

Reply to the Comments

We would like to thank the two referees for their further suggestions and constructive comments, which helped to improve the paper. The changes in the manuscript are highlighted in blue color. Our item-by-item responses to the comments are provided below.

Reviewer #1

The authors did substantially revise the paper. The paper is better structured now, and unreasonable elements of the results are revised.

Two final suggestions:

Line 281: "indicate that the glacier may develop towards destabilization". As you don't know if the glacier will destabilize, I suggest something like "that the glacier may develop into a less stable regime."

Reply: We have modified the text following the suggestion.

Line 395: "getting more active towards destabilization". Similar to my above comment to line 281.

Reply: We have done the modification.

Reviewer #2

L14: rephrase to say that "few opportunities have presented themselves to assess the potential hazards of a glacier prone to detachment" or something similar.

Reply: The sentence has been modified following the suggestion.

L26: Feels like a jump from the information you have provided in the abstract so far. Can you clarify this statement?

Reply: The sentence now reads "With a combined analysis of the geomorphic, climatic, and hydrologic conditions of the glacier, we suggest that the flow of the glacier tongue is mainly controlled by the glacier geometry, while the presence of an ice-dammed lake and a supraglacial pond implies a hydrological influence as well."

L 36: tens of km seems a bit on the high end

Reply: The words have been modified to "more than ten kilometers".

L37: typical volumes = $10^6 - 10^7$, full range would be 10^6 to 10^8

Reply: Corrected.

L86: what do you mean by sand slate? Slate is a clayey rock, I don't think something like sand slate exists.

Reply: We have modified the relevant part, please see Line 85-91.

L86: What are these grains? Sandstone and slate probably do not have grains with diameters of 2-5 cm. That would be a conglomerate. Are you talking about sediment found in the region? That is pretty large... please clarify.

Reply: We have clarified that the glacier lies on a sequence of glacial deposits, Wangkun till. The till is mixed breccia composed of angular, poorly sorted gravels of slate, meta-sandstones, and mudstones (Song et al., 2005).

L87: What do you mean by rock fragments that are filled with fine-grained sediments?

Reply: The sentence has been modified to avoid misunderstanding.

L140: here and everywhere else, change TanDEM to TanDEM-X DEM (TanDEM-X is the satellite, TanDEM-X DEM is the dem generated from the satellites data).

Reply: Done.

L149: higher accuracy than HMA DEM?

Reply: The vertical accuracy of HMA DEM was reported with an accuracy of 3.01 m in the Karakoram region, Tibet Plateau (Kumar et al., 2020). However, the TanDEM-X DEM has a nominal accuracy of 2 m in vertical direction. We have added a citation (Kumar et al., 2020) here.

L198: The figure in the supplementary material shows huge variations in the data. Would be nice to add this information here for a bit more context...

Reply: We have added a sentence at Line 202: "Huge variations of the elevation differences can also be observed (Fig. S3), highlighting the heterogeneous penetration differences between the two SRTM DEMs."

L208: it's not clear to me how you came up with this empirical value...

Reply: We have clarified that the value was estimated from the seasonal snow depth in the KLP region (Tian et al., 2014).

L282: What do you make of the "swollen body" as you call it? Just the healthy state of the glacier during that time? Evidence of an instability? A little bit more explanation would be useful.

Reply: The satellite images show that the glacier tongue has a swollen body in 1975, while the body becomes flat in 2021. This change indicates the continued ice loss of the tongue in the past decades, and the glacier is in a negative mass balance state. We have explained this in the revised paper.

L290: "The lake peaked in summer and decreased in winter" -> is this always the case or just once? Formulate statement to clarify this.

Reply: The sentence now reads "The lake area in summer was commonly larger than that in winter. The area larger than 10000 m² all occurred during July and September."

L312: What is going on in the ASTER DEM difference (Fig. S6)? There seem to be large, non-random offsets between this and the TanDEM-X DEM... I'm not sure these results could be trusted...

Reply: It is true that the ASTER DEM has large errors. However, the large errors are mainly distributed near the mountain ridges and steep slopes, which thus would not remarkably affect the elevation differences over the KLP-37 glacier. We have clarified this in the revised paper, please see Line 324-325 and Line 331.

L321: Delete sentence "Note the estimate..." You've already stated that this is problem, and presented your solution. I think you could even move some of the explanation of how you derive the influence on the measurements into the methods section and then only provide the results here.

Reply: We have deleted the sentence as suggested. The relevant words have also been rewritten.

Fig5: I find it counter-intuitive that blue = elevation decrease and yellow/red = elevation increase. Also, it would be very helpful if you could put the dates of the two DEMs used for every results figure into the figure panel directly, so that the reader does not have to refer to the text to remember the dates.

Reply: The color of Fig. 5 has been changed by using the red color representing elevation decrease. The date of each DEM has also been labeled.

Fig 7: Why are there gray bars between the tongue and the cirque region that are not attributed to either?

Reply: The yellow, cyan, and green bars correspond to the elevation ranges of glacier cirque, transfer zone, and glacier tongue as shown in Fig. 6, respectively. We have added this description in the caption of Fig. 7.

L400: there are two Aru Glaciers (Aru-1 and Aru-2 in Kääh et al., 2018). Change the wording in the paragraph to reflect this or specify which Aru glacier you are referring to.

Reply: We have specified the Aru-1 or Aru-2 glacier when referring to the Aru glacier.

L403: I don't see how the gravitational potential energy is a function of the geometry of the glacier, but rather a function of the height and mass of any given point. Clarify why the geometry is relevant in this context.

Reply: The sentence now reads "the glaciers' widths gradually narrowed from the source region to the tongue, thus resulting in a large amount of ice mass accumulating at the glacier front and further leading to large gravitational potential energy there."

L406: How did you estimate this volume? Are the two decimals justified for this estimate?

Reply: We estimated the ice volumes for the two scenarios based on the ice thickness map derived by Farinotti et al. (2019), who provided an ensemble-based estimate for the ice thickness distribution of all glaciers included in the Randolph Glacier Inventory (RGI) apart from the Greenland and Antarctic ice sheets (See Method Section 3.4, Page 11). We have clarified that the increase of decimals for the

volume values would not affect the runout distance estimates significantly.

Fig. 10: label legend, don't put label over the content of the figure. Also, why does part of the glacier not have a thickness estimate, but the tongue is wider below it?

Reply: The ice thinness map of Farinotti et al. (2019) was derived based on the Randolph Glacier Inventory (RGI). However, the outline of KLP-37 from RGI does not include the glacier tongue region KLP-37. We have clarified this in the Method (Section 3.4) and in the caption of Fig. 10.

L433: What do you mean by “the landform”? Do you just mean the glacier tongue?

Reply: We have modified it into “the glacier front landform” to avoid misguide.

L437: very complicated way of saying that a global permafrost map classifies the area as permafrost with very high likelihood. I suggest rephrasing, because the reader initially thinks that you mapped permafrost yourself.

Reply: The sentence now reads “Global permafrost extent mapping by Obu et al. (2019) also classifies the glacier front area as permafrost with very high likelihood”.

Section 5.1: I am a bit confused by this part of the discussion, because you introduced this as the glacier tongue throughout the paper... I think you need the rephrase this part of the discussion slightly to explain why one could also consider this something that is not part of the glacier. I would say try to make this fairly short and limit to most important key factors only. Otherwise it takes away from the main message of the paper.

Reply: We have rewritten the paragraph to make it more clear. The relevant explanations have also been shorted.

L466: I think there are better papers to cite, or at least additional ones here, especially Faillettaz et al. between 2011 and 2016 and Pralong and Funk around 2005/2006.

Reply: The references have been replaced to Faillettaz et al., (2015) and Pralong and Funk (2005).

L486: Can you see any evidence of upstream ice accumulation in the DEM differences?

Reply: We have modified the sentence to: “The abrupt velocity increase below 4800 m between 2015 and 2016 could likely be the result of mass accumulation, as evidenced by apparent elevation increase above 4700 m from the DEM difference between 2010 and 2014 (Fig. 5g)”.

L525: Which publication are you referring to here? There is no Käab 2020 in your bibliography...

Reply: The citation has been modified to Käab et al. (2021a).

L544: I don't understand what you mean with the sentence about adding to the diversity. Please clarify.

Reply: We have added some explanations in the relevant paragraph.

L545: You mention the geometry of the glacier throughout the paper, but the point that you are trying to make has not become entirely clear to me yet. It seems that you are suggesting that the particular

geometry of this glacier makes it more prone to detaching, but it seems to me that the narrowing at the tongue rather provides important buttressing. However you see this, I think it would be worth stating your points a bit more explicitly.

Reply: Thanks for the reminder. We agree that the narrowing at the tongue could provide a buttressing effect for the upstream ice mass. However, on the other hand, the specific shape also prevents the glacier from adjusting its geometry to the changed driving stresses with the accumulation of ice mass. This thus continuously increases the stresses on the frozen terminus and margins, until reaching a critical point where the resisting force is eventually overcome and an acceleration or detachment occurs. We have clarified these two effects in the revised paper (Line 488-492).

L550: Not really three-dimensional, rather one type of 2-D (horizontal) and one type of 1-D (vertical), so I think it is better to just say horizontal and vertical.

Reply: The words have been revised.

L553: It would be interesting to hear your assessment of what critical signs of further destabilization could be. Up-glacier growth of the fast-moving zone? Additional crevassing? Further acceleration of the front? Appearance of shear margins along the edges?

Reply: Good suggestion. We have added a sentence here, and please see Line 567-569.

“Particular attention should be paid to the critical signs pointing to further destabilization, such as the further acceleration of the glacier front, up-glacier growth of the fast-moving zone, additional surface crevassing, and appearance of shear margins along the edges.”

L567: Change in flow direction – also a point that I’m not sure how it plays into the dynamics. Similar to the V-shaped geometry, I think it’s worth clarifying throughout the manuscript why you think that this is important (other than the fact that the Aru glaciers also had a bit of a bend in them).

Reply: The sentence now reads “The change of flow direction of the glacier at an elevation of about 4800 m due to the local topography, coupled with the “V” shape of the glacier tongue geometry, presumably leads to large ice mass and stress accumulating at the glacier front and plays a crucial role for the surge-like behavior”. We have also added some clarifications at Line 488-492 and Line 558.

L568: how does the hydrology influence the tongue? Do you have any evidence for this happening? Otherwise maybe make this statement more carefully? This topic was not brought up again during the discussion, so it comes as a surprise in the conclusion because I don’t think you have adequately made this point. It’s fine to say that hydrology may play a role but that the mechanisms of it are not clear, but I think you need to be a bit more specific.

Reply: We have added some clarifications in the discussion part (Section 5.2, Line 510-515) to show how does the hydrology may influence the tongue dynamics. We also clarified that the mechanisms of the hydrological effects are not clear in the Conclusion part (Line 585).