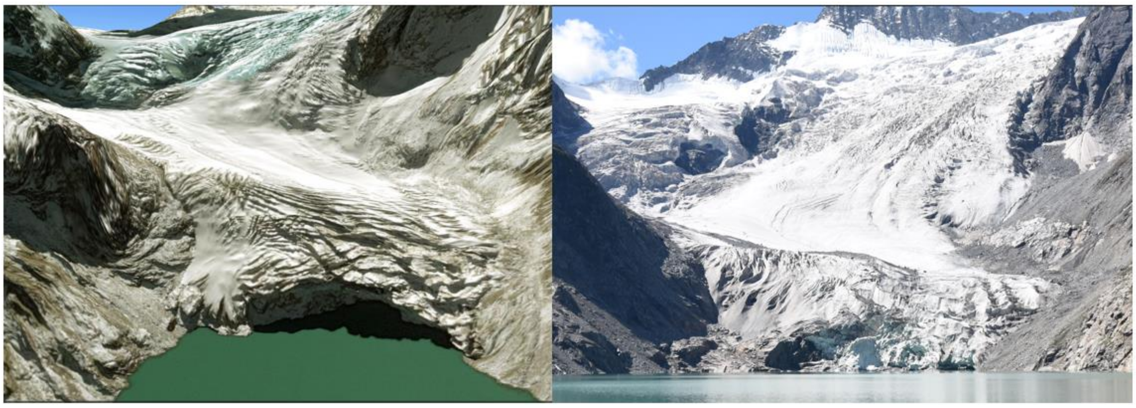


Figure 2. Comparison at the tongue of the mother glacier of Bienong Co in different periods (left: the MapWorld image early than 2020, but the exact date is unknown; right: taken in Aug 27 2020)

For the modelling part (Section 4.3, Table 3, Figures 7 to 10), flow velocities and peak discharge drop in Bada to 0.26 m/s (2,260 m^3/s) in the most extreme scenario, after which it again speeds up to 18.47 m/s (22,992 m^3/s) in Zongri is contra-intuitive and should be discussed / explained. In Figure 10, you even have negative peak discharge in Bada (?). Also the flow velocities of Scenario-1 (S1 to Jiawu; 44 to 65 m/s) seem unrealistically high considering it is supposed to originate from moraine dam breach.

Reply: The Bada village is the object of analysis because it is not located in the downstream channel of Bienong Co, but in another channel that intersects with the downstream channel of Bienong Co. However, in the extreme-magnitude scenario originally simulated, the Bada village was also affected by the huge flood. Therefore, the impact of flooding on it was analyzed. Because the Bada village is relatively far from the main channel of the flood, the flow and velocity are significantly reduced. The flood flows into the cross-section representing Bada village and then flows out in the opposite direction, i.e., exited the region, which is the reason for the negative value of the flow in the later period. In this revision, we fixed this problem by changing the cross section used to measure floods.

Finally, the authors invested a lot of effort in comparing lake volumes (Section 5.2) and lake volume estimates (Section 5.3), but the implications of these comparisons are nebulous to me and the statistical treatment is incorrect. Considering the bathymetry done by the authors, it is clear that: (i) they have the best possible lake volume estimate for their study; (ii) their one bathymetry can hardly be used to validate or evaluate existing area-volume relationships. Strikingly, bathymetric data used to develop the new area-volume relationship (Table 5, Figure 12) are then used for the performance assessment (Tabel 7, Figure 14), which is statistically not correct. Moreover, some of the existing equations (e.g. Fujita's equation developed specifically for Himalayan lakes) are not considered in this comparison. Further, the number of lakes listed in Table 5 is too low to generate any meaningful conclusions about a difference between lakes associated with continental and maritime glaciers. In addition, it seems that simply larger lakes are deeper as you only have one lake > 1 km^2 associated with continental glacier in your dataset while all lakes associated with maritime glaciers are > 1 km^2. This makes the Discussion section overall weak.

Reply: Thank you for the comment. In this revision, we removed the content about the development of area-volume relationship for glacial lakes based on published bathymetry data due to the scarcity of samples. However, information about the volume of water stored in this glacial lake is still stated. Firstly, "*Considering the rarity of bathymetric data but the frequent occurrence of GLOFs in the region, we try to explore more information about glacial lakes in the region by using bathymetry and water storage of Bienong Co. First, relationships with significant correlations for area-volume (Fig .3a), area-depth (Fig .3b) and depth-volume (Fig .3c) of Bienong Co were established (Fig. 3), and the valuable information is pinned on the hope that could provide a data reference for future studies of Bienong Co and other glacial lakes in the region.*" Then, "*We compared the depth and water storage information of Bienong Co with other glacial lakes that have been measured.*". Lastly, "*We estimate the water storage of Bienong Co using published equations based on glacial lakes on the Tibetan Plateau, and the results show that the eight published volume-area/width-length relationships all underestimate the volume of Bienong Co to varying degrees (Tab.1).*" The results show that Bienong Co is the relative deepest glacial lake among these on the Tibetan Plateau that currently have been measured.

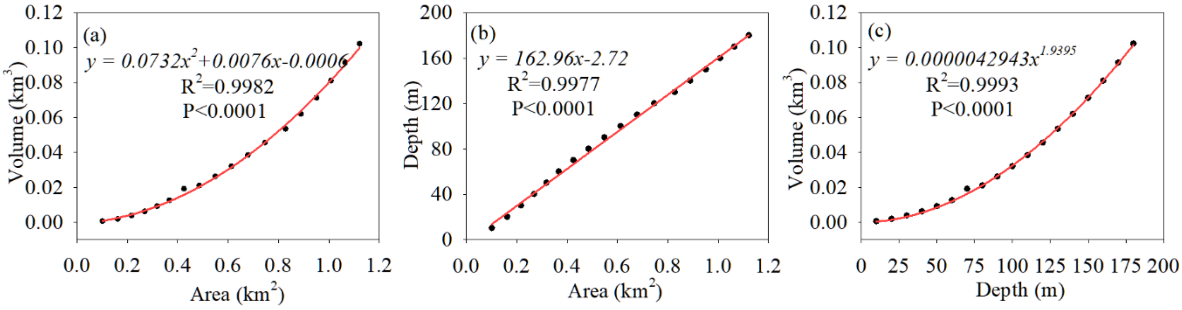


Figure 3. Fitting relationship of (a) area and volume, (b) area and depth and (c) depth and volume of Bienong Co.

Table 1 Calculated volumes of Bienong Co based on published volume-area relationships for glacial lake in Tibetan Plateau.

No	Source		Relationships	Calculated Volume	Error (%)
1	Qi et al., 2022	(1)	$V=0.04066A^{1.184}-0.003207w_{mx}/l_{mx}$	46.9×10^6 m^3	-54%
2		(2)	$V=0.0126A^2+0.0056A+0.0132$	36.3×10^6 m^3	-65%
3	Wang et al., 2012		$V=0.0354A^{1.3724}$	42.9×10^6 m^3	-58%
4	Sakai, 2012		$V=0.04324A^{1.5307}$	53.6×10^6 m^3	-48%
5	Yao et al., 2012		$V=0.0493A^{0.9304}$	56.1×10^6 m^3	-45%
6	Fujita et al., 2013		$V = 0.055A^{1.25}$	65.5×10^6 m^3	-36%
7	Khanal et al., 2015		$V = 0.0578A^{1.5}$	71.3×10^6 m^3	-30%
8	Zhou et al., 2020		$V=0.0717 w_{mx}^2 l_{mx}$	70.3×10^6 m^3	-31%

Note: Error = (Volume of empirical formulas − Bathymetrically derived volume) / Bathymetrically derived volume × 100%.

In additional, we illustrated some shortcomings and uncertainties in the simulation of GLOF. Firstly, "*Trigger is the beginning of the simulated GLOFs process chain in this study and we only consider ice avalanche and landslide scenarios, instead of other factors, such as increased glacial meltwater and heavy precipitation. The magnitude, location and probability of ice avalanche and landslide are the largest sources of uncertainty in this study. Ice avalanche is the trigger for over 70% of GLOFs on the Tibetan Plateau, but there is no reliable reference of the magnitude including release area and depth of previous ice avalanche events. Ice avalanche in this study come from the mother glacier tongue where the slope is relative steep and fissures are well-developed. We simulated three different-magnitude ice avalanches, each scenario assumes that the ice body breaks off in the vertical direction until to the lake surface, which is unrealistic and may overestimate the volume of ice avalanche. In addition, we also consider landslide as a trigger given the failure of Jinwu Co in 2020. Two release areas were selected by referring the slope and location of Jinwu Co's landslide, however, the release depth has no quantified reference data and we assumed three release depths of 2 m, 5 m and 10 m for each release area to simulate the consequences resulting from as many scenarios as possible.*" Secondly, "*the grain size distribution of moraine dam of Bienong Co was not obtained in this study, and the simulation was performed by referencing an inventory of glacial lakes in the Indian Himalaya. Although the data used have been validated to be reliably general, the grain size distribution of the moraine dam of Bienong Co itself would be more useful for an accurate simulation of moraine dam's erosion.*". Finally, "*DEM data are the most important basic data affecting the downstream propagation of GLOFs in this study. ALOS PALSAR DEM data with a spatial resolution of 12.5 m have been widely used in studies related to cryospheric changes and disasters. In this study, the DEM was pre-processed to fill sinks, but there was still the phenomenon of flood water being piled up in some deep puddle during the simulation, i.e., there were errors in the DEM data, especially in the relatively narrow valley. We have manually smoothed several large bumps according to the elevation of the upstream and downstream. However, there are still some smaller bumps that converge the flow to a section of the flow channel, mainly in the downstream area.*".

Table 4: if the lake has a surface outflow, dam freeboard = 0m.

Reply: Thank you for your tips, we used a freeboard of 0 m as the parameter for the simulation in the revised study.

Mean breach (Eq. 3) is used as max. breach in Figure 6; please check

Reply: In this revision, the dam-break process was re-simulated with the BASEMENT model, and Equation 3 and Figure 6 are discarded. We appreciate your comment.

I think that especially GLOF trigger need to be addressed in more detailed and quantitative way first, resulting in re-definition and justification of dam breach scenarios. Also the Discussion section should be re-worked substantially in my opinion. To sum up, I recommend major revisions of this manuscript.

Reply: In this revision, we have simulated the GLOFs process chain, including the initial slope movement, the generation and propagation of wave in the lake, dam breaching and the floods behaviors in the downstream channel starting from quantifying the trigger according to your suggestion. And, for the **Discussion** section, we focused on the water storage of Bienong Co and uncertainty analysis of GLOFs process chain simulation.

Review#2

Dear reviewer,

We sincerely thank you for your valuable comments on this study. After three months of work, we completed the first major revision of this manuscript according to your comments. The revised version is quite different from the initial version due to the addition of the simulation for glacial lake outburst floods (GLOFs) process chain. We first simulated the movement of triggers using the RAMMS model, GLOFs begin with ice avalanches or landslides. Secondly, we simulated and visualized the wave's propagation in the lake based on the output of the RAMMS model using the BASEMENT model. And then, the overtopping flow and erosion of the moraine dam was simulated using the BASEMENT model. Finally, the hydraulic behavior of GLOFs in the downstream region was also simulated using the BASENMENT model.

In addition, we made some modifications in the **Discussion** section according to your and other reviewer's comments. To batter illustrate the potential danger and the typicality of Bienong Co, we moved the description of outburst potential characteristics of Bienong Co from the original **Discussion** section to the **Study area** section in this revision. Furthermore, we removed the content to developing an updated area-volume relationship for glacial lakes based on published bathymetry data due to the scarcity of samples. However, the peculiarity of Bienong Co was still clarified by comparing with glacial lakes with in-site measurement. Lastly, we made some clarifications of the shortcomings and uncertainties in the simulation of GLOFs.

Note: In this response, the black text is the reviewer's comments, and the blue text is our response where name of section is in boldface and the content in our revised manuscript is in italic font.

This is an interesting paper that investigates a glacial lake and conducts analyses aiming to assess its evolution, basin morphology, estimate its water volume, analyses some possible outburst trigger analysis, and conducts simulations of likely inundation under GLOF scenarios. In general, the paper does a good job of developing these themes and forms a comprehensive case study that could be published given some reasonably substantial changes. I list these here and also some more specific issues with the paper.

Reply: We greatly appreciate your approval of this study and we have made some improvements in this revised version.1 The paper is often written in a rather vague and imprecise way. In addition, there is often an incorrect use of English. I sympathise with the authors in this; it is difficult for non-English speakers to write precisely and accurately in English but this paper would benefit enormously from careful editing and rewriting by a native English speaker.

The literature review is generally comprehensive although there are some papers that should have been referenced and I highlight some of these later. The rationale for the study is clear and appropriate.

Reply: Thanks for your approval and your full understanding of our language issues. Combining Reviewer 1's and your comments, we made significant modifications to the manuscript.

3 The sampling strategy and methodology is not clearly discussed. Explain why this lake was chosen. Is this lake representative of others in the region? If so, why and how do you know this? If the lake is not representative, then the authors need to explain its significance.

Reply: Maritime glaciers and moraine-dammed glacial lakes are widely developed in the Southeastern Tibetan Plateau where several GLOFs occurred in recent years. Three GLOFs have occurred in the Yi'ong Zangbo Basin, and there are several glacial lakes assessed as having highly potential of failure, including Bienong Co. Bienong

Co has a relatively high potential of failure, mainly because it is directly connected to its mother glacier, which has a crevasse-developed and steeply sloping terminus. Secondly, both sides of Bienong Co widely distributed loose moraine material with slope greater than 30°, which could slide into the lake under continuous precipitation, thereby undermining the stability of the glacial lake. Jinwu Co, a glacial lake is only 24 km away from Bienong Co, and broke in 2020 due to an initial lateral moraine landslide. The above two features indicate that Bienong Co has the most common triggers that cause most of the GLOFs in Tibet, China, i.e., ice avalanches and landslides. Thirdly, Bienong Co has an area of above 1.1 km^2, which is a relatively large size for most glacial lakes. And the bathymetry data shows that it has a larger depth, indicating that a relatively large amount of water could be released. Fourthly, the moraine dam of Bienong Co is high and steep and consists of loose moraine material. Therefore, Bienong Co is considered to have a high potential of failure as well as be representative of the region. Meanwhile, Bienong Co has been paid more attentions by local government for many settlements in the downstream region, as well as the only road for this region.

4 The methodologies used are explained and justified well, and you have used an appropriate range of techniques to explore the geomorphology, characteristics and evolution of the lake and its future behaviour.

Reply: Thank you very much for your affirmation of the method adopted in this study. However, according to the comments of Reviewer 1, the simulation of this study still has some shortcomings. We adopted more comprehensive models and methods to simulate the process chain of GLOFs.

5 I am interested in why Bienong Co is regarded as a dangerous lake (lines 100 and 239)? The paper demonstrates that the lake has remained stable for some time, and that it cannot expand further. It also argues that the moraine dam does not contain an ice core. So the description of the lake as 'dangerous' requires much more discussion and evidence. This is important because there is always the temptation to describe any moraine - dammed lake as being 'dangerous' even when the evidence for this is lacking. I know of one well-known reviewer of similar papers who regularly rejects all papers who make this assertion without clear evidence!

Reply: Thank you for your comments. The outburst potential is controlled by multi factors, and Bienong Co has GLOF potential under the comprehensive evaluation in several literatures. The small areal variation and the absence of ice cores in the moraine dam are two features that are not conducive to breach. While, other factors such as the connection with the mother glacier, the steep slope and developed fissure at the mother glacier tongue, the loose moraine on both sides, the relatively large area and depth of the lake, and the high and steep moraine dam are factors that are conducive to the failure of Bienong Co. Therefore, we believe that Bienong Co is potential of failure when considered all factors together.

The description in manuscript is "*The area of Bienong Co has remained basically stable in the past 40 years, but it's area of 1.15 ± 0.05 km^2 in 2021 is almost twice the size of the two nearby failure glacial lakes, one is Jinwu Co and the other is Ranzeria Co, which is located just 9 km southeast of Bienong Co. The moraine dam of Bienong Co has an average height of 72 m, enclosing a water volume of 65.2×10^6 m^3, accounting for 64% of the total (Fig. 1e). The greater the volume of water retained in the lake, the greater the volume of water available for potential flooding, and the greater the hazard caused by GLOFs. GLOFs are extremely complex phenomena, each of them is a distinctly unique event with the characteristics determined by the triggering mechanism, lake hypsometry, the geometry, composition, and structural integrity of the moraine dam, as well as the topography and geology of the* *flood path. Studies of history GLOFs reveal that the most common cause of glacial lakes' failure in the Himalaya is mass movement (snow, ice, and/or rock) entering lakes and subsequently overtopping and eroding the moraine dam. Bienong Co is directly connected to Mulang Glacier whose ablation zone that is defined as the mother glacier tongue in this study has an average slope of 20˚ with well-developed ice crevasses (Fig. 1a and b). Lv et al., (1999) proposed that a slope of mother glacier tongue greater than 8˚ is conducive to the occurrence of ice avalanche. In the context of global warming, glacial meltwater can lubricate the glacier itself, increasing the likelihood of overhanging ice sliding into the lake. Therefore, ice disintegration from the Mulang Glacier could be a potential trigger for GLOFs of Bienong Co. In addition, the GLOF of Jinwu Co, a moraine dammed glacial lake located about 24 km to the southeast of Bienong Co, was caused by an initial moraine landslide with slope range of 30˚ - 45˚ on the left side. Bolch et al. (2011) and Rounce et al. (2016) both deemed that non-glacierized areas around a lake with a slope > 30° are potential rock fall, landslide, or other solid mass movement region. There are multi locations with lateral moraines around Bienong Co that fit into this slope range (Fig. 1c, d and e). Thus, lateral moraine landslides could also be a potential trigger for Bienong Co's GLOF.*".

"*Dam characteristics, such as dam geometry (freeboard, width to height ratio, distal face slope), dam material properties, ice-cored moraine conditions govern the stability of the dam. Freeboard refers to the vertical distance between the lake level and the lowest point on the dam crest, which reflects the minimum wave amplitude needed for the occurrence of the overtopping, and a higher freeboard is not conducive to the occurrence of overtopping. A natural outlet with a width of ~50 m in the right of the dam (facing downstream) (Fig. 1e and f), indicating the freeboard of Bienong Co is 0 m, which signals the high potential overtopping of the lake. The moraine dam is 550 m wide and the height is variable with an average height of 72 m and the width-height ratio of 7.64 (Fig. 1e). According to the thresholds favoring GLOFs of dam width smaller than 60 m proposed by Lv et al. (1999), width-height ratio smaller than 0.2 proposed by Huggel et al. (2004), the moraine dam of Bienong Co is stable. However, freeboard of 0 m and the distal facing slope of 35˚ are the conditions conducive to GLOFs based on the favoring thresholds of smaller than 25 m and larger than 20˚. The moraine dam of Bienong Co is covered with vegetation, the surface layer is a larger particle size of the stone, below the smaller particle size, the material is loose and poorly cemented, which is susceptible to destruction by water forces (Fig. 1e). The existence of ice core inside the moraine dam is unknown, but there is no ice core in Jinwu Co's breached dam. The dam crest elevation of Bienong Co is 320 m higher than that of Jinwu Co. Additionally, McKillop and Clague (2007) argued that moraines with rounded surfaces and minor superimposed ridges are considered ice-cored, whereas narrow, sharp-crested moraines with angular cross-sections are interpreted as ice-free, and the dam of Bienong Co clearly fit the latter category. In summary, we consider that the potential threats to Bienong Co are mainly from its mother glacier's ice avalanches and lateral moraine landslides.*"

6 The paper forms a detailed and comprehensive assessment of the site and models some plausible GLOF inundation scenarios. But this is essentially a paper about one lake and therefore could be criticised as being a bit parochial. What does this say about moraine-dammed lakes more generally? Why is this paper significant enough to be published in a mainstream journal like The Cryosphere? It therefore needs much more wider context, and some sense of why the techniques you used are an advance on other similar work, or why you have provided new insights. Otherwise, you have just provided an interesting case study.

Reply: At present, most of the studies of glacial lakes in the maritime glaciation zone of the Southeastern Tibetan Plateau focus on the analysis of glacial lake changes and identification of potentially dangerous glacial lakes, etc. There are few or no published studies on glacial lake depth measurements, lake basin simulations, water volume calculation and the GLOFs simulation. Therefore, the work of this study is of great significance for understanding the basin morphology and glacial lake depth, as well as the water storage of the terminal moraine-dammed lake in the maritime glaciation zone. In addition, the simulation of GLOFs from ice avalanche and lateral moraine landslide to wave generation and propagation in lake, dam erosion and breach, and downstream flood behavior are carried out using the RAMMS Avalanche module and the BASEMENT model in this revision. The simulation of GLOFs process chain provides research paradigm and reference for the simulation of other glacial lake breaches in the region in the future.

7 The title mentions water storage, but little is made of this in the paper. How does it compare with other lakes in the region?

Reply: Bathymetry data accurately reflects the basin morphology of the glacial lake, based on which the water storage of a lake can be calculated. In **Results** section, we simulated the morphology of Bienong Co and estimated its water volume. However, the description of the title does not use "water storage" but "volume", perhaps the former would be better. Comparisons with other lakes in this region are not covered because few bathymetric data for other glacial lakes in the region are currently available. However, in this revision, we compared the water storage of Bienong Co with other glacial lakes having bathymetry data in the **Discussion** section and calculated the water storage of Bienong Co using the currently available area-volume relationship for glacial lakes in the Tibetan Plateau, and the results show that these formulas all underestimate the water storage of Bienong Co in different degrees, which reflects the larger relative depth of Bienong Co and the unique characteristics of glacial lakes in maritime glacierized zone.

8 Under the modelling scenarios presented here, some villages downstream will be completely inundated by the largest GLOF. What are the ethical issues that derive from such an analysis. I agree that we should prepare such assessments but the local inhabitants will be rightly concerned. I'm interested in their views of such analyses.

Reply: The two GLOFs that occurred in the Yi'ong Zangbo Basin have caused serious disasters in the downstream region. The outburst of Ranzeria Co in July 2013 resulted in missing persons, destroyed houses, and serious damage to bridges, roads, and other infrastructure, with direct economic losses of up to 270 million yuan. The outburst of Jinwu Co in June 2020 caused no casualties, but did cause significant damage to infrastructure (such as roads and bridges) and property damage in downstream areas. In addition, Bienong Co is a combination of glacier and glacial lake with beautiful scenery and is a representative of the local Tibetan religious beliefs. GLOFs disaster, therefore, is always an extreme concern for the local government, and during our survey, there was local government staff involved. This study could provide some theoretical help to local governments in understanding this glacial lake. For residents, due to the presence of settlements, infrastructure and farmland, engineering measures such as lowering water levels are most likely to be used to mitigate potential threats based on the potential hazards generated by Bienong Co's GLOF.

Fig 8. Difficult to differentiate colours in depth assessments.

Reply: We changed this expression in this revision.

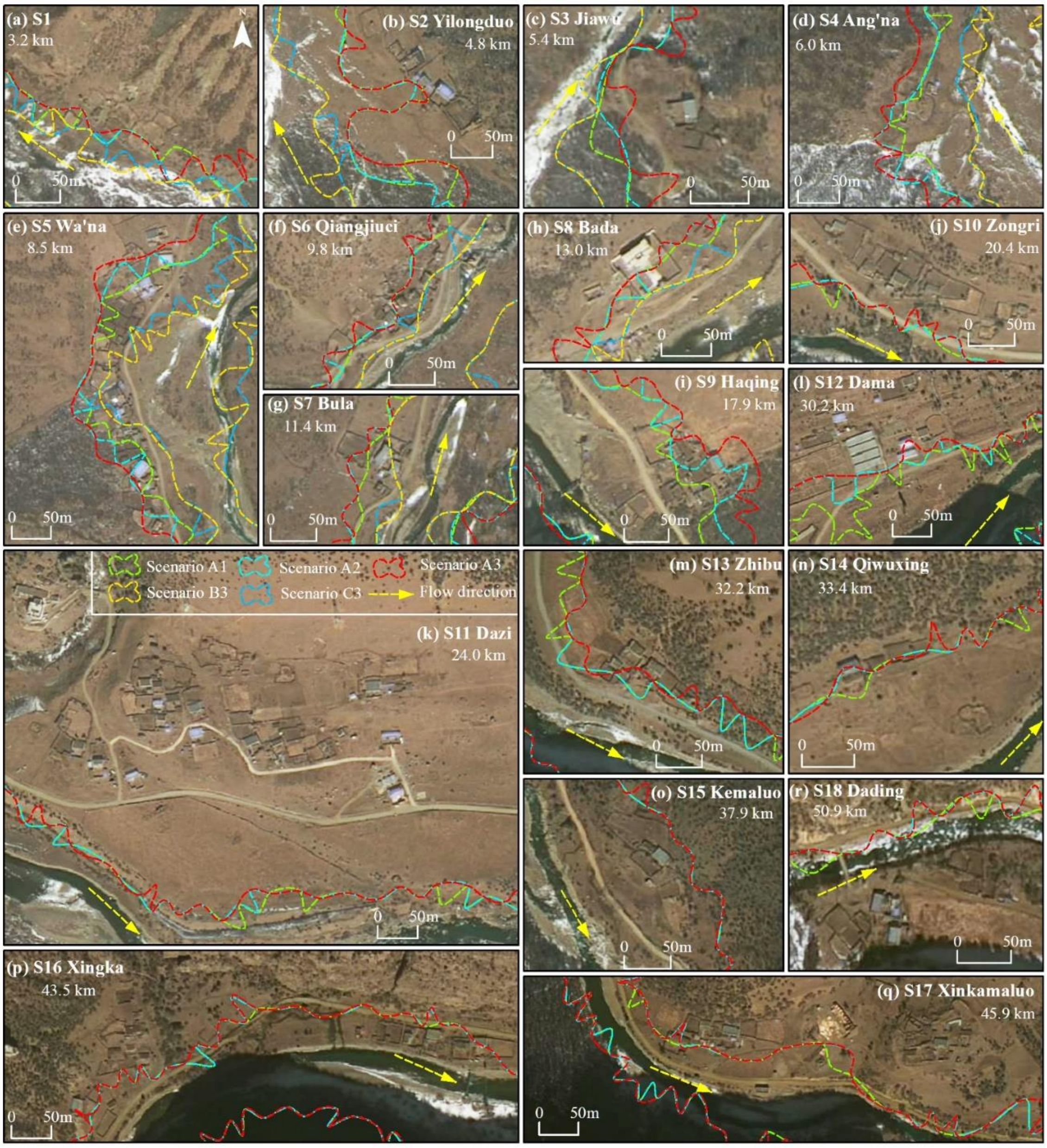


Figure 12. The potential threat of GLOFs to settlements and roads in the downstream under different ice avalanches and landslide scenarios (the background is MapWorld image).

Specific issues.

Line 9. Omit 'the' after 'hazard to'

Reply: We are sorry for this grammar error and thank you for the tip.

Line 10 Insert 'the' before 'potential'.

Reply: We are sorry for this grammar error and thank you for the tip.

Line 11 Explain the typology of 'maritime'. These glaciers aren't maritime (meaning close to the sea).

Reply: China has the largest amount of mountain glaciers at low-and middle-latitude regions in the world. Based on the development conditions and physical properties, glaciers in China are divided into continental glaciers and maritime glaciers. Continental glaciers are distributed from the Altai Mountains in the north, to the Northern Slope of the middle Himalayas in the south, from the Pamirs in the west, and to the Lenglongling and Anyemaqen Mountains in the east. They are characterized by low recharge, weak ablation, high snow line, low temperature, slow movement speed, and weak geological and geomorphological effects. According to the Second Chinese Glacier Inventory, the glacier number (37,770) and area (46,200 km^2) account for 81. 4% and 77.8% of the total number and area in China, respectively. Maritime glaciers are mainly located in the eastern and southern parts of the Himalayas, the eastern and middle sections of the Nyingchi Tanggula Range, and the Hengduan Mountains on the Southeastern Tibetan Plateau. They are characterized by abundant recharge, strong ablation, low snowline distribution, high temperature, fast movement, and strong geological and geomorphological effects. The number of glaciers (8,607) and area (13,203 km^2) account for 18.6% and 22.2% of the number and area of glaciers in China respectively. Maritime glaciers are not distributed on the seashore, but their development and changes are controlled by the Indian monsoon. Table 1 shows the main features of continental glacier and maritime glacier in China. In this study, the Yi'ong Zangbo Basin is located in the Southeastern Tibetan Plateau and therefore is a maritime glaciation zone.

Table 1 The main features of continental glacier and temperate glacier in China (Shi et al., 1964; Yang 1991; Su et al., 2000; Ding 2012)

Glacier type	Climate	Average annual precipitation/ mm	Average annual temperature/ °C	Average summer temperature/ °C	Ice-forming effect	Ice temper-ature	Motion speed/ (m a^{-1})
maritime glaciers	Indian Monsoonal circulation climate	1000~3000	>-6	1~5	Warm soaking-Recrystallization	-1~0	>100
continental glaciers	Highland monsoon and continental climate	200~1000	<-6	<3	Soaking-Freezing	<-1	10~100

References:

1 *Ding Yihui. Environmental Characteristic of West China and Its Evolution. Beijing: Science Press. 2002: 166-173.*

2 *Shi Yafeng, Xie Zichu. The characteris- tics of existing glaciers in China. Acta Geographica Sinica. 1964. 30(3): 183-208.*

3 *Su Zhen. Shi Yafeng. Response of monsoonal temperate glaciers in China to global warming since the little ice age. Journal of Glaciolgy and Geocryology. 2000. 22(3): 223-229.*

4 *Yang Zhenniang. Glacier Water Resources in China. Lanzhou: Gansu Science and Technology Press, 1991.*

Line 12 Cite: Harrison, S., Kargel, J.S., Huggel, C., Reynolds, J., Shugar, D.H., Betts, R.A., Emmer, A., Glasser, N., Haritashya, U.K., Klimeš, J. and Reinhardt, L., 2018. Climate change and the global pattern of moraine-dammed glacial lake outburst floods. The Cryosphere, 12(4), pp.1195-1209.

Reply: Thank you for recommending this paper to us and we will make citations where appropriate.

Line 13 'such as the ice and/or rock avalanches'. There is no need for the definite article (ie 'the) when the noun is plural. This rule applies throughout this paper.

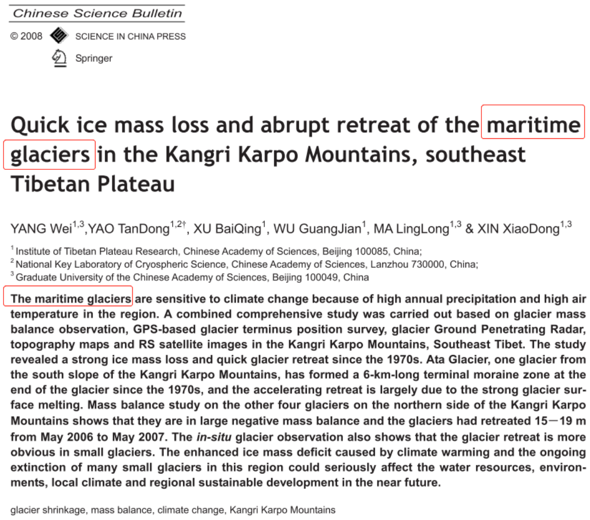
Reply: Thanks a lot for your guidance on our grammar. We correct this situation throughout the text.

Line 14 Sentence starting 'Study shows…'. This sentence requires rewriting. It is ambiguous and vague. This is also an hypothesis and presupposes that we understand the link between climate change, glacier recession and GLOF incidence.

Reply: Unfortunately, our description of this sentence confused the reader. What we were trying to convey here is that the area of Bienong Co is relatively large for most smaller glacial lakes. However, the area of the glacial lake has not undergone a dramatic expansion in the last 40 years. In this revision, we weakened the glacial lake evolution and emphasized the simulation of GLOFs process chain, so this sentence was removed from the abstract.

Line 48 Re 'maritime glaciers'. Reword this sentence. Maritime is the wrong description of these glaciers. This means close to the sea.

Reply: Literally, maritime means close to the sea, and the glacier in the study is not near the sea. However, this writing style was adopted in published papers (such as the following two papers), so we used this writing style.



Chinese Science Bulletin

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Quick ice mass loss and abrupt retreat of the maritime glaciers in the Kangri Karpo Mountains, southeast Tibetan Plateau

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The maritime glaciers are sensitive to climate change because of high annual precipitation and high air temperature in the region. A combined comprehensive study was carried out based on glacier mass balance observation, GPS-based glacier terminus position survey, glacier Ground Penetrating Radar, topography maps and RS satellite images in the Kangri Karpo Mountains, Southeast Tibet. The study revealed a strong ice mass loss and quick glacier retreat since the 1970s. Ata Glacier, one glacier from the south slope of the Kangri Karpo Mountains, has formed a 6-km-long terminal moraine zone at the end of the glacier since the 1970s, and the accelerating retreat is largely due to the strong glacier surface melting. Mass balance study on the other four glaciers on the northern side of the Kangri Karpo Mountains shows that they are in large negative mass balance and the glaciers had retreated 15—19 m from May 2006 to May 2007. The *in-situ* glacier observation also shows that the glacier retreat is more obvious in small glaciers. The enhanced ice mass deficit caused by climate warming and the ongoing extinction of many small glaciers in this region could seriously affect the water resources, environments, local climate and regional sustainable development in the near future.

glacier shrinkage, mass balance, climate change, Kangri Karpo Mountains

Articles Chinese Science Bulletin

SPECIAL TOPIC
Glacial Retreat and Its Impact on Lakes in Tibetan Plateau

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Glacial distribution and mass balance in the Yarlung Zangbo River and its influence on lakes

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Glaciers in the Yarlung Zangbo River witness severe glacial retreat nowadays, which gives important influence on lake processes in the region. We have studied glacial distribution, glacial mass balance and found large deficit in glacial mass and its impact in the region. Our study also integrated the variation in glacial-fed lakes of the Nam Co and Ranwu Lake, and presented an initial assessment of the impact of glacial mass balance on lakes. The study has shown a significant contribution of glacial melting to recent lake expansion and lake level rising.

Yarlung Zangbo River, glacial distribution, glacial mass balance, lake variation

Line 51 Sentence starting 'Therefore'. I completely understand what you are trying to say here....but the use of language is incorrect.

Reply: Unfortunately, our description of this sentence was so succinct that it confused the reader, and we rewrote the sentence.

Line 71 Delete 'Whereas'.

Reply: Thank you for your tips, we have corrected it.

Line 82 I don't agree with this. USV are used quite a lot. Lots of other examples. Cite: Wilson, R., Harrison, S., Reynolds, J., Hubbard, A., Glasser, N.F., Wündrich, O., Anacona, P.I., Mao, L. and Shannon, S., 2019. The 2015 Chileno Valley glacial lake outburst flood, Patagonia. Geomorphology, 332, pp.51-65. Also papers therein.

Reply: Bathymetric data of glacial lakes in China on the Tibetan Plateau are extremely scarce. In recent years, the unmanned vessels have been used for glacial lake bathymetry, but the extremely harsh natural environment and poor traffic conditions make this application still rare.

Line 149 the data acquisition module, the data acquisition module. This is repeated.

Reply: Sorry for our carelessness, here is a mistake that it should be the data acquisition module, the data transmission module.

Line 239 Why is the lake described as 'dangerous' if it is stable?

Reply: Here we may not have described it clearly enough. The stability of Bienong Co refers that its area remains unchanged. But the surrounding environment, such as the mother glacier, the lateral moraine, and climate are unstable, and they may act on the glacial lake to destroy the original stability, thus may inducing GLOFs. In this revision, we describe it as "*The area of Bienong Co has remained basically stable in the past 40 years, but it's area of 1.15 ± 0.05 km^2 in 2021 is almost twice the size of the two nearby failure glacial lakes, one is Jinwu Co* *and the other is Ranzeria Co, which is located just 9 km southeast of Bienong Co. The moraine dam of Bienong Co has an average height of 72 m, enclosing a water volume of 65.2×106 m^3, accounting for 64% of the total. The greater the volume of water retained in the lake, the greater the volume of water available for potential flooding, and the greater the hazard caused by GLOFs. GLOFs are extremely complex phenomena, each of them is a distinctly unique event with the characteristics determined by the triggering mechanism, lake hypsometry, the geometry, composition, and structural integrity of the moraine dam, as well as the topography and geology of the flood path. Studies of history GLOFs reveal that the most common cause of glacial lakes' failure in the Himalaya is mass movement (snow, ice, and/or rock) entering lakes and subsequently overtopping and eroding the moraine dam. Bienong Co is directly connected to Mulang Glacier whose ablation zone that is defined as the mother glacier tongue in this study has an average slope of 20° with well-developed ice crevasses. Lv et al., (1999) proposed that a slope of mother glacier tongue greater than 8° is conducive to the occurrence of ice avalanche. In the context of global warming, glacial meltwater can lubricate the glacier itself, increasing the likelihood of overhanging ice sliding into the lake (Wang et al., 2015). Therefore, ice disintegration from the Mulang Glacier could be a potential trigger for GLOFs of Bienong Co. In addition, the GLOF of Jinwu Co, a moraine dammed glacial lake located about 24 km to the southeast of Bienong Co, was caused by an initial moraine landslide with slope range of 30°-45° on the left side. Bolch et al. (2011) and Rounce et al. (2016) both deemed that non-glacierized areas around a lake with a slope > 30° are potential rock fall, landslide, or other solid mass movement region. There are multi locations with lateral moraines around Bienong Co that fit into this slope range. Thus, lateral moraine landslides could also be a potential trigger for Bienong Co's GLOF.*

Dam characteristics, such as dam geometry (freeboard, width to height ratio, distal face slope), dam material properties, ice-cored moraine conditions govern the stability of the dam. Freeboard refers to the vertical distance between the lake level and the lowest point on the dam crest, which reflects the minimum wave amplitude needed for the occurrence of the overtopping, and a higher freeboard is not conducive to the occurrence of overtopping. A natural outlet with a width of ~50 m in the right of the dam (facing downstream) (Fig. 2e and f), indicating the freeboard of Bienong Co is 0 m, which signals the high potential overtopping of the lake. The moraine dam is 550 m wide and the height is variable with an average height of 72 m and the width-height ratio of 7.64. According to the thresholds favoring GLOFs of dam width smaller than 60 m proposed by Lv et al. (1999), width-height ratio smaller than 0.2 proposed by Huggel et al. (2004), the moraine dam of Bienong Co is stable. However, freeboard of 0 m and the distal facing slope of 35° are the conditions conducive to GLOFs based on the favoring thresholds of smaller than 25 m and larger than 20°. The moraine dam of Bienong Co is covered with vegetation, the surface layer is a larger particle size of the stone, below the smaller particle size, the material is loose and poorly cemented, which is susceptible to destruction by water forces. The existence of ice core inside the moraine dam is unknown, but there is no ice core in Jinwu Co's breached dam. The dam crest elevation of Bienong Co is 320 m higher than that of Jinwu Co. Additionally, McKillop and Clague (2007) argued that moraines with rounded surfaces and minor superimposed ridges are considered ice-cored, whereas narrow, sharp-crested moraines with angular cross-sections are interpreted as ice-free, and the dam of Bienong Co clearly fit the latter category. In summary, we consider that the potential threats to Bienong Co are mainly from its mother glacier's ice avalanches and lateral moraine landslides.".

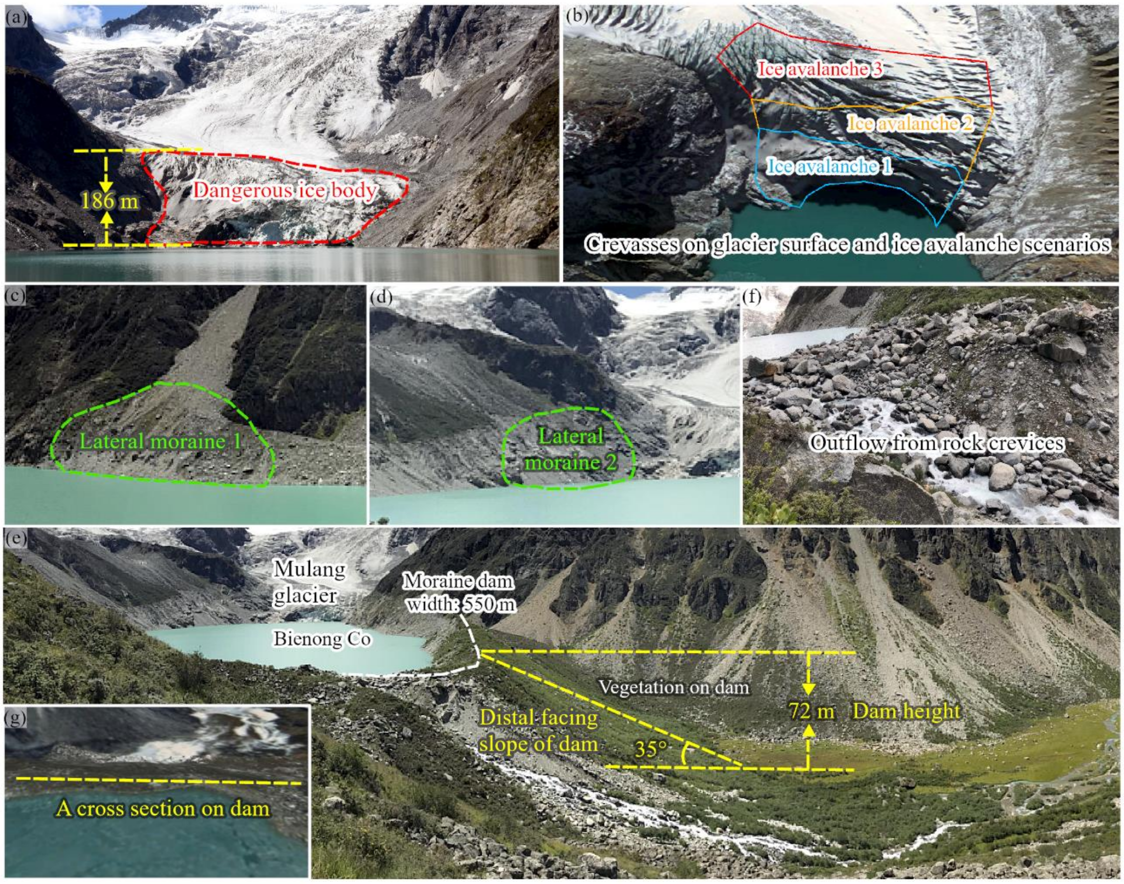

Figure 2. The hazards assessment of Bienong Co. (a) The connection condition of Mulang Glacier and Bienong Co, (b) the crevasses on glacier surface and the assumed ice avalanche scenarios of Mulang Glacier, (c) and (d) the assumed lateral moraine location, (e) and (f) the moraine dam of Bienong Co, and (g) a cross section on the moraine dam for statistic. Fig (b) and (g) is based on the MapWorld image, other pictures were taken by Xiaojun Yao and Qi Wang on Aug 27, 2020.

Line 273 Where is the evidence that strong earthquakes can produce a full-depth incision in a terminal moraine?

Reply: A full-depth incision in moraine dam was informed by the hypothesis of Sattar et al. (2021) for Lower Barun Glacial Lake, for which they set the extreme scenario of the outburst incision reaching the bottom of the moraine (104 m) due to the initial erosion of the overtopping floods. Our assumption is to simulate the impact of an extreme-magnitude GLOF on the downstream region, but the occurring possibility of the scenario is poorly considered. Reviewer 1 also questioned this assumption. Therefore, we paid enough attention to this situation and improved it. According to Reviewer 1's suggestion, we simulated the GLOF process chain starting with detailed quantitative analysis of potential trigger, followed by the generation and propagation of waves in the lake, the erosion of the dam by overtopping floods, and the resulting flood in the downstream region.

Line 296 the ~52.98 km downstream. Explain this.

Reply: We only study the impact of GLOFs in the downstream channel within the distance of ~53 km from Bienong Co.