Response to Reviewer 1

We thank the reviewer for their detailed and helpful comments on our manuscript. Below we present our point-by-point response. The reviewer's comments are in black and our answers in blue.

General comments:

This study investigates the thinning patterns, surface mass balance and dynamics of neighboring two debris covered glaciers on the SW Tibetan Plateau using UAV-SfM data and in situ measurements (debris thickness, GPR…). Authors find distinct characteristics in thinning patterns, but similar mass balance patterns and they hint at effect of the supra glacial ponds and ice cliffs on the melt patterns and they draw conclusions on the ice dynamics.

The data used in this study are rich, and the comparison of the two glaciers is interesting. However, I find the writing to be vague in many places and at times difficult to follow, Numerous results re-introduced in the discussion section (for ex the analysis of data from Hugonnet et al, and Dehecq et al), while this can be rather used to support the current findings. Also, I find there is not enough evidence of the topographic characteristics, no mention on slope controls or the distribution of ice cliffs and ponds with slope and with elevations. The mapping of ponds and cliffs is only mentioned in passing. While the results are rich, the reader gets somewhat lost as they need to be better condensed.

Another key point is that there is not a thorough discussion of the co-registration of the DEMs, and all figures (except Fig 7 and 8 from the global data) present the results clipped to the glacier outlines (thinning, bn, velocity) and so the bias on the stable terrain cannot be evaluated.

I suggest a through revision of the manuscript as well as outing this comparison of the 2 glaciers in a wider perspective. See below the specific comments.

Reply: We thank the reviewer for their constructive perspective on our manuscript. In response to both reviewers, we have revised the results and discussion sections for clarity and to provide a wider perspective, as requested. We also reworked the text for completeness with respect to the several points the reviewer mentions, and we respond to each of these detailed points below.

1. ***Analysis of Hugonnet et al (2021) and Dehecq et al (2015) datasets.***
   Following your suggestion, we have shifted this part ('*Glacier change in the early twenty-first century*') from the discussion section (*L420-443*; *Figure 8 and Figure 9*) to the result section in the new

manuscript.

2. ***Clarification of the contribution of ice cliffs and ponds.*** We have now moved Table 5 and Figure 7, previously in the discussion section, to the results section. We have also added the following sentences in the results section:

   L298-303: "*To better evaluate the role of emergence velocity replenishment on thinning, we calculated the ratio of emergence velocity to surface mass balance (Table. 5). The greater of the absolute value of this ratio indicates the greater impact of emergence velocity replenishment on thinning ('-1' indicates perfect compensation of ablation by ice flow). The ratio of annual emergence velocity and annual surface mass balance for 23K (resp. 24K) Glacier is -0.09 (-0.49). The ratio values for 23K (24K) Glacier during cold and warm periods are -0.11 (-0.87) and -0.09 (-0.15), respectively. The ratio absolute values for 24K Glacier are always higher than those for 23K Glacier, and this is especially evident in the non-ablation period*".

   L318-321: "*By extracting the ablation contribution of the ice cliffs and supraglacial ponds (Fig. 7), we found that the total melt from ice cliffs and supraglacial ponds areas accounted for 31.5 ± 2.2% of the total melt in the UAV survey area for 23K Glacier and 11.4 ± 1.3% for 24K Glacier*".

3. ***Analysis of slope controls***. We carried out the analysis of the slope controls for the two glaciers, and investigated the distribution of ice cliffs and ponds (during the warm period) with respect to slope and with elevation by determining, for each elevation band, the density of stream-influenced ice cliffs, as well as the mean slope (i.e., the longitudinal gradient; Fig. S8). We found that the slope of 24K Glacier is consistently higher than that of 23K Glacier. The mean slope of each zone (A-F) of 23K Glacier increases with altitude, while 24K Glacier has the opposite slope pattern. There is a correlation (r = -0.85; p-value = 0.03) between the density of ice cliffs and supraglacial ponds and mean slope on 24K Glacier (i.e., the lower the slope, the higher the ice cliff density), but there is no clear relationship for 23K Glacier. The added figure (in SI) is shown below.

   Other studies (e.g., Kneib et al., 2023) have highlighted the relationships between ice cliff distribution and the dynamic state of a glacier, whereby a stronger dynamic state results in a higher density of

ice cliffs and ponds and debris thickness, where the thinner the debris cover the higher the density of ice cliff and pond) of debris-covered glaciers. The dynamic state of 23K Glacier is weak (promoting the formation of ice cliffs related to the presence of ponds), but its thicker debris cover (relative to 24 Glacier) restricts more extensive development of ice cliffs (stage 3a, Kneib et al., 2023). 24K Glacier is more dynamically active, but its relatively thinner debris facilitates the development of ice cliffs along supraglacial channels via debris remobilization (stage 2, Kneib et al., 2023).

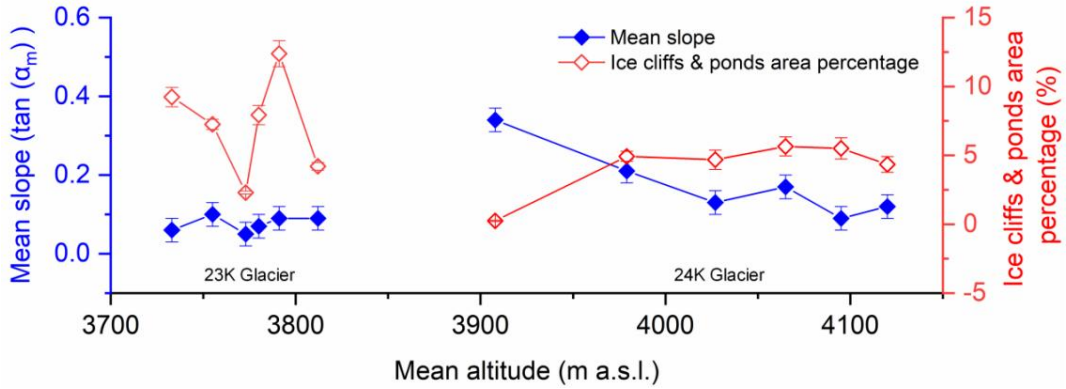


Figure S8: The mean slope (blue solid line) and the mean area percentage of the ice cliffs and supraglacial ponds (red solid line) for the individual zones of the two glaciers.

We added some additional explanations in the discussion (L366-369): "The *ablation area of 23K Glacier is largely stagnant with a low thinning rate (> -0.5 m a^{-1}) and the lower mean surface velocities and reduced driving stress, which favor the presence of supraglacial ponds that enable the persistence of relatively large pond-influenced cliffs (Quincey et al., 2007; Sakai and Fujita, 2010; Miles et al., 2017; Kneib et al., 2023). On the contrary, due to a steeper longitudinal gradient and stronger ice flux, 24K Glacier is characterized by thinner debris which, combined with the steeper gradient, allows for the development of supraglacial streams and corresponding stream-influenced cliffs (Mölg et al., 2020; Kneib et al., 2023)".*

We also added the following sentence to the Discussion section (L340-341): "*We found that the mean longitudinal gradient of 24K Glacier (~0.18) is consistently higher than that of 23K Glacier (~0.08), which explains the faster surface velocity of 24K Glacier due to higher driving stress (Fig. S8)*".

4. ***Delineation of ice cliffs and supraglacial ponds.*** We have now expanded the description of how the ponds and ice cliffs map is obtained in section 3.5 (L226-229): *"We manually extracted ice cliff and supraglacial pond outlines from the flow-corrected orthomosaics*

(August 2020 and October 2020; August 2019 and August 2020; October 2019 and August 2020). The outlines of the ice cliffs and supraglacial ponds area were obtained by taking the union of the outlines before and after each study period (Brun et al., 2018), thereby encompassing the entire planimetric area affected by ice cliff backwasting (Mishra et al, 2021).The total area of icecliffs and supraglacial ponds for each zone was estimated by summing the area of the individual features".

5. ***Coregistration of DEMs.*** We thank the reviewer for their query, which highlights that we were not clear enough regarding our processing of the DEMs. In fact, we do not co-register the DEMs, because the source imagery has been precisely registered at the time of acquisitions. Specifically, we applied Post-Processed Kinematic (PPK) and real-time kinematic (RTK) techniques during the survey flights and ensured that the static base stations were fixed at the same location for different surveys. As we outline in section 3.1, we estimated the XYZ positional error of our UAV-SfM data products by using a combination of on-glacier ground validation points (October 2020 only), and by analyzing the location of boulders located on stable, off-glacier terrain (remaining data products). We summarize these data in Tables 2 and 3. Propagated errors for our DEM differencing pairs are <0.10 m, which is comparable to results for Parlung No.4 (Yang et al., 2020), which was surveyed in a similar manner.

   This is the related description in the manuscript: *"A Huaxing A10 GNSS GPS was used as a static base station (Fig. S1b; fixed position for different surveys), and these data were attached to EXIF metadata of every geotagged image (Yang et al., 2020) and thereby integrated into a Post-Processed Kinematic (PPK) correction workflow to improve the accuracy of the UAV-SfM reconstruction. The DJI Phantom 4 real-time kinematic (RTK) UAV is permanently connected to a GNSS receiver (D-RTK 2, Fig. S1d), so that each survey image already has its high-precision position information embedded".* (L126-131)

   Following your comment, we have now added the following sentences in section 3.3: *"We applied the Post-Processed Kinematic (PPK) and real-time kinematic (RTK) and ensured that the static base stations were fixed at the same location for different surveys, which lead to DEMs with only very small minor offsets in XYZ (Yang et al., 2020). Therefore, we did not perform the co-registration of DEMs for the*

thinning (dh) calculation".

6. ***Off-glacier values.*** We show the spatial distribution maps (thinning, surface velocity) including both glacial and non-glacial areas and present them in the appendix section. Most of the non-glacial area is close to zero in surface elevation change, but there are some unusual spots at the domain edges. We believe that some of the unusual spots are related to data quality (insufficient photo overlap in marginal areas), and some are related to seasonal changes in vegetation and snow (e.g., north lateral valley of 24K Glacier). To better show the results of the glacial area, we have retained the previous distribution map in the manuscript:

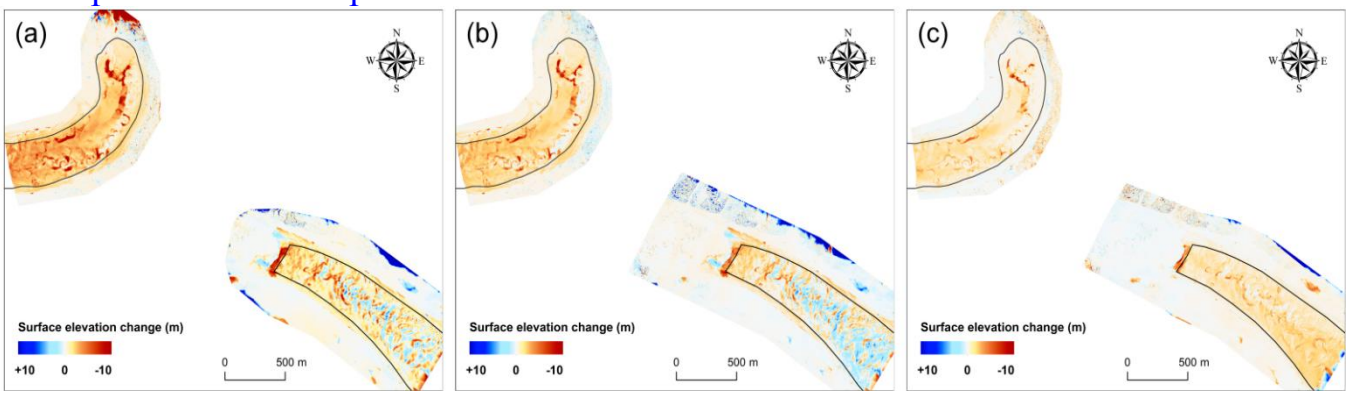


Figure S6: Annual surface elevation changes between UAV-derived DEMs for August 2019-August 2020 (a), surface elevation changes of the cold period (b) and the warm period (c) for the 23K Glacier and 24K Glacier.

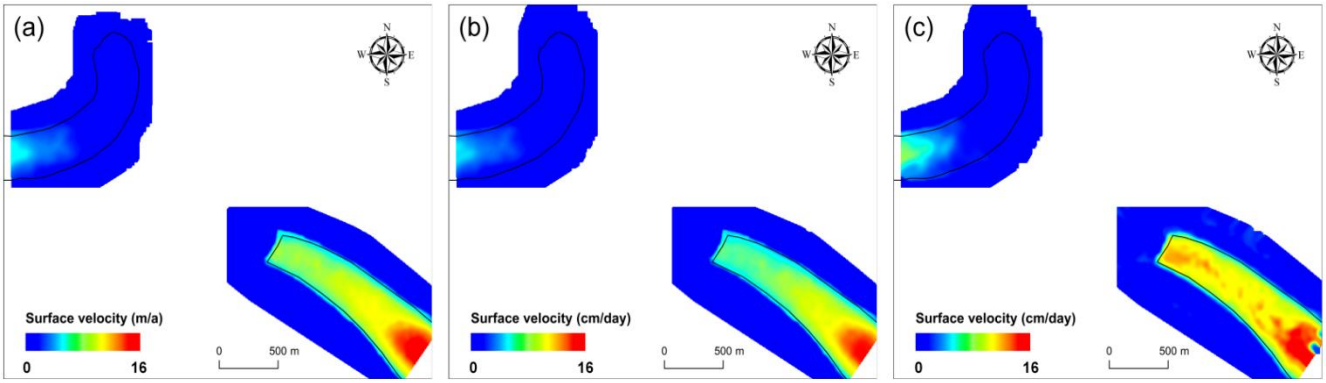


Figure S7: Annual surface velocity for August 2019-August 2020 (a), daily surface velocity of the cold period (b) and the warm period (c) for the 23K Glacier and 24K Glacier.

Specific comments:

Abstract

I strongly suggest refraining from the use of acronyms on the abstract. These can be introduced later.

Reply: Thank you. We have removed the acronyms (SMB, UAV) in the abstract.

L 15 remove “change” or rephrase “a better understanding of the way these glaciers change” etc…
Reply: Following your suggestion, we have removed “*change”* in this sentence. We re-wrote the sentence as: “*A better understanding of these glaciers is necessary to reduce the uncertainties of the regional water resource variability...*”. (L15)

L 16 I suggest removing dh and SMB acronyms
Reply: Done.

L 18 give the time period
Reply: The period is 13th Aug. 2019 - 20th Oct. 2020. We rewrote the sentences as follows: “*In this study, we quantify seasonal thinning and surface mass balance patterns of two neighboring debris-covered glaciers (23K Glacier and 24K Glacier) in the southeastern Tibetan Plateau with repeated unpiloted aerial vehicle surveys and in-situ measurements (13th Aug. 2019 - 20th Oct. 2020).*” (L16-18)

L 19 does not say much, be more specific with regards to “distinct”; L 20 “all periods” --> the time period was not specified yet.
Reply: We re-wrote the sentence as follows: “*We observe that the thinning magnitude of the 23K Glacier is ~1.4-3.0 times greater than that of the 24K Glacier at all periods (annual, cold period, warm period)*”. (L19-20)

L 20 “which is mainly driven” rewrite here - the magnitude of dh one glacier cannot be driven by the dynamics of the other - and dh is not the result of ice dynamic states but rather influenced by topo-climatic conditions, debris cover etc.. Terms need clarification here
Reply: We deleted the “*...which is mainly driven by the stronger dynamic state of 24K Glacier*”. And we re-wrote the sentence as follows: ”*The surface movement velocity of 24K Glacier is higher than that of 23K Glacier (~5-6 times) at all periods.*”

L 21 – 26 are vague, for ex what do you mean by “the contrasted behavior is valid in the 21st century..” etc.
Reply: We deleted the “*the contrasted behavior is valid in the 21st century*” in the abstract.

Introduction
L 31 is this % based on the given refs?
Reply: Yes, they (southeastern Tibetan Plateau: ~17-19%; global scale:

~4.4%-7.3%) are based on the Scherler et al. (2018) and Herreid and Pellicciotti (2020).

L 33 quantify "close"
Reply: We have changed the "*Notably, the rate of thinning of debris-covered glaciers is close to that of debris-free glaciers in the southeastern Tibetan Plateau (Neckel et al., 2017; Brun et al, 2019; Ke et al., 2020)*" to "s*everal studies also confirm the strong surface thinning of debris-covered glaciers in the southeastern Tibetan Plateau (debris-covered glaciers: -0.52 - -0.83 m* a^{-1}*; debris-free glaciers: -0.50 - -0.52 m* a^{-1}*; Neckel et al., 2017; Ke et al., 2020)*". And we have shifted this sentence to the next paragraph.

L 34 the link is not clear, what is the research gap if the rates of debris-covered glaciers are known. "therefore" is perhaps not the good link word. Suggest splitting the phase in two (way too long) and make clear what the gap is, and why the GLOF link is
Reply: We deleted the sentence related to the rates of debris-covered glaciers. And we reconstructed the sentences as follows: "*A better understanding of the evolution and mass balance patterns of debris-covered glaciers in the southeastern Tibetan Plateau is essential for constraining changes in regional water resources (Zhang et al., 2011; Neckel et al., 2017). Because potentially hazardous glacial lakes can develop on or in front of debris-covered glaciers (Wang et al., 2011; Allen et al., 2019), and because glacier thinning may affect slope stability (Kääb et al., 2021; An et al., 2022; Zhao et al., 2022), expanding this knowledge base may also inform understanding of mountain geohazards".*

L 40 this is contradictory with what was said on l 33 - are rates "close" or "considerably different"? Also, the global distribution of DC is already presented on l 30, merge these two paragraphs
Reply: We have changed "*...and their response to climate change is considerably different to that of debris-free glaciers due to the melt-buffering effect of supraglacial debris cover that exceed a few centimeters in thickness*" to "*The presence of debris can influence the glacial response to climate change due to melt-buffering effect of supraglacial debris cover that exceed a few centimeters in thickness*"in L40. We also deleted the "*Debris-covered glaciers are globally widespread (Scherler et al., 2018; Herreid and Pellicciotti, 2020)*" here.

We introduce the characteristics of the southeastern Tibetan Plateau (high thinning rate & high percentage of debris-covered area) and the

importance of investigating debris-covered glaciers in this region in the first paragraph. In the next paragraph, we introduce the "debris-covered glacier anomaly" and its related hypotheses. Based on the above scheme and to maintain a clear paragraph structure, we did not merge the two paragraphs.

L 43 duplicate with l 33. Again contradictory: this is now the accepted idea. ±Mention ogther studies who show the contrary, for ex Vincent et al 2013 https://tc.copernicus.org/articles/7/569/2013/
Reply: We have deleted the "*Notably, the rate of thinning of debris-covered glaciers is close to that of debris-free glaciers in the southeastern Tibetan Plateau (Neckel et al., 2017; Brun et al, 2019; Ke et al., 2020)*" in L33 (last paragraph) and have added the *Vincent et al. (2013)* in the list of references. (L43)

L 50 "in ", "on"
Reply: Done.

L 50 what was Miles et al 2022 based on as opposed to the citations given afterwords? Split the phrase as this is a new set of refs-
Reply: Miles et al (2022) carried out systematic energy-balance modelling of debris, clean ice, ice cliffs, and supraglacial ponds at a variety of sites around the world (including 24K Glacier) using on-glacier meteorological stations, in order to assess the climatic controls of melt enhancement/suppression. We re-wrote/split the sentences as follows: "*The areas influenced by cliffs and ponds are characterized by high melt rates relative to surrounding debris-covered ice, as shown by the differencing of high-resolution DEMs and energy-balance modelling (Thompson et al., 2016; Brun et al., 2018; Miles et al., 2018, 2022; Buri et al., 2016, 2021; Kneib et al., 2022; Sato et al., 2021; Mishra et al., 2021; Miles et al., 2022)*".

L 51 remove "results of"
Reply: Done.

L 53 remove "There is a debate on so-called…since" as this does not mean much. Start with "Some research"
Reply: Done.

L57 in order to do what, exactly? what is the research gap from all these existing, multiple studies?
L 60 clarify this - one hypothesis suggests that dynamic thinning under thick debris (hence similar rates with clean ice) is caused by declining ice

flow (see Anderson et al 2021).
Reply: The research gap is that there is a lack of accurate observations to evaluate the hypotheses, and no prior study has done so in the southeastern Tibetan Plateau.
Following your suggestion, we clarified this hypothesis and re-wrote the sentence as follows: "*Additionally, glacier dynamics play an essential role that influences the debris-covered glacier elevation change, and the rapid thinning of the debris-covered glacier is speculated to be partly caused by reduced ice supply (Nuimura et al., 2017; Brun et al., 2018; Anderson et al., 2021a, 2021b; Rounce et al., 2021). However, this has been evaluated with precision at few sites, none of which are in the southeast Tibetan Plateau*".

Overall the paragraph from 39 – 61 need to be condensed, and the two hypotheses presented clearly. It is not clear to me with the missing gap that this study aims to address-
Reply: Combined with all above comments, we re-wrote the paragraph as follows (L39-61): "*The presence of debris can influence the glacial response to climate change due to the melt-buffering effect of supraglacial debris cover that exceeds a few centimeters in thickness (Østrem, 1959; Nakawo et al., 1999; Nicholson and Benn, 2006; Reid and Brock, 2010; Yang et al., 2017). However, some satellite remote sensing studies have found similar thinning rates for debris-free and debris-covered glaciers (Kääb et al., 2012; Immerzeel et al., 2013; Gardelle et al., 2013; Pellicciotti et al., 2015; Brun et al., 2019); there is even a higher thinning rate of debris-covered- compared to debris-free glaciers in the Lahaul and Spiti region, Indian Himalaya (Vincent et al., 2013) and several studies also confirm the strong surface thinning of debris-covered glaciers in the southeastern Tibetan Plateau (-0.52- -0.83 m* a^{-1}*; Neckel et al., 2017; Ke et al., 2020). This phenomenon has been referred to as the "debris-cover anomaly" (Pellicciotti et al., 2015; Vincent et al., 2016). Ice cliffs and supraglacial ponds could partly explain this anomaly, because they are directly exposed to incoming radiations and therefore act as melt "hotspots" (Sakai, 1998, 2002; Reid and Brock, 2014; Juen et al., 2014; Steiner et al., 2015; Buri et al., 2016; Miles et al., 2016; Miles et al., 2018; Buri et al., 2021). The areas influenced by cliffs and ponds are characterized by high melt rates relative to surrounding debris-covered ice based on the differencing of high-resolution DEMs and energy-balance modelling (Thompson et al., 2016; Brun et al., 2018; Miles et al., 2018, 2022; Buri et al., 2016, 2021; Kneib et al., 2022; Sato et al., 2021; Mishra et al., 2021; Miles et al., 2022). However, some researchers consider that the insulating effect of debris cover has a larger effect on total thinning than the enhanced ice*

ablation from ice cliffs and supraglacial ponds area (e.g., Hambrey et al., 2008; Vincent et al., 2016; Brun et al, 2018; Anderson et al, 2021a). Additionally, glacier dynamics play an essential role that influences debris-covered glacier elevation change, and the rapid thinning of debris-covered glaciers is speculated to be partly caused by declining ice flow (Nuimura et al., 2017; Brun et al., 2018; Anderson et al., 2021a, 2021b; Rounce et al., 2021). However, to date this has been evaluated with precision at very few sites, none of which are in the southeast Tibetan Plateau".

L 62 link not clear- this seems to address hypothesis one, the hot spots of melt

Reply: We have added the sentences as follows: "*These hypotheses therefore need to be supported with very high-precision data to account for the local effects of these melt hotspots*".

L 67- remove "These studies confirm.." and start with "High resolution data..

Reply: Following your suggestion, we have removed "*These studies confirm…*".

L 69 "the glaciers thinning patterns" –"glacier thinning patterns"

Reply: We have changed "*the glaciers thinning patterns"* as "*glacier thinning patterns".*

L 78 Again it is not clear which of the 2 hypotheses the authors propose to address in this study, as the two were presented, this needs to be clarified. For example, the two glaciers can be presented as two sites to test these two hypotheses (if that is the goal?), due to their geographic proximity and similar topography/debris cover, something like that?

Reply: We have clarified the hypotheses in the second paragraph of the introduction section.

And we have now rewritten this paragraph as follows (L78-86): "*Here we systematically compare the glacier change patterns of two neighboring debris-covered glaciers, 23K Glacier and 24K Glacier, in the southeastern Tibetan Plateau for the period from 13th August 2019 to 22nd October 2020 by using change detection applied to high-resolution repeated DEMs and orthoimages acquired via UAV-SfM surveys, and in-situ measurements. The glaciers are located in the same catchment and climatic setting, but the topography of the glaciers, as well as their dynamic behaviors and supraglacial debris thickness varies considerably. The objective of this study is to explore the factors that control the inter-glacier variability in surface thinning (dh) and surface mass balance*

(SMB) patterns of these two glaciers, with a view to advance the understanding of the key mechanisms that control debris-covered glacier change in the southeastern Tibetan Plateau, and to assess at the glacier scale the two different hypotheses (additional melt from hot spots or reduced ice supply) that currently explain the anomalous thinning of debris-covered glaciers".

L 84 add "the" before "key"
Reply: Done.

L 85 what exactly is meant by "may have relevance beyond…" – do you imply that results can be upscaled to an entire region?
Reply: We have removed "*and which may have relevance beyond this region of interest*".

Study area
L 87 I would mention already here that this is a climatically monsoon influenced region to situate the two glaciers
Reply: Following your suggestion, we mention this region is monsoon-influenced first and re-wrote the sentences as follows: "*The southeastern Tibetan Plateau is monsoon-influenced, and has a glacierized area of ~10,000 km^2. 23K (~4 km^2) and 24K (~2 km^2) Glaciers are located in the southeastern Tibetan Plateau (~29.77° N, 95.70° E; Fig. 1)"*.

L 90 "monsoon - dominated" refers to climate, rather. Please use the standard term of "summer-accumulation" type glaciers and reference the appropriate papers (Thayyen et al 2010 etc.)
Reply: As described in the manuscript (L91-95), "*The region is mainly affected by two streams of humid air: the Bay of Bengal Vortex (in Spring) and the Indian Summer Monsoon system (in Summer), respectively (Ye and Gao, 1979; Yang et al., 2013; Yang et al., 2016). Thus, the monthly precipitation distribution exhibits a double-peak type occurring in both spring and summer (Yang et al., 2013).* ***This is significantly different to the temporal patterns of mass gain on the Tibetan Plateau, which are so called 'summer accumulation' type*** *(Fujita et al., 2000; Maussion et al., 2014)*". Based on the above reasons, we considered to retain the "monsoon-dominated" in the manuscript.

L 95 can be shortened to "Regional geodetic mass balance studies"
Reply: We shorten the sentence as follows (L95): "*Regional geodetic mass balance studies indicate that the magnitude of ice loss in the region exceeds the average for High Mountain Asia*".

L 96 “recent” relates to what time period?
Reply: It refers to the last ~20 years. We re-wrote the sentence as follows: “*...exceeds the average for High Mountain Asia (Kääb et al., 2012; Yao et al., 2012; Brun et al., 2017; Shean et al., 2020; Hugonnet et al., 2021) in the past 20 years, also affecting debris-covered glaciers*”.

L103 what is the % debris cover based on? Any reference?
Reply: We estimated the percentage of debris cover area based on satellite data (Pléiades-1A false-color image from 2021-09-20). We rewrote the sentence as follows: “*Both glaciers are partly covered by a layer of rock debris (Fig. 1a, 1c) and the debris-covered area represents approximately 34% and 41% of the total area for 23K Glacier and 24K Glacier respectively based on satellite data (Pléiades-1A false-color image from 2021-09-20, 2m resolution)*”. (L101-103)

L 105 “takes the form” rather exhibits or “presents”
Reply: We have changed “takes the form” to “presents”

L 106 same here, for AWS data, which year and what altitude?
Reply: We re-wrote the sentence as follows: “*Data from an automatic weather station (AWS, 3900 m a.s.l., running between June and September 2016) on 24K Glacier indicates a warm and humid climate, with mean temperature and total precipitation reaching ~9 °C and ~1700 mm, respectively*”.

L 116 add “s” to “Method”
Reply: Done.

L 119 suggestion “that took place” conducted
Reply: We have changed “*that took place*” to “*conducted*”.

L 121 spelling error. Also can you be more specific here what exactly you mean with regards to gl. dynamics? Land and cliff distribution? Debris properties? I assume it is the surface displacement (as per section 3.3) so please be specific
Reply: The “gl. dynamics” refers to the glacier thinning and surface displacement. We modified the spelling error and re-wrote the sentence as follows: “*... to capture the high-resolution annual and seasonal patterns of glacier thinning and surface displacement*”.

L 146 I think acronyms are not needed here; I suggest avoiding over-use of acronyms
Reply: In the revised version, we delete the “*(GVPs)*” and instead write

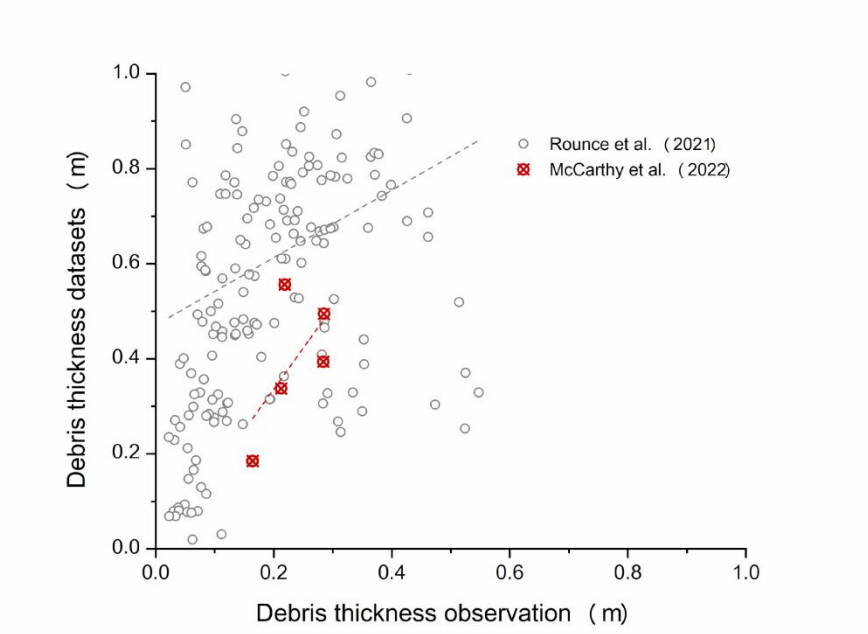
"*ground validation points*" in full.

L 146 – 149 pertains to processing of the imagery so I suggest shifting it up to section 3.1
Reply: We have shifted this up to section 3.1.

L 150 please mention that this was done on the debris cover part of the two glaciers?
Reply: Two observation lines are in the debris-covered area on 24K Glacier and the other one is in the debris-free area. We re-wrote the sentence as follows: "*In October 2019, three ice thickness cross-sections (two in the debris-covered area and one in the debris-free area, Fig.1a and Fig. S2) were measured on 24K Glacier using a Kentech ground penetrating radar (GPR) monopulse transmitter with 2.5 MHz antennas*".

L 153 Farinotti dataset not listed in data sources, perhaps it can be added. The spatial resolution of this dataset is not mentioned (25m)- how was the difference in resolution dealt with between GPR data and this? Also, have the authors also investigated supraglacial debris thickness from Rounce et al 2021 rather than correcting the Farinotti data?
Reply: We have mentioned the Farinotti et al. (2019) ice thickness data in the manuscript, and now also include this in the list of data sources. Notably, we modified these estimates based on field measurements of ice thickness. The Farinotti et al. (2019) dataset was bias-corrected against the GPR measurements and glacier outlines. This is described in Kneib et al (2022), and accounts for the difference in extent and spatial resolution.

Regarding the debris thickness data, we believe that our debris thickness distribution data is closer to the actual debris thickness distribution than the Rounce et. al. (2021) results, as is based exclusively on direct *in-situ* observations. We compared our debris thickness observation with Rounce et al. (2021) and McCarthy et al. (2022) respectively, as shown below (we also added this in SI). We found that the McCarthy et al. (2022) debris thickness is closer to the measured value, but with low resolution. The Rounce et al. (2021) debris thickness is moderately overestimated for 24K Glacier.



Also, change "thickness dataset" to just "thicknesses" because this does not relate to the entire dataset.
Reply: Done.

L 155 vague, can you specify? Also, perhaps present the AWS before
Reply: Since the information of AWS is presented in the previous section, we have removed this sentence.

L 157 suggest adding "patterns" or similar after "dh"
Reply: Done.

L 158 I suggest spelling out dh here to read better
Reply: We have changed "d*h*" as "*thinning (dh)*".

l 160 clarify - annual rates of what and what do you mean by adjusting?
Reply: This adjustment is aimed at making this result (13th Aug. 2019 - 20th Oct. 2020, 373 days) closer to that of the natural year (366 days).
We have changed the sentences (L160-161) as follows: "*The annual rates were adjusted according to the ratio of days (366/373) to make this result (13th Aug. 2019 - 20th Oct. 2020, 373 days) closer to that of the natural year (366 days)*".

L 162 this last phrase needs more developments- discuss how the DEMs were obtained from the imagery (stereo imagery was not mentioned in the methods by the way), how the how the co-registration was performed, its accuracy etc. Only differencing in GIS is not sufficient here.

Reply: In section 3.1, the generation of DEMs has been described. It uses Structure-from-motion photogrammetry from UAV images with a large overlap. Due to the high accuracy of the generated DEMs and orthophotos (Table. 2; Table. 3), it is not necessary to perform co-registration when carrying out thinning calculations. We summarized these data in Tables 2 and 3. Propagated errors for our DEM differencing pairs are <0.10 m, which is comparable to results for Parlung No.4 (Yang et al., 2020), which was surveyed in a similar manner.
We have changed the sentences (L161-163) as follows: "*We applied the Post-Processed Kinematic (PPK) and real-time kinematic (RTK) and ensured that the static base stations were fixed at the same location for different surveys, which lead to DEMs with only very small minor offsets in XYZ (Yang et al., 2020). Therefore, we did not perform the co-registration of DEMs for the thinning (dh) calculation*".

L 164 belongs to background; here, stick methodology
Reply: We have deleted this sentence in the method section.

L 168 rephrase to something like "surface displacements > 30m were considered noise and were filtered"
Reply: We re-wrote the sentence as follows: "*The surface displacements greater than 30 m were considered as noise and were filtered out*".

l 169 also, justify why the nearest neighbor interpolation was chosen
Reply: Based on the high-resolution UAV data and ImGRAFT, our acquired surface velocity results have been of high resolution (1.5 m), and they can well present the details of surface velocity. Furthermore, there are a very small percentage of outliers in the surface velocity result (<5%). Therefore the simple interpolation method (nearest neighbor) can be used to interpolate the missing values in this case. We have added the sentence (L169) as "*Due to the high-resolution velocity data and the small number of gaps (<5%), we interpolated the velocity values in the data gaps using nearest neighbor interpolation*".

l 173 Should be AW3D30. Not clear why the DEM was smoothed with an 8-pixel windows while the resolution is already not very high?
Reply: We have changed "AW3D" as "AW3D30".
Here we are interested in computing the general slope of the glacier, representative of the whole section, and therefore need to remove any effect from local surface topography (Kneib et al., 2022; Mishra et al., 2021; Miles et al., 2018; Brun et al., 2018). We have added the sentence (L174) as "*...smoothed with a Gaussian filter (8 pixels window) for removing any effect from local surface topography*".

L 175 Also, need to mention that RGI outlines used for the thickness estimates are outdated (~2000). Again, more reason to compare with recent estimates from Rounce et al (even if they are also subject to the same limitations). Including the glacier headwall is not necessarily wrong.
Reply: Yes, we agree that the outdated outline (~2000) is also one of the reasons for its limitation. We consider that there is a repetition here and the section above (ice thickness correction for 24K Glacier), so we deleted this part in the manuscript. The Rounce et al (2021) data is the debris thickness distribution and is therefore not relevant here.

L 173 unclear- what kind of correction?
Reply: The correction is based on linear regression. We re-wrote the sentence as: "*However, in the ablation area, we applied a local correction (using a linear regression) using GPR measurements...*".

L 178 do you mean here "glacier-wide" smb?
Reply: This refers to the SMB in the UAV survey area. We re-wrote the caption as: "*Surface mass balance (SMB) of UAV survey area*" in L178.

L 180 not clear why this was not done using an uniform altitudinal band?
Reply: We divide the UAV survey area based on the principle of area proximity instead of using a uniform altitudinal band directly. We think it is more reasonable to discuss the proportion of the ice cliffs and ponds area on the basis of the approximate area of different analyzed zones (Kneib et al., 2023).

L 181 until here, the mapping of the ponds and ice cliffs was not mentioned. This would need a separate section prior to this one, e.g. section 3.3 – as this is also needed later for 3.5
Reply: We have now included a description of how the ponds and ice cliffs are delineated in section 3.5.
'*We manually extracted ice cliff and supraglacial pond outlines from the flow-corrected orthomosaics (August 2020 and October 2020; August 2019 and August 2020; October 2019 and August 2020). The outlines of the ice cliffs and supraglacial ponds area were obtained by taking the union the outlines before and after each study period (Burn et al., 2018), and the total ice cliffs and supraglacial ponds area for each zone was established by summing the area of these features.'* (L226-229)

L 187 "which took the form of" "using a"
Reply: We have changed "*which took the form of*" to "*using a*".

L 190 to l 220 this can perhaps be compacted using the form [Equation] …., where A [m^2] is the area Etc
Reply: We have changed this as suggested. We have put the equations 2-7 together. The remaining ones have more information to describe, so we chose to keep the previous format.

L 215 re-write for clarity, for ex simply "We assumed a uncertainty of"..- also what is this based on? For the area uncertainty, was this done using the buffer method? If so, the correct reference is Bolch et al 2019. Please justify why 20 m
Reply: Following your suggestion, we have changed the previous sentence as "*We assumed the uncertainty of the zonal area to be +/-20 m from the outlines with the buffer method (Bolch et al., 2010; Miles et al., 2018)"* in L215.
Yes, we used the buffer method similar to Bolch et al. (2010) to estimate the area uncertainty. Bolch et al. (2010) and Mölg et al. (2019) estimated the uncertainty based on the data resolution. In this study, we assume that the error here is influenced by the uncertainty of the manual outlines, in addition to the limitations of the data resolution. Therefore this error is a composite error, which we default to a generous value of 20 m (following Miles et al., 2018).

L 224 see my comment above; the mapping of ice cliffs and ponds need to be explained in more detail. Not sure it is appropriate to merge these all under the "hotspots" term as their melt contribution has not been yet determined in this study
Reply: We agree to use the term 'hotspots' with caution. In this study, we replaced 'hotspot areas' with 'ice cliffs and supraglacial ponds'.

Results
L234 I suggest starting with the SMB results rather than the technical results. The uncertainty section can come last, and ideally it would have a corresponding last section in the methods. Then this would allow also combining other uncertainty sources in the same section, which are now spread throughout the paper
Reply: We believe that the thinning pattern is also an important result from this study, as one of the goals for this study is to test the hypotheses that explain the anomaly thinning of debris-covered glaciers in the southeastern Tibetan Plateau.
Furthermore, we obtained the thinning results and the glacier surface motion velocity results first, and then the surface mass balance was obtained based on the above results. So it is logical that the results of the surface mass balance are placed later.

Therefore, we would keep the arrangement of the results as is.

L147 I suggest reminding again the reader the period for this
Reply: Following your suggestion, we re-wrote the sentence as follows: "*The dh distribution of different periods (annual: Aug. 2019-Aug. 2020, cold: Oct. 2019- Aug. 2020, warm: Aug. 2020-Oct. 2020) for the two glaciers is shown in Figure 2*".

L 148 I suggest the use of past tense (here and throughout paragraph)
Reply: We have used the past tense here and throughout the paragraph.

L 249 "in the survey area" "over the surveyed area". Figure reference here?
Reply: Following your suggestion, we have changed "*in the survey area*" as "*over the surveyed area*". The figure reference is "*Fig. 2b, 2e"*.

l 251 "was more comparable to the other" is unclear
Reply: We re-wrote the sentence as follows: "*...the magnitude of the thinning of both glaciers is very similar; ...*".

l 250 - 252 it would really help to have these in a table as the reader gets lots and it is hard to follow the numbers
Reply: We have included the following table:

Table. 3: Total thinning and its daily rate for 23K & 24K Glaciers during different periods

		Aug. 2019- Aug. 2020	Oct. 2019-Aug. 2020	Aug. 2020-Oct. 2020
23K Glacier	Thinning (m)	-2.3 ± 0.1	-1.5 ± 0.1	-0.7 ± 0.1
	Daily rate (cm d^{-1})	-0.6 ± 0.03	0.5 ± 0.03	-1.2 ± 0.03
24K Glacier	Thinning change (m)	-1.2 ± 0.1	-0.2 ± 0.1	-1.0 ± 0.1
	Daily rate (cm d^{-1})	-0.3 ± 0.03	-0.1 ± 0.03	-1.6 ± 0.03

l 256 do you mean elevation bands?
Reply: Yes. It is the elevation band.

l 256 – 260 are these trends statistically significant? (Man Kendal Test for ex?)
Reply: We applied the MK test for trend analysis and rewrote the sentence as follows: "*The relationships between dh rates and altitude show that the absolute dh of 23K Glacier increases with altitude (i.e., a negative gradient; Z value: -3.75 - -3.25) for every analysis period, while the dh of 24K Glacier decreases with altitude in the annual scale and cold period (positive gradient; Z value: +3.65 - +3.69). In particular, the*

dh-altitude gradient of 24K Glacier in the warm period follows the opposite trend to its annual scale and cold period (i.e., consistent with 23K Glacier; Z value: -0.77)".

l 261 period's not grammatically correct; same for Glacier's
Reply: We have deleted the "s".

l 270 – 282 same here, I suggest use of past tense
Reply: We have used the past tense here.

l 272 – is this not already specified in methods?
Reply: It was indeed specified in methods (3.3 section). We removed this sentence.

l 279 the writing is confusing "23k (24k)"- do you mean 23 k and 24 k respectively?
Reply: Yes. For clarity of presentation, we rewrite the sentences as: " *In this case, the annual emergence of 23K (resp. 24K) Glacier is 0.18 ± 0.04 m (1.36 ± 0.14 m), ...*".

l 282 emergence velocity (beginning and end of line)
Reply: We have changed to "emergence velocity".

l 282 "not remarkable" is vague – please use to statistical significance instead
Reply: We have deleted this sentence and rewrite it as follows: "*24K Glacier has consistently higher emergence velocity than 23K Glacier during all periods*".

l 293 p-value of statistical test?
Reply: Yes, it is.

l 295 "higher" "larger"
Reply: We have changed the "*higher*" to "*larger*".

l 301 here again, I do not fully agree merging the ponds and cliffs in one denomination as they may have a different effect on ablation. If this is argued, references are needed to support this
Reply: We agree to use the term 'hotspots' with caution. In this study, we replaced "*hotspot*" with "*ice cliffs and supraglacial ponds*".

L 310 this should be in the methods section (section 3.5)
Reply: We have changed this section to the method section.

l 314 p-value?
Reply: Yes, it is.

l 323 confidence interval?
Reply: It is 95%. We re-wrote the sentence as follows: "*For 23K Glacier, the correlation coefficient r (95% confidence interval), between debris thickness and surface mass balance during the warm period is 0.88 (p-value: 0.02), indicating that the debris thickness is highly correlated with the melt.*".

Discussion
l 332 Correct to "Controls ON x ..etc on glacier thinning patterns" as this is rather the control of certain variables on thinning. Again, too much use of acronyms, here and throughout section
Reply: We have corrected the text as suggested. We have added the full name before the acronyms in this section such as "thinning (d*h*)", "surface mass balance (SMB)" (L332-439).

l 333 which figure? also, "very different" is vague; l 333 during THE cold period or ALL cold periods? in any case an article is needed
Reply: It is Fig. 2. And we have added this in the modified sentence. We deleted the "*very*". It refers to the cold period in this study (Oct. 2019-Aug. 2020). Following your suggestion, we re-wrote the sentence as follows: "*The dh patterns of the two glaciers are different at the annual scale and during the cold period in this study as indicated by its magnitude and spatial distribution (Fig. 2)*".

l 335 "These" "The"
Reply: We have changed "*These*" to "*The*".

l 336 unclear if this is a result of this study or here you refer to general patterns from the cited studies, please revise. Also what specifically do you mean by "dynamic state"
Reply: Both this study and the cited studies were included. The "dynamic state" is the active intensity of glacier ice flow replenishment. Following your suggestion, we re-wrote the sentence as follows: "*Some studies show that the large differences in dh between two glaciers are mainly caused by different dynamic states (Fig. 4; Brun et al., 2018; Anderson et al., 2021a, 2021b; Rounce et al., 2021)*".

l 339 while this can be correct, it is vague, "glacier health" etc.
Reply: Following your suggestion, we re-wrote the sentences as follows:

"*The replenishment of ice into the ablation area by ice motion is crucial to the glaciers' long-term sustainability, and net annual ablation exceeds ice resupply for the study areas of both glaciers. We therefore assess the ratio of emergence velocity to surface mass balance as an indicator of the local balance between ablation and ice supply (a direct local metric of glacier health), and this study illustrates that glacier health can vary greatly even over small distances (Table 5)*". (L339-342)

l 340 – 342 same here, vague, remove "may be thought to.." and rephase the rest of the phrase

Reply: Following your suggestion, we have deleted the "*may be thought to…*" and re-wrote the sentences as follows: "*The dynamic state of a glacier is a clear indicator of its sustainability (Miles et al., 2021), and this study illustrates that glacier health can vary greatly even over small distances. 23K and 24K Glaciers experience the same climatic forcing, but have a distinct geometry. We found that the mean slope of 24K Glacier is consistently higher than that of 23K Glacier, which may be one possible reason to explain the faster surface velocity of 24K Glacier (Fig. S8). In addition, the possibly distinctive dependence on avalanche and rockfall mass supply, which also lead to marked differences in mass supply to the glacier terminus*".

l 343 "similar" please quantify; l 344 please revise substantially – "ablation determined the dh pattern and dilutes the emergence velocity" as this does not make much sense; l 345 same here

Reply: The "similar" means the thinning of 23K (resp. 24K) Glacier is -0.7± 0.1 m (-1.0 ± 0.1 m), with an average daily rate of -1.2 ± 0.03 cm d^{-1} (-1.6 ± 0.03 cm d^{-1}). The thinning rete for each glacier is more comparable to the other during warm period. In addition, the thinning of both glaciers increases with altitude.

Following your suggestions, we have changed the sentences as "*Using the ratio of emergence to surface mass balance, we can identify, for each season, whether ice resupply or surface mass balance is the main factor leading to the thinning rates. In Table 5, we clearly see that at 23K Glacier, ice supply is considerably smaller (-0.11) than surface mass balance for all periods, indicating that surface mass balance is directly responsible for contemporary thinning patterns. 24K Glacier also exhibits a strong imbalance between ice emergence and surface mass balance over the warm period (-0.15), but emergence nearly compensates for surface mass balance during the cold period (-0.87). Thus, 24K Glacier exhibits a healthier cold-season and annual balance between ablation and ice supply than 23K Glacier*" (L342-L346).

l l 346 – l 353 this is a mix of methods and results, please revise
Reply: Following your suggestion, we have shifted this section to the method section.

l 355 which ablation period? annual? There are other studies that noted similar rates of thinning, please review the literature; some of these have been noted in the last years only due to an acceleration of thinning trends
Reply: Following your suggestion, we specify the ablation as follows: "*...during an ablation period (June. 2018-Oct. 2018)...*". We found another similar study in the southeastern Tibetan Plateau based on UAV data, and its results are similar to those of Glacier 23K. Therefore, we have added follows sentence there: "*…He et al. (2023) have also observed the tongue area of a debris-covered glacier (Zhuxi) in the southeastern Tibetan Plateau by UAV from 2020-2021. The tongue part of this glacier is similarly characterised by high rates of thinning (>1 m* a^{-1}*) and slow movement (< 7 m* a^{-1}*). Other studies concerning the mass balance of Himalayan debris-covered glaciers also report on glaciers which possess a high thinning rate (~-0.9-1.8 m* a^{-1}*) and weaker dynamic state (Vincent et al., 2016; Nuimura et al., 2017; Brun et al., 2018; Rowan et al., 2021)…*".

l362 please be specific- observations of what?
Reply: It is the *in-situ* observations. Following your suggestion, we re-wrote the sentence as follows: "*In-situ observations show that the terminus of two glaciers differ (Fig. 1c, 1d, Fig. S4)*".

l 362 "between each glacier" rewrite (the termini of the two glaciers differ)- and please specify what the differences are; l 363 this talks about ice dynamics while the phrase before just emphasizes the differences in termini. Unclear – I suggest shifting this phrase down after the termini differences are explained
Reply: The differences are the terminus retreat patterns of the two glaciers. Following your suggestions, we re-wrote the sentences as follows: "*In-situ photo shows that the terminus of two glaciers differ (Fig. 1c, 1d, Fig. S4). The terminus retreat patterns of the two glaciers are also conspicuously different. The terminus of 23K Glacier appears largely stagnant and is enclosed by a latero-terminal moraine complex, while the terminus of 24K Glacier exhibits a large ice cliff, and which is bounded by lateral moraines*". And we shift this phrase (L 363) down the L 406.

l 363 re-give the rate of d*h*
Reply: The rate of thinning is > -0.5 m a^{-1}. Following your suggestion, we

re-wrote the sentence as follows: "*The terminus of 23K Glacier is largely stagnant with a low thinning (dh) rate (> -0.5 m a^{-1})*".

l 366 which regions are we discussing here; what about other Himalayan glaciers, see Sakai et al papers on pond formation. The conditions for pond formation should be mentioned here for ex is terminus slope < 2 deg?
Reply: This discussion is about our study area (23K Glacier and 23K Glacier) and the extended himalayan region. We re-wrote the sentences as follows: "*...a suppressed dynamic state, and the presence of supraglacial ponds (in agreement with Quincey et al (2007) and Sakai and Fujita (2010)); i.e., low slope and low surface speed). The above evolution pattern is consistent with observations of stagnating debris-covered glaciers in other glacierised regions of himalayan (e.g., Benn et al, 2012; Kneib et al., 2023)*".

l 374 "existence" "presence". Also need to mention here that this is a function of debris thickness
Reply: Thanks for your suggestion. We have changed the "*existence*" as "*presence*". And we have added: "*...due to the melt-buffering effect of supraglacial debris cover that exceeds a few centimeters in thickness...*".

l376 I suggest splitting the phrase which is too long "Our results.."
Reply: Following your suggestion, we re-wrote/split the sentence as follows: "*Our results show inverted melt-season SMB profiles for both 23K and 24K Glaciers. In addition, debris-covered glaciers tend to develop ice cliffs which enhance melt locally, even relative to clean ice*".

l 377 this is not always the case, for ex in the W Himalaya supraglacial ponds are much less common, even areas such as central Himalaya, see Racoviteanu et al 2022 etc..
Reply: We have deleted the "*and supraglacial ponds*".

l 382 "correlation is strong" – please quantify. Statistical significance? same on l 382-383 "little correlation"
Reply: The correlation results (23K: r=0.88; 24K: r=0.82; all p-values <0.05) are shown in the result section. Following your suggestion, we re-wrote the sentence as follows: "*We find that the correlation between the melt and the debris thickness distribution is strong for both glaciers (23K: r=0.88; 24K: r=0.82) during the warm period, while there is little correlation between the melt and the ice cliffs and supraglacial ponds area distribution (23K: r=-0.29; 24K: r=-0.48)*".

l 389 I suggest presenting this in the results section

Reply: We have shifted this to the result section.

l 285 I am lost here as the discussion is mixed between ice cliffs, since ice cliff and “hot spots”, please revise
Reply: We agree to use the term 'hotspots' with caution. In this study, we replaced “hotspots” with “ice cliffs and supraglacial ponds”.

l 402 not sure what you mean by “merged outlines”?
Reply: We re-introduced the mean as follows: “*...as digitized for warm periods were obtained by merging outlines of Aug. 2020 and Oct. 2020 (Brun et al., 2018)*”.

l 405 revise to “for both 23K and 24K Glaciers”. This not an altitudinal control, you mean a control on SMB?
Reply: Yes. It means a control on SMB. Following your suggestion , we re-wrote the sentence as follows: “*Though the ice cliffs and supraglacial ponds are local controls of melt patterns, the debris thickness is the dominant control on the altitudinal SMB pattern for both 23K and 24K Glaciers, similar to the conclusion at Kennicott Glacier in Alaska (Anderson et al, 2021a)*”.

l 410 what does “it” refer to? rephrase
Reply: The “*it*” refers to “*this study*”. Following your suggestion, we re-wrote the sentence as follows: “*This study gives us insight into the clear controlling role of the debris on melt pattern*”.

l 411 to focus the debris supply rewrite, something is missing here; l 412 “According to” not correct (as it is not a person) “Based on”
Reply: Following your suggestions, we re-wrote the sentences as follows: “*In future research, it will be beneficial to improve our understanding of the responses of debris-covered glaciers to climate change by focusing on the debris supply and evacuation differences. Based on field photography (Fig. S5), we also found that paraglacial slope failure events have occurred...*”.

l 412 again refrain from using so many acronyms
Reply: Thanks for your suggestion. We have changed and removed the acronyms in this section.

l413 what is the evidence of these rock slope failures?
Reply: The field photography (Fig. S5) is the evidence of these rock slope failures.

l 420 “Glaciers change” not correct, remove “s”
Reply: We have removed “s”.

l 421 grammatically incorrect (present tense). clarify that this is based on Hugonnet data; l 422 “current”- give the time period.
Reply: We change the tense and mention the Hugonnet et al (2021) data. We deleted the “*current*” and change the sentence as: “*The thinning of 23K Glacier tongue was greater than that of 24K Glacier since 2000 (Hugonnet et al, 2021; Fig. 8), which is generally in agreement with the thinning pattern of this study*”.

l 422 “It is found”- “We found” (please be specific rather than using “It”
Reply: We have changed “*It is found*” to “*We found*”.

l 423 increase in what? area? thickness?
Reply: It means that the inverted relationship of thinning against altitude. We have changed the expression to another one: “*show the inverted relationship of thinning against altitude over the last two decades*”.

l 429 this reads like a methods phrase please rewrite. This introduced new analysis in the discussion section, I suggest moving this up.
Reply: We have moved this section to the results section.

l 432 of THE two glaciers
Reply: We have added “the”.

l 433 mention that this is based on Dehecq et al data, I assume
Reply: We have mentioned the Dehecq et al (2015) data here.

l 434 not correct, “it is necessary for 24K glacier to carry out..” “it is necessary we carry out”
Reply: We have changed the“*it is necessary for 24K glacier to carry out..*” as“*it is necessary we carry out*”.

l 436 again this reads like results, please rewrite/interpret
Reply: We have changed it to the result section.

l 450 I suggest marking this as a speculation or suggestion, as this may not be the only cause
Reply: We have changed the previous sentence as a speculation: “*These contrasting patterns may be driven by the stronger dynamic state of 24K Glacier, which has a much higher down valley emergence velocity replenishment*”.

l 459 “velocities are decreased by analyzing…” grammatically awkward, please rewrite entire phrase

Reply: We changed the sentence as: “*Based on the analysis of the elevation and surface velocity changes over the last two decades, both glaciers experience accelerated thinning and reduced flow in their ablation area*”.

l 461 I suggest presenting it the other way around, SMB shows an accelerating trend in the 2019-202 period.

Reply: We agree with presenting it the other way around, and we re-wrote the sentences as follows: “*The annual surface mass balance for both glaciers has become more negative from 2000-2016 to 2019-2020*”.

l 462 what exactly is higher? please be specific

Reply: The specific value is '*2000-2016: -1.5 m w.e. a^{-1} (23K), -1.6 m w.e. a^{-1} (24K); 2019-2020: -2.5 m w.e. a^{-1} (23K), -2.8 m w.e. a^{-1} (24K)*'. We rewrote the sentences as follows: “*The SMB of 24K Glacier (2000-2016: -1.6 m w.e. a^{-1}; 2019-2020: -2.8 m w.e. a^{-1}) is consistently slightly more negative than 23K Glacier (2000-2016: -1.5 m w.e. a^{-1} ; 2019-2020: -2.5 m w.e. a^{-1})*”.

L 463 remove” Such a”; L 464 “debris covered glacier” two debris covered glaciers

Reply: We have removed “*such a*” and changed the “*debris covered glacier*” as “*two debris-covered glaciers*”.

Response to Dr. Leif S. Anderson's comments

Thank you for your detailed and valuable comments on our manuscript. Below we present our point-by-point response. The reviewer's comments are in black and our answers in blue.

General comments:

In general, this is a well-argued paper that presents an interesting comparison between two adjacent debris-covered glaciers. The methods are sound, and the conclusions follow the results nicely.

The text should be streamlined where possible and typos remedied. In some places words are missing or there are atypical uses of some words. This is most evident in the abstract. Some citations are present in the main text but not in the references. Some citations cite the correct author but the wrong paper the author wrote.

For me it would have been nice to foreshadow the sub-annual SMB estimates in the introduction. It is impressive that these have been quantified. After reading through, I am wondering why are the sub-annual SMB rates important and what do they add to the main conclusions and our understanding of DCGs? A bit more justification and discussion will strengthen the paper.

A bit more work on the writing and this will be a strong, novel contribution.

Reply:

1.Typos and streamlining of the text. Following your suggestions, we have checked and corrected the abstract, introduction, result, discussion and conclusion sections. In particular, we re-wrote the abstract as follows:

"Debris-covered glaciers are a common feature of the mountain cryosphere in the southeastern Tibetan Plateau. A better understanding of these glaciers is necessary to reduce the uncertainties of the regional water resource variability, and to anticipate potential cryospheric risks. In this study, we quantify seasonal thinning and surface mass balance patterns of two neighboring debris-covered glaciers (23K Glacier and 24K Glacier) in the southeastern Tibetan Plateau with repeated unpiloted aerial vehicle surveys and in-situ measurements (13th Aug. 2019 - 20th Oct. 2020). We observe that the thinning magnitude of 23K Glacier is ~1.4-3.0 times greater than that of 24K Glacier for all periods (annual, cold period, warm period). The surface velocity of 24K Glacier is higher than that of 23K Glacier (~5-6 times) for all periods. In contrast with the thinning patterns, the mean surface mass balance patterns of the two

glaciers closely agree across the different periods, but their altitudinal patterns strongly disagree. We find that the debris thickness distribution strongly correlates with the spatial distribution of surface mass balance for both glaciers (23K Glacier: r=0.88; 24K Glacier: r=0.82). Ice cliffs and supraglacial ponds are prevalent (~4.4-7.2 ± 0.5 %) and enhance melt overall (~ -2.5), but do not control the overall SMB pattern of either glacier. This high-resolution comparison study of two neighboring glaciers confirms the significance of both glacier dynamic and debris thickness in controlling the thinning and melt for the different debris-covered glaciers of the southeastern Tibetan Plateau in the context of climate change".

2.References. There were indeed some errors (such as incorrect match, missing references) in the references section. Thank you for pointing this out. We have rechecked and revised as needed.

3.Sub-annual SMB. Thanks for your suggestion related to the sub-annual SMB estimates. We have added a sentence to foreshadow these data in the introduction section (L75):

"*However, there are few studies that estimate the seasonal surface mass balance (SMB) of debris-covered glaciers based on repeated UAV data*".

We think the seasonal mass balance is important for several reasons, which we now better highlight in the manuscript. Firstly, seasonal observations of mass balance are simply rarely available in the region, and can be essential for calibration and evaluation of mass balance models. Perhaps more importantly, these data allow us to move beyond an annual perspective to understand how ice emergence and ablation interact seasonally (as at Parlung No.4 Glacier; Yang et al 2020). This highlights the distinct situation of the two neighboring ablation areas in terms of the balance of ice resupply and ablation.

We found that the dominant control for the thinning pattern of 24K Glacier (greater ice dynamics) switches from the ice dynamics to ablation dominated during the warm period. Essentially, we argue that ice deformation is a gradual, continuous mechanism of surface change, whereas surface ablation is seasonally pronounced, and dominates the surface elevation changes during the ablation season. Notably, at 23K Glacier the ice supply is sufficiently weak that ice dynamics have little role in the contemporary elevation changes of the glacier, even during the cold season when ablation is suppressed. Finally, the seasonal results revealed that 24K Glacier melts at a higher rate than 23K Glacier during

the ablation period due to its thinner debris cover, which is not directly evident from annualized results. Based on the above findings from warm period, we added the following discussions:
L346: *"In contrast to the annual and cold period, the thinning patterns of the two glaciers are similar during the warm period (i.e., the magnitude of thinning increases with altitude). In this period, the 24K Glacier melt is little compensated by the emergence velocity (Table 5), and the pattern of surface mass balance (SMB) is clearly driven by the spatial distribution of debris thickness. Therefore, during the warm period, the thinning pattern of 24K Glacier goes from being controlled primarily by ice dynamics (for the annual and cold period) to being controlled by debris thickness".*

L379: *"Overall, the annual surface mass balances of 23K Glacier and 24K Glacier are similar, but the rate of mass loss is higher for 24K Glacier during the warm period due to its thinner debris cover".*

We also added the sentence in the conclusion section (L452): *"However, the thinning pattern of 24K Glacier is similar with that of 23K Glacier during the warm period (i.e., the magnitude of thinning increases with altitude). In this period, the thinning of 24K Glacier is controlled by melt".*

Minor comments follow:

Line 62. Might consider another word than 'dynamic' here as it conflates with the dynamic in 'ice dynamics.'
Reply: Thanks very much for your suggestion. We have changed the '*dynamic*' as '*changeable*'.

Line 420. This section makes more sense in the results to me.
Reply: Following your suggestion, we have shifted this part ('*Glacier change in the early twenty-first century*') from the discussion section (L420-443; Figure 8 and Figure 9) to the result section in the new manuscript.

Line 451. down valley instead of downward (makes it seem submergence is occurring)?
Reply: Following your suggestion, we have changed "downward" to "down valley".

Figure 3. Need to add in subplot labels to connect the figure to the caption.

Reply: Following your suggestion, we have added the subplot labels in Figure 3 (*a-f*):

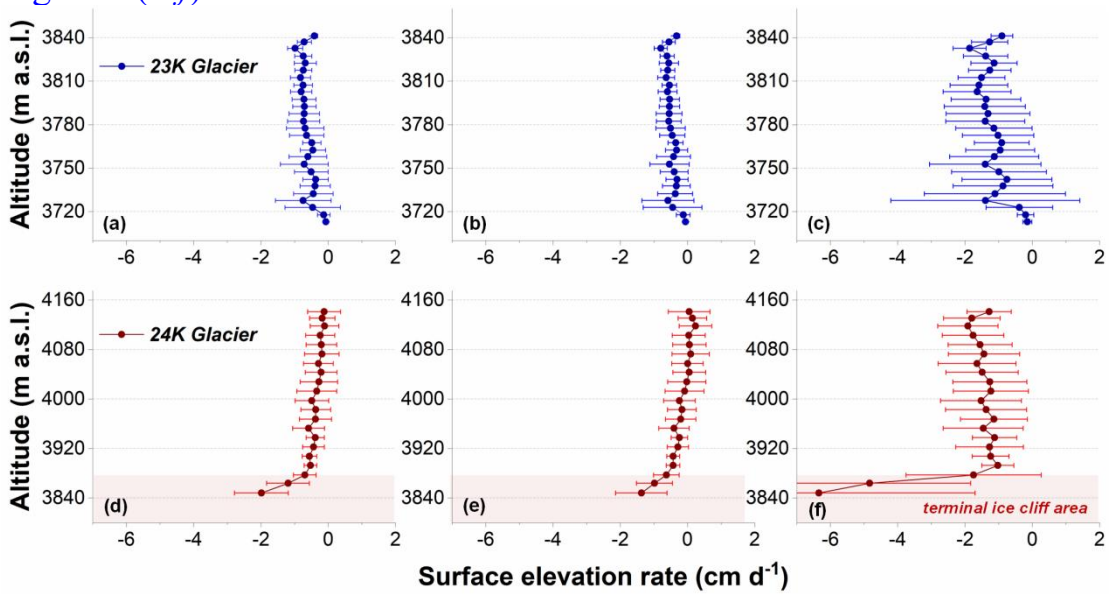


Figure 4. Putting the names on the glaciers again here in panel d1 will help the reader compare the various panels. I had to scroll up to remember which glacier is which.

Reply: Following your suggestion, we have added the glacier names in the new figure (*d1*).

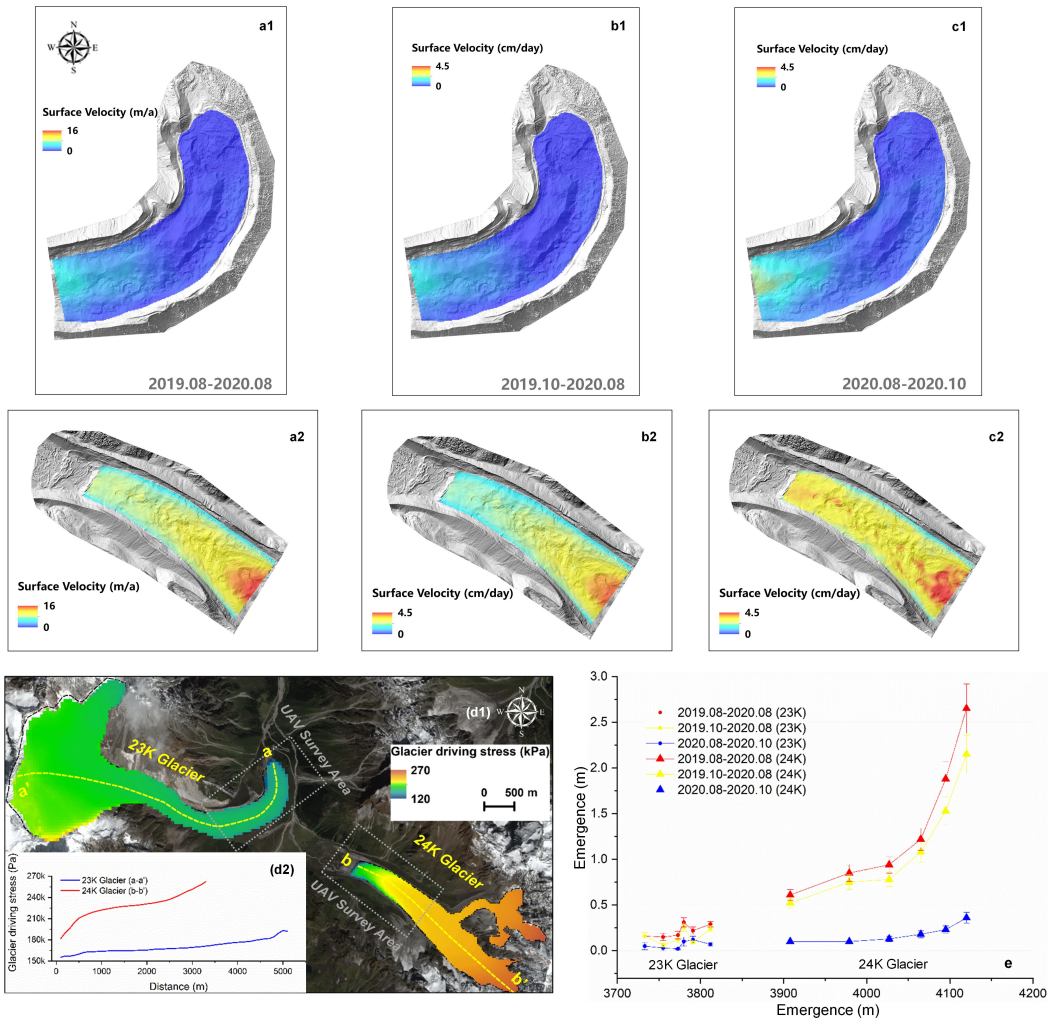
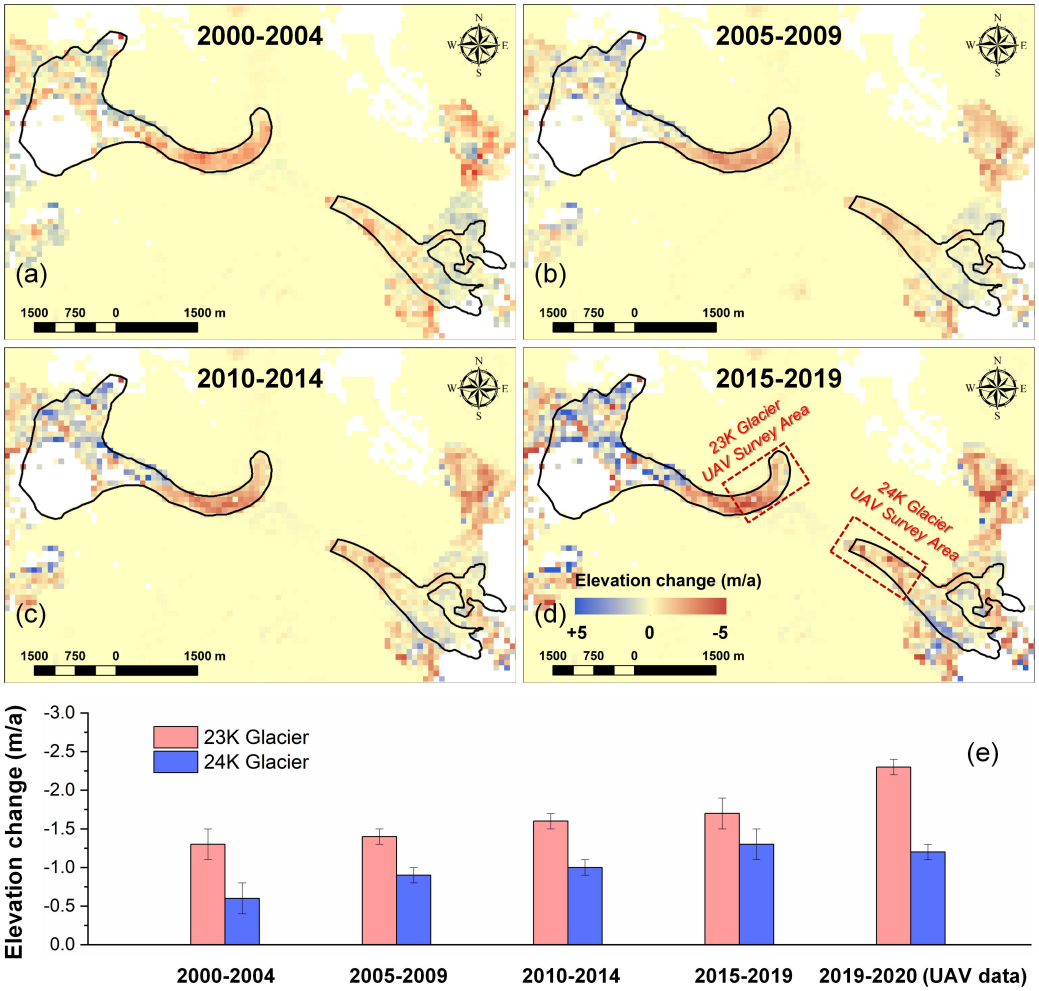


Figure 6. typo in caption

Reply: We re-wrote the caption as follows: "*Daily SMB during the warm period (black solid line), mean debris thickness (blue solid line) and mean percentage of ice cliffs and supraglacial ponds area (red solid line) for the individual zones of the two glaciers*".

Figure 8. You might consider increasing the size of the colormap so it is easier to view.

Reply: Following your suggestion, we have changed the figure's colorbar size in the new manuscript (in *d*).


2000-2004
(a)
1500 750 0 1500 m
2005-2009
(b)
1500 750 0 1500 m
2010-2014
(c)
1500 750 0 1500 m
2015-2019
23K Glacier UAV Survey Area
24K Glacier UAV Survey Area
Elevation change (m/a)
+5 0 -5
(d)
1500 750 0 1500 m

Elevation change (m/a)
-3.0
-2.5
-2.0
-1.5
-1.0
-0.5
0.0
23K Glacier
24K Glacier
(e)
2000-2004
2005-2009
2010-2014
2015-2019
2019-2020 (UAV data)