REVISION NOTES for TC-2022-238_R1

Asynchronous glacial culmination during the Last Glacial Maximum in Ikh Bogd massif of Gobi-Altay range, southwest ern Mongolia: Aspect control on glacier mass balance

These revision notes accompany a track-changes file (TC-2022-238)-

REVIEWER#1

Line number	Comment	Change made ("*in blue italic*") for text.
General comment	I would like them to revise one important issue before publication: reporting of total uncertainty. In the current draft they calculated the standard deviation of the ^{10}Be ages for a moraine, and reported it as the uncertainty of the group age. For example, the group age for moraine M_{Ih1} is reported to be 20.1 ± 0.7 ka, whereas individual external uncertainties of the ages range from 1.3 to 1.5 kyr. That is simply wrong. Please compound the external uncertainties of the ages with the standard deviation of the group age and report the compounded error as the total uncertainty of the group age. Make the revisions accordingly in the text and on the maps.	Thanks for your comment. We recalculated and reported the group total uncertainty including standard deviation of the group ages and individual external errors. *"We tested the boulder populations to find outliers using the Chauvenet and Pierce criterion and normalized deviation methods (Ross, 2003; Chauvenet, 1960, Batbaatar et al., 2018) before we assigned deglaciation ages of moraine sequences. The idea behind using Chauvenet's criterion is to find a probability band centered on the mean of a normal distribution containing all samples. Any data points that lie outside this probability band can be considered to be outliers. In contrast, Peirce's criterion is based on Gaussian distribution, and the data point is rejected if its deviation from the mean exceeds the maximum allowed deviation (calculated from the standard deviation of the group and Peirce's criterion table). For the normalized deviation, a sample in groups was rejected if its normalized deviation from the group mean (excluding the tested sample) was greater than two (Batbaatar et al., 2018). The sample was excluded from the group if its exposure age was recognized as an outlier in any of these three methods. We also calculated the reduced chi-square value and the relative uncertainty of the group (Balco, 2011) after rejecting outliers. The arithmetic mean and group standard deviation were considered as a representation of the group age.* ***However, we also calculated the total uncertainty, including group standard deviation and external uncertainty (systematic uncertainty) of each sample within the group (Batbaatar et al., 2018).*** *We presented minimum exposure ages assuming zero erosion because it has been negligible (at least for the sampled surface) since the boulders were deposited based on field observations and considering almost negligible erosion in arid regions. We also performed boulder erosion sensitivity tests on our exposure ages, using erosion rates of 1-4 mm kyr-1 (Blomdin et al., 2018). We omitted corrections for snow cover and vegetation change due to the ephemeral winter snow cover at the elevations of the sampled boulders (e.g., Gosse and Phillips, 2001) because modern winter snow cover (Oct-Apr) is very thin and no tree cover exists due to aridity. "*
Ln 16-18	It's reads a bit awkward to say "facing south into" a valley.	We have modified this sentence as: *"This study documents the asynchronous response of two paleoglaciers to the local topoclimatic factors using 10Be exposure age dating and 2D ice surface modelling."*
Ln 19	The uncertainty for the exposure age is too low. The "timing" of the glaciations should be based on the "total uncertainty" of the group of ages—compounding total of the individual external errors and the st.dev of the spread. From my experience ^{10}Be ages usually have ~20% total uncertainty.	After calculating total uncertainty, we got 8-12% of uncertainty for distal moraine groups and 21-59% of uncertainty for inner moraines (with high inheritance) of Jargalant. *"^{10}Be surface exposure age dating revealed that the Ikh Artsan short valley glacier reached its maximum position (M_{Ih1}) around 20.1 ± 1.6 ka, coinciding with the gLGM. In contrast, the Jargalant paleoglacier (M_{J1}) reached its*

		maximum extent around 17.2 ± 2.0 ka, around Heinrich 1 stadial and during the post-gLGM northern hemisphere warming."
Ln 25-26	It's redundant to mention the ^{10}Be ages. Maybe say the timing "modeled extents are consistent within ±1 sigma of the ^{10}Be ages"? Is there uncertainty for the modeled ages?	Ok. We deleted the ages and modified the text. Unfortunately, our model does not provide the uncertainty. *"The timings of the modelled maximum extents are consistent within ±1σ of the ^{10}Be exposure age results."*
Ln 48	Delete "in" before "due to"	Thank you, we did. *"The timing and extent of the maximum glaciation in many regions are still poorly understood and may differ from one region to another due to distinct ice masses respond differently to local and regional climatic conditions."*
Ln 49	No need for "However,". Just start the sentence with "New ..."	We modified the text. *"New geochronological techniques such as in situ cosmogenic surface exposure dating (e.g., Heyman, 2014; Hughes et al., 2013) permit reliable temporal comparisons between the maximum advances of different mountain glaciers."*
Ln 53	-No need for "~" before 100 ka. ">100 ka" would be OK and correct. -MIS is not introduced in the paper yet. It would be good to introduce MIS in Ln 44-46, saying "... (Clark et al., 2019), the timinig of which roughly coincides with the extent of MIS 2 (Lisiecki and Raymo, 2005)" or something like that.	Yes, we removed and explained the MIS in full words here. *"In some parts of central Asia, for example, the largest glacial extent occurred before Marine Isotope Stage (MIS) 2, >100 ka in the northeastern Tibetan plateau…"*
Ln 60	I understand that the name of the range is "Gichgine" (Đ□Đ¸Ñ□Đ³Đ¸Đ½Ñ□) in the non-possessive form. However, there's no other Gichgine exists (e.g., there's no Gichgine town/Đ□Đ¸Ñ□Đ³Đ¸Đ½Ñ□Ñ□Ñ□Đ¼), and only Gichginii nuruu (range) exists. would it be appropriate to keep the name in possessive form if the name is used in conjunction with "range"? In short, I suggest "Gichginii Nuruu" or "Gichginii range".	Actually, we had several versions of the transliteration of this range. Google (or/and Google Earth) gives us various names such as "Gichgenii nuruu", "Gichgeniyn nuruu", but not Gichginii nuruu. However, Gichginii Nuruu is used in Batbaatar et al. (2018). Gichgene or Гичгэнэ (In Mongolian language) is the right spelling of non-possessive form. The name is driven from the plant named "silverweed"). If we must change, we would like to change into "Gichgeniyn nuruu" based on Google and the standard Mongolian Cyrillic romanization ("э" is "e" here). https://en.wikipedia.org/wiki/Mongolian_Cyrillic_alphabet
Ln 62-63	You may want to specify that "a scale of a few hundred km" in "glacier length". A more relevant glacier metric to climate would be ELA, though. I suggest to report variation of ELA-depressions from one place to another. Glacier length can be very different even under the same ELA-depression due to bedrock slope, for example, without requiring a different perturbation in climate.	We agree and changed the paragraph. *"These studies suggest that glaciers in continental interior Asia respond to regional-scale climate fluctuation in different ways; hence, the last glacial maxima differed from place to place. Equilibrium Line Altitude (ELA) depression of MIS 2 maximum varied ~100 to 1100 m from the arid to humid continental environments. ELA depression estimated 800-1100 m in sub-humid regions (Russian Altai, Khangai, Eastern Sayan, SE Tibetan plateau), 500-600 m in semi-arid Gobi Altai mountains, and 100-600 m in arid northern Tibetan plateau and Tian Shan (Batbaatar. 2018; Fig. 1)"*
Ln 72	I suggest to replace "topographic changes" with "topographic variations" or "variations in topography". "Topographic changes" may suggest that the topography is changing, but I understood that you meant glaciers in different topographic conditions.	Thank you. We revised the text. *"Although spatio-temporal variations in the glacial extent in response to regional climate change have been mentioned in numerous studies, the influence of topographic variations has not been adequately explored."*
Ln 74-75	1) You mentioned in the previous paragraph (e.g., Ln 65) that aspect can make a noticeable difference. Then why would you first assume to have "synchronous" glaciations on these valleys with different orientations? 2) One small phrase you may add to avoid such criticism is to specify that you expected different lengths on two valleys but timing of maximum advances would have been synchronous.	Thanks. We revised this paragraph. *"Although spatio-temporal variations in the glacial extent in response to regional climate change have been mentioned in numerous studies, the influence of topoclimatic factor has not been adequately explored. The present study aims to evaluate how topographic shading affects fluctuations in the glacier surface mass balance and consequent millennial changes in glacier length (advance and retreat pattern using 2D ice surface mass balance model. Our particular interest in the current study is to compare spatial and temporal response of glaciers to the aspect-driven microclimate between two contrastively oriented paleo glaciers; Jargalant and Ikh Artsan of Ikh Bogd massif, southwestern Mongolia (Jargalant; Fig. 1)."*
Ln 80	I strongly suggest to change Altay to Altai and Khangay to Khangai, and follow the modern Mongolian conventions to spell these names. Since the Russian occupation of central Asian countries, the transliterations of Mongol and Turkic names have been botched in Cyrillic letters and their romanized derivations. These countries have	According to your suggestion we got to follow transliterations of Cyrillic letters. However, Russian Cyrillic romanization does not match with Mongolian pronunciation of some letters (i.e, ж and zh). Hence, we decided to use Mongolian Cyrillic romanization (https://en.wikipedia.org/wiki/Mongolian_Cyrillic_alphabet). Here "ж" is transliterated in "j". According to the standard romanization, we replaced Altay into Altai, Khangay into Khangai, Ikh Artsan into Ikh

	reclaimed their national identities since the collapse of the USSR and been trying to assert it worldwide since then. Please use the proper spelling according to the local conventions and spelling. Changing the spellings wouldn't require a lot of work -- just a "replace" function in Word.	Artsan, and Ih Bogd into Ikh Bogd.
Ln 83	What exactly mean to be "in the heart of Gobi"? Does it mean the precipitation there rainshadowed by Altai and Hangai, and is less influenced by them? or is temperature different? seasonality is different? I'm all for everything Mongolian, but I'm biased. Other readers may not understand or appreciate the significance of your study site.	Sorry for confusing you. We wanted to note that Ikh Bogd is an important representative location for the paleoglaciological research of arid, semi-arid central Asia. Accordingly, we revised the text as below: *"Ikh Bogd is one of the key sites for paleoglaciological research in landlocked arid, semi-arid central Asia."*
Ln 87	Please be consistent in names. In Ln 80, you say "Gobi-Altai range" (which I prefer) but here you say "Gobi-Altay Mountain range". Saying "mountain range" is not only redundant, but is wrong. Please fix here and elsewhere in the paper.	Thanks, we fixed the error. *"The highest peak of the massif, Terguun Bogd (3957 m a.s.l), is the highest point of the Gobi-Altai range as well (Fig. 1)."*
Ln 90	Change to "gneiss" (singular) unless you want to specify the variety of the gneiss there.	Ok. We used the "gneiss" in singular form. *"The highest part (>3000 m) of the flat summit plateau consists mainly of Mesozoic granite, while lower parts are mostly occupied by Cenozoic gneiss."*
Ln 91	Please change spelling to "Tumurtogoo". It is consistent with his name in Cyrillic, and the same romanized version was used in other publications (e.g., https://www.gsj.jp/data/openfile/no0344/GeolBayankhongor.pdf)	We changed this reference into Environmental Information Center EIC, 1981. *"EIC.: Geologic map of Mongolia 1:1000000. Environment Information Center of National Agency for Meteorology, Hydrology and Environmental Monitoring, Ulaanbaatar, Mongolia, 1981"*
Ln 103-104	Ln 103-104: it could be redundant to say "less than 200 mm of precipitation per year" and "188 mm, an average of 2005–2019". Just say "annual precipitation is ~190 mm (2005–2019 average, NAMEM, 2020), while it reaches ~100 mm..."	We revised the sentence. *"Bayankhongor (Fig. 2), the nearest aimag center (the largest unit of the Mongolian province) is 140 km distant and receives ~190 mm of precipitation per year (2005–2019 average, NAMEM, 2020), while it reaches ~100 mm (Yu et al., 2017, Fig. 2b, 2c and 2d) near Orog lake (1168 m a.s.l, Zhang et al., 2022)."*
Ln 109	add "it" before "starts to snow"	*"In the adjacent Gobi Lakes Valley, it starts to snow at the end of September but melts rapidly."*
Ln 110-111	Maybe extrapolate the monthly average temperatures to the summit using the environmental lapse rate, just to demonstrate that it's cold up there, instead of saying "sometimes it snows". It hard to grasp how frequently it happens without describing what "sometimes" entails. I would also note that environmental lapse rate is probably a minimum estimate for temperature extrapolation and dry lapse rate would suggest that the temperature at the summit is indeed cold in the desert. Your readers don't appreciate how cold it could get even in summer if you mention the temperatures at Bayangobi and Bogd.	We calculated present-day monthly average temperatures using dry lapse rate (9.8 ℃) at 3800 m, at which temperature is slightly below 0 ℃ (Supplementary 1). We revised the paragraph like this: *"Even in summer, temperature is mostly below 0 ℃ at altitudes above 3800 m a.s.l in Ikh Bogd (Long-term monthly temperatures are calculated using dry lapse rate of 9.8 ℃/km from nearby Bayangobi weather station; Supplementary 1). In the adjacent Gobi Lakes Valley, it starts to snow at the end of September but melts rapidly. However, as a result of relatively cold temperature, a thin snow cover persists on the summit plateau of Ikh Bogd between the end of September and the middle of April, while from time-to-time precipitation falls in the form of snow during summer (Landsat imagery, Farr et al., 2007)."*
Ln 121	Change to "abundant"	Thank you. We did it. *"The Ikh Bogd massif contains abundant well-developed alpine glacial erosional landforms..."*
Ln 122	Remove "glacial" before "till". There's no other till than glacial, it's redundant.	We agree with you. *"…depositional landforms such as lateral, terminal and recessional moraine ridges, tills on its northern and southern slopes."*
Ln 123	stream (water) cannot flow out as fans (sediment). Maybe change to "sediments in the stream deposit later as alluvial fans"?	We revised these sentences. *"Headwater systems of intermittent streams merge and turn into main streams, which later flow out of the mountain front and transport abundant sediments into large alluvial fans. According to the episodic sediment supply, alluvial fans from adjacent valleys coalesced (forming bajadas) and extend their length toward large endorheic intermontane basins such as the Gobi Lakes Valley (Fig. 2)."*
Ln 124	Please don't say "sediment transport by alluvial fan". Fan is a depositional landform made of sediments. It cannot move sediments. Streams, on the other hand, can move sediments and deposit them as alluvial fan.	
Ln 128	replace "headwater" with "headwall"?	We changed it into "uppermost part" of Bituut valley.
Ln 128, Ln 129	above ~3100 m than what? did you mean m asl? please fix also in Ln 129.	We added "a.s.l." after elevations.

		"Glaciers in both valleys were started from cirque above ~3100 m a.s.l and flowed down to elevations of ~3000–3200 m a.s.l."
Ln 131-132	Bituut valley studied in Batbaatar et al. (2018) originates from the Otgontenger peak, in the Khangai. I don't understand the meaning of mentioning that here in Ih Bogd, unless you're suggesting that Bituut in Fig. 1 is the same Bituut reported in Batbaatar et al. (2018)? If that's the case, it's a big case of mistaked identity. The latitude and longitude of each sample were reported in Batbaatar et al. (2018) and you would have easily seen that their Bituut is not in Ih Bogd.	It is the different one. Batbaatar et al. (2018) mapped some moraine bodies near the cirque which is located east of "Terguun Bogd". No name was mentioned, but it is consistent to the uppermost valley of Ikh Bogd's Bituut river, not the Khangai's Bituut. For clarity, we modified this sentence. *"Several well-preserved moraine ridges have previously been identified and mapped in some cirques of the massif including Ikh Artsan, Jargalant (Batbaatar et al., 2018)."*
Ln 139-140	Did you talk to local herders to confirm the name of the valleys? That's usually the easiest and most trusted source.	Yes, we did. They told me the cirque in the south is called Ikh Artsan and the north is called Jargalant.
Ln 145	Headwaters is a hydrological term describing the beginning of a stream, not the valley where the stream resides. Please change "headwaters" to "cirque" or "headwall" here and other places in the article.	"Headwater" is replaced with appropriate words in the text. e.g.: "*A few well-preserved moraine ridges have been previously identified near the headwall of Bituut."*
Ln 153	Here and elsewhere, add dash in "clast-supported", like matrix-supported.	Ok. We modified. *"M_{J4} moraine lies between 3365–3410 m a.s.l, containing angular to sub-angular clast-supported pebble to boulders. Downvalley from M_{J4} moraine, M_{J3} and M_{J2} moraines have smooth matrix-supported flat tops and steep clast-supported sides."*
Ln 206-207	Please use a total uncertainty for the group age, accounting both the external uncertainty of the ages and the standard deviation of the group. See my comment for Ln 19 and below for the Results section.	We followed your suggestion.
Ln 223-225	First, judging from the ages mentioned for Ih Artsan, it seems like you've accepted LSDn scaling as factor. You need to say explicity say so in the Methods (e.g., Ln 200). The mean of ages calculated using Stone scaling is 22.3 ka, which is ~2 ka larger than 20.1 ka based on LSDn ages. This is a significant deviation, comparable to the total uncertainty of the individual ages. Second, I would not accept the standard deviation of the ages as the uncertainty for the total age for the moraine. This is just a metric for how tight your ages are. You can't ignore the external uncertainties of the ages. The total uncertainty should be a compounding error accounted for both the standard deviation of the spread and the individual external uncertainties. Here's how I calculate it: Total uncertainty = SQRT(stdev^2 + average of external uncertainties^2). According to this calculation, the age for M_{Ih1} moraine should be 20.1 ± 1.6 ka (based on LSDn scaling) or 22.3 ± 2.1 ka (based on St scaling). If we trust LSDn scaling, the age range is 18.5–21.6 ka, and the St scaling would suggest an age range of 20.2–24.4 ka. The true age is somewhere between these ranges, but we can't tell.	Thanks for your great suggestion. 1. Previous studies present ^{10}Be exposure ages referenced to the Stone (2000) for neighboring mountain ranges of Ikh Bogd. Initially, we reported exposure ages referenced to Stone (2000) for simple comparison with them. However, in the comparison section (Fig. 8), we recalculated all of ^{10}Be exposure ages from neighboring areas with LSDn scaling for comparison. Therefore, we decided to remove age dating result referenced to (Stone 2000). 2. We recalculated group uncertainty as you suggested. Hence, we added the discussion part about the true age of the groups in concern of total uncertainty.
Ln 235	The age for M_{J1} should be 17.2 ± 2.0 ka (LSDn scaling ±compounding errors). Please address this.	Yes, thank you.
Ln 241	Please better define "undermined by growing ice". It's not clear what surface process is being implied here.	We revised like below. *"These unusually old boulders are pieces of the summit plateau that were transported onto the glacier surface by rockfall, which seems to happen in the recent times as well. For temperate glacier, rock fracturing occurs not only on the headwall above the glacier, but also within the bergschrund (bottom of the headwall) by ice segregation. This kind of undermining (sapping) process, would drive consequent upper headwall collapse and give large amount of rock supply to the glacier (Sanders et al., 2012)."*
Ln 249	Please better define what you mean by "concordant". In the abstract you used "synchronous" which is a good term to suggest similar timing. However, "concordant" could mean moraines in two valleys could be similar in timing and extent. Which is it? Both? Say so. In other words, your hypothesis needs to be unambigous.	Yes, as your suggestion, we removed all expressions about that. We meant synchronous glaciation at first.

Ln 250	I'm not too sure about 3 ka difference between these two moraines. As I said in my comments for Ln 223–225, the true age is somewhere within the range indicated by the total uncertainty, not the arithmetic mean. In other words, age for MIh1 is 18.5–21.6 ka and age for Mj1 is 15.1–19.2 ka. These two ranges overlap! I suggest to reframe your modeling experiment as not a test of asynchronous advances, but present it as a test of climate perturbations for these awesome glacier advances in the Gobi. Nobody's done that before, and that's totally normal and acceptable exercise to do. Or, you need to provide more evidence to support that indeed Jargalant glacier started advancing 3 kyr later than Ih Artsan glacier. There's no evidence provided in the current draft to support that idea. Even if these "exposure" ages were indeed separated by 3 kyr, that doesn't mean the glaciers were advancing at different times. ^{10}Be ages for these boulders merely tell you the time when the boulders were abandoned on the moraine crest. In other words, the boulder ages from terminal moraines (not recessional moraines) could indicate the timing of glacier standstill (Batbaatar et al. 2018, QSR), time of glacial advance (Heyman 2014, QSR), or completion of glacial advances (Heyman 2018, QSR). The point is, these boulder ages don't tell you exactly what the glacier was doing.	Yes. The true age must be between 18.5–21.6 ka for M_{IA1} and age for M_{j1} is 15.1–19.2 ka. Since we do not know the true age, we need some scientific support to conclude. Statistics is a crucial process behind how we make discoveries in science, make decisions based on data, and make predictions. Rejecting outlier is also statistical work. It gives us the data close to the truth. Hence, we think the arithmetic mean age is reasonable and has statistically high probability to represent the true deposition age with some uncertainty. Additionally, we used Welch's T-test to compare mean exposure ages of two distal moraines (M_{IA1} and M_{J1}) And related values and results are described in the 'Result' part. We modified text about the reason to run a model like this: *"Although spatio-temporal variations in the glacial extent in response to regional climate change have been mentioned in numerous studies, the influence of topoclimatic factor has not been adequately explored. The present study aims to evaluate how topographic shading affects fluctuations in the glacier surface mass balance and consequent changes in glacier thickness and length (advance and retreat) using 2D ice surface model. Our particular interest in the current study is to compare spatial and temporal response of glaciers to the aspect-driven microclimate between two contrastively oriented paleo glaciers; Jargalant and Ikh Artsan of Ikh Bogd massif, southwestern Mongolia (Jargalant; Fig. 1)."* We already have a model result about glacier state (See supplementary 2). According to this we modified text. *"Ikh Artsan glacier abruptly retreated from its maximum extent near 20.2 ka (age dating result was 20.1 ka), while Jargalant glacier almost constantly advanced until 17.8 ka and started to retreat from its maximum extent by 17.1 ka (age dating result was 17.2 ka) with short stagnation around its maximum extent."*
Ln 261	I'm afraid you need to spell out "JJA" in this first instance.	We revised the text. *"To infer the net gain and loss of glacier mass along the longitudinal profile (Fig. 7a, b, c) for both catchments, we calculated and plotted the variations in June, July, August (JJA) mean melt rate and winter precipitation (i.e., snow in the whole year) during 22-16 ka ago."*
Ln 329	Please consider spelling out the modeling steps as First, Second, Third etc. or just use 1) 2) and 3) without st and th. The combination of "1st)" and "2nd)" looks awkward.	Oh, thank you. We changed it into 1), 2) and 3).
Ln 335	Yes, it snows sometimes in Gobi in summer. It snowed in late May at Sutai when I camped there in 2013, and my equipment was still frozen when I came back in June and I had to abandon it. But when you phrase it like that it sounds like anecdotal accounts. Please try to demonstrate the coldness of this continental climate by mentioning long-term average of the extreme minimum temperatures in June-July-August, scaled by lapse rate to high elevations of the moraines.	We revised the text according to your comment. *"We use only summer temperature because even today, monthly mean temperatures between August to May are less than 0 ℃, in which no melt occurs (NAMEM, 2020). The long-term average of the extreme minimum temperature at the mean glacial toe altitude (Ikh Artsan and Jargalant) is -5.2 ℃ (calculated from Bayankhongor 1874 m a.s.l using lapse rate of 8 ℃/km)."*
Ln 365	Please better describe what you mean by "A cross-section of the thickest ice was recognized as ELA" or provide justification for why ELA should be at the thickest part of the glacier.	In fact, our glaciers are likely to be considered cirque glaciers, rather than valley glaciers. Hence, we assumed that the ELA must be linked to the maximum erosion or maximum ice thickness. *"Therefore, we applied corresponding paleo mass balance values on the initial ice thickness profiles. Artsan and Jargalant glaciers mostly developed within a cirque. The maximum erosion related to the rotational movement beneath a cirque is closely linked to the ELA for cirque glaciers (Dahl et al., 2003). Hence, in our modelling, thickest ice surface related to the maximum erosion was recognized as ELA. Accordingly, paleo ELAs were calculated regarding the ice thickness change."*
Ln 373	Define "significant". Do you mean significant in statistical term or just to infer that the insolation was different enough between the valleys to cause different glacier advances?	Yes. We tried to express that the insolation was different enough between two slopes. For clarification, we deleted "significant". *"The result approved that the south-facing slopes in mountainous regions receive more solar radiation than the north-facing slope in the northern hemisphere."*

Ln 375-376	Did the timing of max insolation at Ih Artsan coincide with min insolation at Jargalant? Please rephrase the sentence.	We revised the text as below. *"At solar noon, the sun is always directly south in the northern hemisphere, hence southern slopes of mountainous area receive their maximum insolation. However, the orientations of two valleys are not true north or south. The azimuth of the Ikh Artsan is 247° (SSW) and for the Jargalant it is 40° (NNE). According to the exact orientation, peak of the daily insolation contrast between two valleys is calculated 3 to 4 pm, not at noon."*
Ln 385	Please indicate that the melt was calculated using Eq. 12. It's worth repeating here referring back to the model.	Yes, we referenced the equation 12. *"For simplicity, the melt was calculated (Eq. 12) along valley profile of Ikh Artsan and Jargalant valleys (Fig. 7)."*
Ln 388	Please say that the glacier melt is in [m water equivalent]. Otherwise, melt of 4 m of snow or ice would be very different things.	Mass balance is summation of winter snow and summer ablation. For our model, the ablation (melt) formula contains the melt factor and the ice radiation coefficient for ice surfaces which are expressed in mm or m unit. It was necessary to express the melt in mm or m due to usage of the same units.
Ln 388	Describe "higher" than what value, or just say it was a "substantially high value" for the area.	We modified it into "*high value*"
Ln 401–406	Why report timing from the models in two decimal points? The group ages are rounded to one decimal point, why not round the model timing to one decimal point as well (e.g., 20.3 ka and 17.1 ka).	Good point. We rounded all age dating results in one decimal points in the text.
Ln 412	Considering the age for the moraine (group age) should be reported with the total uncertainty, the statement "Ih Artsan glacier reached its maximum ... at 20.1 ± 0.7 ka" is false. The age should be 20.1 ± 1.6 ka, if you trust LSDn. Then there's the matter of St scaling.	Yes. We calculated total uncertainty and added some discussion about determining the exposure age of the group. St scale is removed from our study.
Ln 414	No need to say "on the other hand", especially when you consider that the total uncertainty for the group ages from the two valleys overlap.	We removed the "on the other hand" here. *"Our study also documents the farthest found moraine (MJ1) in Jargalant valley formed around 17 ka (17.2 ± 1.5 ka), three millennia later than the south-facing Ikh Artsan valley."*
Ln 415	The group age should be 17.2 ± 2.0 ka, accounting for external uncertainties of the individual ages and the age spread within the group.	Yes. We calculated total uncertainty and added some discussion about determining the exposure age of the group. St scale is omitted from our study.
Ln 487	First, you need to add a paragraph in the Methods or Results section, specifically and unambigiously describing how you interpret the ^{10}Be exposure ages from boulders. According to this sentence in Ln 487, are you interpreting that these boulders were deposited and exposed to cosmic rays at the onset of deglaciation? It can be a good assumption, but you need to explicitly say so about your interpretation of ^{10}Be ages. The context matters too. For example, Putnam et al. (2014) mapped terminal and recessional moraines separately based on geomorphic features and the ^{10}Be ages meant different things depending on the moraine: timing of advance or standstills during retreat. Second, I'd re-emphasize the importance of total uncertainty in reporting group ages. Ih Artsan moraine deposition age is 18.5–21.6 ka, coinciding with the timing of local LGM based on Yu et al.'s (2017, 2019) Orog lake cores. I think this is awesome that the moraine records match with the lake records. ^{10}Be ages are not precise enough for comparing ages within a few kyr.	We modified text about the reason to run a model like this: *"Although spatio-temporal variations in the glacial extent in response to regional climate change have been mentioned in numerous studies, the influence of topoclimatic factor has not been adequately explored. The present study aims to evaluate how topographic shading affects fluctuations in the glacier surface mass balance and consequent changes in glacier thickness and length (advance and retreat) using 2D ice surface model. Our particular interest in the current study is to compare spatial and temporal response of glaciers to the aspect-driven microclimate between two contrastively oriented paleo glaciers; Jargalant and Ikh Artsan of Ikh Bogd massif, southwestern Mongolia (Jargalant; Fig. 1)."* We already have a model result about glacier state (See supplementary 2). According to this we modified text. *"Ikh Artsan glacier abruptly retreated from its maximum extent near 20.2 ka (age dating result was 20.1 ka), while Jargalant glacier almost constantly advanced until 17.8 ka and started to retreat from its maximum extent by 17.1 ka (age dating result was 17.2 ka) with short stagnation around its maximum extent."* 2nd Yes, the exposure age coincides with the lake proxy result within its uncertainty. *"A suite of granulometric, palynological, ostracod, and geochemical proxies from the Gobi Lakes Valley reveal several harsh and dry climates, including the local LGM (19–18 ka) and Younger Dryas (Mischke et al., 2020; Yu et al., 2019; Lehmkuhl et al., 2018; Yu et al., 2017; Lee et al., 2013; Felauer et al., 2012; Fig. 9). This result is consistent with our exposure ages from two valleys within total uncertainty range."*
Ln 556–560	First, this seems to belong in Results section, rather than in Discussion. No mention of these erosion rate was implied in the introduction section or the Methods section, so it caught me by surprise.	We removed the summit plateau samples from the table. And some explanation added to method part following your suggestion. **Method:**

	Second, describe in more detail how you calculated the erosion rate based on the ^{10}Be concentration in boulders. I don't understand it. Perhaps this confusion warrants a separate description in the Methods section about these erosion rates.	*"Since our study area is thought to be well-preserved paleo peneplanation surface, ^{10}Be concentration of the flat summit must be measured very high. If our sampled boulders have an "inherited" component from the summit plateau, the apparent exposure age should greatly exceed the moraine deposition age. We assumed that the ^{10}Be concentration from extremely old boulders could represent the concentration of summit plateau itself. Hence, we tried to calculate the lowest erosion rate of the summit plateau using the highest measured ^{10}Be concentration from the oldest moraine boulder. Therefore, we selected a point (44.6°N, 100.2°E) that is representable of the summit plateau. The point was chosen at the highest elevation (3625 m) between Jargalant and Ikh Artsan cirques (Fig. 12). The erosion rate was calculated with "Erosion rate calculator" of Cronus Earth V3.0.2"*
Ln 581–584	This reads like results, not discussion. For example, the erosion rates were not mentioned before this sentence, and the methods on calculation of erosion rates were not included in the Methods section. I'm sure about that. Please revise and make this story of erosion rate into a coherent part of the paper.	**Result:** *"^{10}Be concentration in the oldest sample (JAM003, ^{10}Be concentration was ~262.9×105) likely represents nuclide concentration at the surface of summit plateau. Based on ^{10}Be concentration of JAM003, the elevation of summit plateau (3625 m a.s.l), and shielding factor of 1, the assuming exposure age of the flat summit plateau was calculated as 442.3 ± 29.8 ka, and the corresponding erosion rate was calculated 1.23 ± 0.10 m Myr-1."*
Ln 804	Please spell out the acronyms for the organization names.	We corrected the acronyms. *ALAMGCM., 1970. Topographic map of Mongolia, Geodesy and Cartography division of Agency for Land Administration and Management, Geodesy and Cartography of Mongolia, Ulaanbaatar, Mongolia.*
Ln 806	Please spell out the acronyms for the organization names.	We corrected the acronyms. *NAMHEM., 2020. Climate data. Institute for Hydrology and Aviation Meteorological Center of National Agency for Meteorology, Hydrology and Environmental Monitoring, Ulaanbaatar, Mongolia.*
Table 1	Is it global LGM in the title, like you mentioned in intro section? Please be consistent and use the same abbreviation you've used before.	Actually, we also wanted to use the same abbreviation. However, the exposure age from Jargalant (~17 ka) moraine did not fall within gLGM range before we calculate total uncertainty of the moraine group. After your suggestion, we revised the abbreviation.
	The values are all altitudes. Make a single note that they're all altitudes in m a.s.l. and remove the redundant "altitude" from the table header?	We removed "Altitude".
	The glacier will always be above and upvalley from the terminal moraine. I understand it's probably negligible but isn't the minimum altitude *inside* of the moraine would be the glacier toe? This is just a technicality, though--I don't it'll make a difference for these small glaciers and moraines.	We agree with you. This expression was not appropriate. We deleted this expression from the caption.
	I understand it's mentioned in the text, but please make note about the vertical uncertainty of the DEM you used, just to give the sense of uncertainty for these ELA estimates.	We added the vertical uncertainty. *"ALOS PALSAR DEM with spatial resolution of 12.5 m is used to extract corresponding elevations. Altimetric error (vertical uncertainty) is ~5-7 m (Chai et al., 2022, Ferreira and Cabral, 2021)"*
Table 2	There's a dash in "shield-ing" factor. remove it.	The table is now fixed.
	Please report the "summit" production rates you've used for these two samples.	According to the location of the site, the production rate is calibrated automatically in Cronus Earth. *^{10}Be concentration of the oldest sample (JAM003 with ^{10}Be concentration of ~262.9×105) likely represents nuclide concentration at the surface of summit plateau. The production rate for summit plateau must be higher than the moraine samples due to its higher elevation (3625 m) than sampling sites and 100% exposure (topographic shielding is 1) to cosmic-ray bombardment. The older version of Cronus Earth (V2.3) provides the production rate (referenced to Lal (1991)/Stone (2000) scaling scheme for spallation) of 60.49 atoms g^{-1} yr^{-1} for summit plateau and 38.45 atoms g^{-1} yr^{-1} for sampling site (all sampling points including Ikh Artsan and Jargalant). With high ^{10}Be concentration of JAM003 and production rate of summit plateau (3625 m a.s.l), the assuming exposure age of the flat summit plateau was calculated as 442.3 ± 29.8 ka, and the corresponding erosion rate was calculated as 1.23 ± 0.10 mm kyr^{-1}.*
	I think it's wrong to report the data from the same samples as "new" samples with completely different sample IDs. I strongly suggest to remove the last two rows for "summit plateau". The only difference	We removed the summit plateau samples from the table. Some explanation is added to method and result parts following your suggestion. See the reply on Ln 581-584

	between the real samples and the SP samples are that you've higher production rate calculated from shielding factor of 1 and higher altitude. Please describe it so explicitly in the text--not in the table--and just say "we calculated new production rate based on altitude of 3625 m asl and shielding factor 1 and applied to 10Be concentrations for samples JAM003 and JAM006" and so on. If you report these as "new" samples with "real" sample IDs in the data table, the data will be scraped from the tables automatically someday and these repeats will be tabulated as separate samples, and the confusion will ensue. It's better be careful than sorry.	
	Your interpretation of the data relied on the ages calculated using Lifton (2014) scaling. The implication or the reason for calculating the ages using Stone (2000) scaling was not mentioned in the discussion or results section. What was the purpose of reporting St-derived ages in the results table if you didn't use them in your interpretation at all?	St scaling was for comparison to exposure ages from other neighboring sites (previous studies). However, we calculated all those ages in LSDn scale. So, we completely deleted the St scaling.
Table 3	I suggest changing "Run" to "Model". Or simply say "Parameters used for..."	We need to separate site parameters (altitude, latitude, temperature), glacier parameters (headwall altitude, toe altitude, glacial valley area, basal shear stress), and other key parameters run in the basic equations (Insolation, melt, mass balance model equations). Therefore, we distinguished title of Table 3 and 4 as below. *"Table 3. Site parameters and glacier parameters used for the 2D ice surface model* *Table 3. Key parameters of 2D ice surface modelling"*
Figure 1	Why emphasize "Darkhad" in the (a) inlet? There's no mention of Darkhad in the text.	According to a comment from the other referee, we changed the (a) panel.
	Place (a) inside the inlet map, just like in (b)	
	Include the label "Elevation, m asl" for the color-scale in (b)	
	Enlarge "N" of the north arrows in both (a) and (b). It's barely visible	We enlarged them.
	In caption: change "...described as a red box." to "...indicated with a red box".	Caption is simplified due to a new figure (a). *Fig. 1. Study area. (a) Central Asian glaciated mountain ranges during late Quaternary. (b) Study area. Boxed areas indicate Ikh Artsan and Jargalant valleys. See detailed maps of both valleys are visualized in Figs. 4-6. The background image is shaded SRTM DEM with 30 m resolution.*
	In caption: change "...areas show..." to "...areas indicate..."	
	In caption: "See detailed maps of both valleys in Figs. 3-5."	
Figure 2	I don't like how the black in (c) is not completely bounding the inlet. I suggest to enlarge the box in (a) accordingly, so that (c) will have bound by black lines perfectly. Why Bogd needs to be mapped outside the black box?	Thank you. We fixed this problem.
	Why it says "not to scale" above the scale in (a) and (b)? Please remove those texts.	Sorry for confusion. It belonged to the north arrow. We deleted it.
	I suggest to replace the north arrows in (a) and (b) with the north arrows you used in Fig. 1. That's much cleaner and appealing.	We substituted the north arrow.
	Maybe change the color of the lakes to neutral gray or white, because the deep blues for MAP in (b) make the contrast low.	We tried many color ramps for (a), (b), and lakes. Due to their color contrast (a is in light, b is in dark color), it was little bit difficult to choose color of the lakes. Dark blue was the best choice. According your suggestion, we changed the color into white and grey. It looks very awkward. So, we changed the lake color with black for better contrast.
	I'm not sure about labeling the black box as "massif" because Orog nuur is not part of the massif, for example. Just label it "Study area in Ih Bogd" something like that.	Yes, it is better to describe like that. We revised it.
	Is the extent of the red box will be used somewhere later in other figures, or it's being referred to in the text? I would have gotten rid of it.	We agree. We removed it.
	I strongly suggest to align the x-axis of the blue bars for the precipitation with the -20C of the temperature. The x-axis for the bars doesn't need to align at 0C--it just looks awkward. Usually, the minimum values of precip and temp of climographs	Thanks. We followed your suggestion.

	align at the same x-axis (https://en.wikipedia.org/wiki/Climograph).	
Figure 3	What's the black dashed line with an arrow in (c). Say so in the caption that it's a moraine ridge.	It also describes moraine ridge. The white dashed line is not visible on light screen (c). Thus, we described it with black dashed line. However, we changed it into white, so readers don't get confused.
Figure 4	Caption: why "valleys rise from cirque"? Perhaps valleys "extend" from the cirque? Please revise the phrasing.	Thank you. We revised it.
	Change "last" to "late"	We revised. *"Fig. 5. Geomorphologic setting and moraine stratigraphy in Jargalant valley. (a) Jargalant valley and Bituut trunk valley that extends from the cirque near the highest peak (3957 m a.s.l). Jargalant valley is one of the large tributaries of Bituut valley, while covered by a large amount of late Quaternary moraine complex. (b) The stratigraphic boundary between MJ4 and MJ3 moraines in the Jargalant cirque. Moraines are dissected by longitudinal gullies. (c) Pair of MJ2 moraine and oldest MJ1 moraine ridge. Horses (red circle) are for scale. (d) Boulder sizes on MJ2 moraine range from sub-meter to several meters. (e) Downvalley view of the moraine sequences from the uppermost moraine sequence."*
Figure 5	Gorgeous images! Are these drone images you took during your trip? Say so in the caption. I would love to see the high-resolution version of these images.	No, it is not. We wanted to take drone imagery, but we got a charging problem. We used the Bing maps imagery by Microsoft. *"Background images of (a) and (b) are © Bing Maps (2023) aerial imageries."*
	-The hummocky terrain in Jargalant valley always puzzled me. What was the main criteria for delineating the white lines there? For example, the elongated features running ~parallel with the valley are believed to be the same flow features (like in rock glaciers) the samples JAM006–010 and the outer three samples in MJ2 could be lumped in together. Then the inner two samples in MJ2 could be grouped together with the samples in MJ4. Just a thought...	Yes, they could be lumped together. We added the phrase about the main criteria to distinguish the individual moraine sequences. The age dating result also did not help with distinguish them. We left the boundary of inner moraine sequences as inferred (or uncertain). *"The Jargalant paleoglacier has a larger accumulation area and length than Ikh Artsan glacier, advancing 1.5 km downvalley. The moraine stratigraphy of Jargalant hummocky moraine was quite complicated. The original moraine surface of the inner moraines has been dissected by longitudinal stream forming the parallel moraine mounds or elongated moraine ridges along the valley. In the field, we matched such uneroded surfaces (or ridges) with the similar elevation and assumed them as an individual sequence. Stratigraphically, we identified four different moraine sequences in the Jargalant complex: M_{J4}, M_{J3}, M_{J2}, M_{J1}, from youngest to oldest; Fig. 6). M_{J4}, M_{J3}, M_{J2} moraines are distinctively separated on the left side of the valley. Elongated moraine feature (M_{J3}, M_{J2}) at the right side of the valley looks like a single flow feature. However, we assumed that the original form of the moraine (separation) had been removed or reworked by the stream erosion (Fig. 6c). According to these matters, some moraine boundaries are still uncertain, hence we marked the boundary with dashed line (Fig. 5 and Fig. 6b, c)."*
Figure 6	The low standard deviation indicated by the dashed lines on these camel plots show the "tightness" of the age values around the mean. I would not have objected to the reporting of st-dev as just the metric for that. However, you've interpreted these st-deviations as the total uncertainty for the moraine age. Please compound the st-dev values with the external uncertainties of the ages and report the total uncertainty as the "true" age for the moraines.	We did calculate the total uncertainty and added the total uncertainty in this figure. *"The range of total uncertainty of the group is marked as two vertical dashed lines."*
	Caption: "valleys" in Ln 44 (plural).	We revised it. *"Kernel density plot (KDP) of estimated ^{10}Be exposure ages from distal moraine crests in Jargalant and Ikh Artsan valleys."*
Figure 7	Indicate in the caption that the values in color scales in (a–c) are in [WH/m2]. I know you mentioned the unit in the first sentence, but you still define what the color scales are in each map.	The unit is added to the color ramp.
	How did you choose the values for yellow in these maps? This blue-red color-scale is clearly showing the distinction between the insolation on the summit and on the slopes, for example. In other words, the yellow colors are visualized to be the "inflection" points between the blue and red colors, very contrasting colors.	The color is one of the default color-ramps of ArcGIS. We tried it in so many other choices. This red, yellow, and blue combination was the best. However, we changed the yellow into grey as you suggested. We hope it become better than before.
	The three maps look exactly the same to me, except the different values indicated in the color-scale on the	Yes. Main difference (14%) in summer insolation between N and S valley was maintained between 22 to 16 ka. According to your

	bottom left corners. I don't think it's a very effective way to show the differences in insolation. One suggestion would be to show these insolations not as their absolute values, but "anomalies" from the modern values. Then it would be very apparent to the readers how much insolation has changed between LGM and modern conditions, which would awesome and more useful!	suggestion, we used total summer insolation between 22 to 16 ka. We also described the summer solstice (June 21) anomaly in 20 ka from modern value.
	The minimum value for June 21 at 20 ka is 0. The minimum summer insolation at 21-20 ka is 9.5*10^7 WH/m2. Any product of 0 should be zero, no? How does the 0 insolation could add up to 9.5*10^7?	Our insolation value is not the minimum or average. It is integration of hourly, daily, monthly, and summer values. First, we calculated incoming solar radiation every hour (corresponding the date and year). And we integrated it => daily (Insolation at 00 am + insolation at 01 am + …. + Insolation at 11 pm) => monthly (summation of 30 to 31 days of the month) => summer (summation of Jun 1 to Aug 31) => kyr.
	Place the white arrow for Ih Artsan on top of the black line.	We changed the figure.
	Indicate the melt values in [m water equivalent], or just show the numbers on the maps and describe the units in the caption. Are these total glacier melts for the entirety of the times for each map? For example, does the 509 mm for Jargalant in (b) mean that ~510 m w.e. glacier ice melted in total within 1 kyr?	We had to use the mm or m units rather than mm or m w.e, because mm or m are used in melt calculation formula. The melt factor (MF) in this formula is expressed as mm d^{-1} $°C^{-1}$ and our accumulation data units are also in mm. If it is not a big matter, we would like to use mm and m units for not be confused.
	Please revise this sentence "Melt when the present-day temperature in Jargalant is considered 0.5 °C (LGM anomaly is the same, -5.5 °C) colder than Ih Artsan is written in parenthesis." Maybe split it into two.	We revised the sentence: *"Total melt (22-16 ka) was calculated as 16.3 m w.e. in Jargalant valley, when we assume average summer temperature in Jargalant is 0.5 lower than that in Ikh Artsan."*
	Explain why lower insolation on north-facing slopes are correlated with more trees. You can't just show the difference of trees on south and north-facing slopes without a commentary. I can't find the reference, but the trees on north-facing slopes in Mongolia are associated with the active layer thickness (ALT). The north-facing slopes have thinner ALT and the permafrost is closer to the surface, allowing for trees to grow.	We referenced our ideas to previous studies and added the ideas about asymmetric distribution in discontinuous permafrost and glaciers. *"The vegetation, discontinuous permafrost, and modern and paleo glacier distribution and their magnitude in semi-arid mid-latitude regions prove the contrast in temperature and soil moisture on sunny and shady slopes (Barr and Spagnolo, 2015; Evans 2006; Klinge et al., 2021). As a result of topographically induced differences of solar radiation and evapotranspiration, forests, consisting of Siberian larch (Larix sibirica) and discontinuous permafrost are limited to north-facing slopes, whereas mountain steppe covers south-facing slopes in Mongolian forest-step zone (Klinge et al., 2021; Fig. 8b, c). Klinge et al. (2021) determined that the annual incoming solar radiation, permafrost table depth, and soil moisture (topographic wetness index) are significantly correlated. Aspect-driven solar radiation and temperature contrast also give more glacier, lower (altitude) glacier, and larger glacier on the poleward slope (e.g., Barr and Spagnolo, 2015; Evans 2006). For instance, Sutai mountain (closest modern glacier to Ikh Bogd) has large, well-developed valley glaciers flow northward into low altitude from the ice dome, but the glaciers at the south-facing slope end near the summit margin without developing into valley glaciers (Fig. 8c)."*
Figure 8	Please spell out Ih Bogd in (a). All other names are spelled out and it's awkward to have the main study area abbreviated like that	We spelled out it on the map.
	Remove "not to scale" below the north arrow in (a)	We changed the north symbol.
	Label Mongolia and China on the other sides of the border. The border line is not described in the legend or in the caption.	We added national border label and wrote China and Mongolia on the map.
Figure 9	I don't understand the timing indicated by the colors and the labels on the profiles. They seem to contradict. For example, in (a) a yellow box labeled 18.57 ka is coinciding with light-blue glacier of 22.00 ka. If I understand it correctly, the two glaciers were confined to their cirques at 22 ka and advanced beyond their cirques until 20 ka in Artsan and until 17.1 ka in Jargalant? Then Artsan glacier has retreated to the yellow box area by 18.6 ka? Please provide a better explanation in the caption.	Sorry for confusing. Your explanation is right. We revised the figure and added some explanation in the caption.
Figure 11	What's LLGM in (d) and (e)? Describe in the caption.	We added explanation in the caption.
	Why do you think the summit was ice-free during LGM? I thought of the glaciers on Ih Bogd and on Gichginii to be similar to modern Sutai: There was a large ice dome on covering the whole summit and the outlet glaciers flowed downhill into separate valleys. Take a look at this Sutai ice cap: https://goo.gl/maps/WuuDyYDMkkuK23Ki9.	Actually, we could not explore the summit plateau due to lacking of time. Our samples are not the real ones (see the interpretation of them in the 'Method' and 'Result' part). The satellite images and DEM provides only the flat surface of it. However, Vasallo et al. (2011) and Jolivet (2007) who had been on the summit plateau suggest that the absence of Quaternary glacial landforms on the summit plateau. That is why we could not suggest about ice cap erosion on the summit with

	There's a clear ice divide, separating the ice cap into four different catchments. There you can clearly see the difference between the glacier-free south-facing slopes and the glaciated north-facing slopes. When the ice flow northward from the main ice dome, it develops into a well-defined valley glacier (sort of like outlet glaciers, if you will), but the south-facing part of the ice dome end abruptly near the summit margins without developing into a finger-like valley glacier. This is also could be another demonstration of insolation differences between south- and north-facing slopes.	full confidence. However, our age dating results (with high inheritance and old exposure ages of 636.2-35.9 ka) from Jargalant inner moraines suggest the ice-free condition at least during LGM.
	Back to the assumption that the Ih Bogd summit was ice-free during gLGM. The transport of old summit material post-LGM makes sense. However, if the summit was ice-free during gLGM and the old material was moving with the glacier during gLGM, as indicated in (d), then the boulders on MJ1 should be also old. Please emphasize your point in the caption that the MJ1 till would have more plucked material than boulders with inheritance (orange pieces) but that changed completely the opposite post-LGM.	Thanks for your suggestion. We also demonstrated this idea on Fig. 11. Caption is also revised. *(d) LLGM (Local LGM ~17 ka) glacial extent. Plucking of fresh rocks was intensive due to glacial length and thickness. Enhanced supply of highly inherited rocks into M_{J4}, M_{J3}, and M_{J2} moraine series which are formed by successive glacial advances or/and stagnation. According to a shortage of glacier length, low number of fresh rocks are plucked out. Thinned glacier allows intensive ice segregation along the bergschrund and more inherited rockfalls into the ice surface. Hence, boulder supply with inheritance of paleo surface would be increased. (f) Present-day rockfall deposit without supraglacial transport.*

REVIEWER#2

Line number	Comment	Change made ("*in blue italic*" for text.
General comment	The manuscript suffers from a few structural problems, including mixing and matching between results and methods, and in general a lack of clarity in the many methodological steps. I would like to see this manuscript published but I hope the authors want to address my comments below, to enhance clarity and structure, and to better streamline the manuscript. Finally, in the future I hope they plan to extend their analysis to include more paleoglaciers in similar settings, with similar asynchronous behavior.	Thanks for your time and efforts. All comments are very productive, which we incorporated into the revised manuscript.
Ln 14-15	Consider changing this sentence as you spend an entire paragraph in the introduction chapter to explain that there is a much more complicated global signature. Also, isn't this pertaining to ice sheets?	It corresponds to ice sheets; however, many mountain glaciers also reached its maximum extent during gLGM as well. According to your suggestion, we got concentrated on the aspect effect on glacier mass balance. *"Mass balance of mountain glaciers varies not only with major climatic factors but also with the non-climatic factors, such as topography. Particularly, the north-south aspect contrast in mid-latitude high mountain regions can generate substantial differences in insolation and melt, leading to local asynchrony in the glacial dynamics."*
Ln 16	Do you really document maximum extent or rather specific glacier culminations? You have dated moraine ridges but are you sure they are they represent maximum extent?	We are not sure for Jargalant distal moraine. However, it seems the culmination is more reasonable based on the moraine characteristics and 2D ice surface model. *"Under the same temperature and different insolation, glaciers on the south- and north-facing slopes across small regions behave almost synchronously. Both of Ikh Artsan and Jargalant glaciers culminated near 20.2 ka and abruptly retreated to the cirque headwall. Also, their changes in glacial dynamic were almost the same (See supplementary 2 file). However, there was no glacier stagnation observed in the Jargalant valley around 17 ka (i.e., this result does not match our exposure age dating). We sampled from possible most distal moraine from Jargalant valley to avoid sampling from of reworked boulders in steep slope. Likewise, we could not find any other evidence that the Jargalant glacier reached the trunk valley of Bituut river. If we consider both glaciers moved synchronously, the most distal moraine must locate more downvalley from the ~17 ka culmination. In this case, the geological evidence (terminal moraine) near 20 ka must have been degraded by Bituut mainstream or/and reworked with the mass movement."*
Ln 52-63	All of these places need to be referenced on a map in a figure. For example, Gichgene range is very local, and the average reader will have no idea of where this is. Consider adding the place names to one of your overview maps and reference the figures when you mention them in the text.	Gichgeniyn nuruu is already illustrated in Fig. 9 (Former Fig. 8). Other places are described on the Fig. 1. We added relevant figure reference. *"Evidence from mid-latitude glaciers reveals a more complex behavior than that of synchronized 'global' glaciations. In some parts of Asia, for example, the largest glacial extent occurred before Marine Isotope Stage (MIS) 2, >100 ka in the northeastern Tibetan plateau (Heyman et al., 2011a) and late MIS 5/MIS 4 in the Kanas lake, Chinese Altai (Gribenski et al. 2018). In the Tian Shan (Blomdin et al., 2016; Li et al., 2014; Koppes et al., 2008), Altai (Blomdin et al., 2018), Khangai (Batbaatar et al., 2018; Pötsch, 2017; Smith et al., 2016; Rother et al., 2014), and Eastern Sayan, Khovsgol (Batbaatar and Gillespie, 2016; Gillespie et al., 2008) mountains, the largest glaciers dated to MIS 3, while the MIS 2 glaciers appeared to be smaller (Fig. 1). It is noteworthy that most of the MIS 3 advances are based on a few and/or widely scattered ages of moraine boulders (Gribenski et al., 2018; Blomdin et al., 2016). On the other hand, in the Gichgeniyn range (Fig. 9)"*
Ln 72	Should it be "topoclimatic" factors?	We changed it into "topoclimatic factor" *"Although spatio-temporal variations in the glacial extent in response to regional climate change have been mentioned in numerous studies, the influence of topoclimatic factor has not been adequately explored."*
Ln 71-77	The research questions are interesting but I I'm having some problems following the sentences. I think you can clarify the aim and research questions much easier if you move away from the hypothesis-testing formulations.	Thanks for the suggestion. We modified the paragraph. *"Although spatio-temporal variations in the glacial extent in response to regional climate change have been mentioned in numerous studies, the influence of microclimate or topoclimatic factor has not been adequately explored. The present study aims to evaluate how topographic shading affects fluctuations in the glacier surface mass balance and consequent changes in glacier length (advance and retreat pattern) for two contrastively oriented paleo glaciers in Ikh Bogd massif, southwestern Mongolia using 2D ice surface mass balance model".*
Ln 74	It's not unstudied. Wasn't Batbataar there already? Consider removing	Thank you we did remove it.

	"unstudied".	*"The present study aims to reconstruct the glacier extent and chronology of major glacial events during the last glacial cycle in Ih Bogd massif of southwestern Mongolia."*
Ln 92-96	Is it also possible that they are a result of ice cap erosion?	Actually, we could not explore the summit plateau due to lacking of time. Our samples are not the real ones (see the interpretation of them in the 'Method' and 'Result' part). The satellite images and DEM provides only the flat surface of it. However, Vasallo et al. (2011) and Jolivet (2007) who had been on the summit plateau suggest that the absence of Quaternary glacial landforms on the summit plateau. That is why we could not suggest about ice cap erosion on the summit with full confidence. However, our age dating results (with high inheritance and old exposure ages of 636.2-35.9 ka) from Jargalant inner moraines suggest the ice-free condition at least during LGM.
Ln 100	What about paleoclimate records? I think you should talk about other records that exist here? Or are they non-existent?	We added the small phrase in the end of the 2.2 (Climate of the study area). *"Much colder than present-day winters and summers in Mongolia are consistent with the strengthening of the winter high pressure over northern Eurasia. LGM summers were 1 to 7℃ colder than today in Mongolia. The southward shift of westerly storm tracks should, therefore, contribute to the lower than present precipitation values (Tarasov et al., 1999). Multi-proxy records indicate that the local LGM climate if the study area was very dry and harsh (Yu et al., 2012)."*
Ln 120-133	In my opinion, this section should focus on presenting the general topographic setting and reviewing previous mapping and research efforts. I think any observations made by the authors should be included in the results sections.	We combined the 2.1 (Geology) and 2.3 (Glacial landforms and general setting) into General settings of study area (2.1). We also moved the content from field observation to the result part. *"Headwater systems of intermittent streams merge and turn into main streams, which later flow out of the mountain front and transport abundant sediments into large alluvial fans. According to the episodic sediment supply, alluvial fans from adjacent valleys coalesced (forming bajadas) and extend their length toward large endorheic intermontane basins such as the Gobi Lakes Valley (Fig. 2). The Ikh Bogd massif contains abundant well-developed alpine glacial erosional landforms such as cirques, short-valleys and depositional landforms such as moraine and tills. Some well-preserved moraine ridges have previously been identified and mapped in some cirques of the massif including Ikh Artsan, Jargalant (Batbaatar et al., 2018)."*
Ln 125-127	Consider moving this sentence somewhere else. This should already be clear from the aims-research questions paragraph.	We moved this sentence into introduction part. *"Although spatio-temporal variations in the glacial extent in response to regional climate change have been mentioned in numerous studies, the influence of topoclimatic factor has not been adequately explored. The present study aims to evaluate how topographic shading affects fluctuations in the glacier surface mass balance and consequent millennial changes in glacier length (advance and retreat pattern using 2D ice surface mass balance model. Our particular interest in the current study is to compare spatial and temporal response of glaciers to the aspect-driven microclimate between two contrastively oriented paleo glaciers; Jargalant and Ikh Artsan of Ikh Bogd massif, southwestern Mongolia (Jargalant; Fig. 1)."*
Ln 139-141	How do you identify a depositional property from a topographic map? Consider removing this phrase or clarify. How did you exactly identify your landforms?	We removed the phrase.
Ln 142	Morphology and weathering traits should be described here—what characteristics were used to distinguish the moraines—other than morpho--stratigraphic position?	Due to the hummocky characteristic (with low relief) of the moraine, the satellite images and DEMs are insufficient to distinguish them into different moraine sequences. We recognized them based on field observation and relevant contents are described in result section. See 'Section 4.1'.
Ln 144	This whole section does not contain any methodological descriptions but rather lists specific field observations who should belong in a result or interpretation section. The section also includes speculations which do not belong in a methods chapter. Consider restructuring this I write a proper methodology on how the mapping of moraine ridges have been performed.	We moved this whole section into result part and revised again. See 'Section 4.1'
Ln 145	Did you focus on moraine ridges? Did you look for other traces such as glacial erratics or tills further downstream the moraines?	Yes, we looked for tills, erratic boulders and other traces. The farthest extent is mapped on this observation.
Ln 147-149	Since you present some lithological descriptions in the text, I think you can show this with photographs to aid	Unfortunately, the photographs we show in Fig. 4 are the best ones we have. We revised the sentence due to lacking of the appropriate proof photos.

	our understanding in how you separated between the different moraines.	
Ln 160	Consider, including an uncertainty discussion regarding the headwall position. Could you use several values? The same goes for the toe position if this is uncertain? Additionally, I miss some more details on the method you are using and why you are using it? Why are you making ELA reconstructions?	The ELA reconstruction is for simple comparison of different behaviors of two glaciers. We illustrated ELA estimations of two catchments on the Fig. 10. We mentioned about this simple purpose doing ELA reconstruction in the 'Method' part. *Ikh Bogd massif is unglaciated today. Furthermore, the nearest modern glaciers are glaciers in Otgontenger (Khangai), Sutai (Mongolian Altai), which are approximately 350 to 550 km north and west of the study area. Thus, we could not calculate present ELAs or ELA depression; hence only ELAs for former glaciers were estimated for comparing glacier behavior of Ikh Artsan and Jargalant glaciers.*
Ln 171	Are you using the MELM method? In this paragraph this is unclear to me.	Sorry for the confusion. It is not MELM (Maximum Elevation of Lateral Moraine). We just mentioned the MEG (Median Elevation of Glacier) which has toe to headwall altitude ratio of 0.5) as most simple and most used method in former ELA calculation. For clarity we revised the text as below. *"Relatively lower value of THAR (Meierding 1982) is commonly used in previous studies of mid-latitude glaciers; however, according to glacier type or location, higher value is applicable (Gillespie et al. 2008). For this reason, we also used a higher THAR ratio of 0.58 because Ikh Bogd massif must have higher ratio due to its arid environment during the last glaciation (Lehmkuhl et al., 2018; Felauer et al., 2012)."*
Ln 206	I think the reference is wrong here. It should probably be Balco (2008) or someone earlier. Remove the Blomdin et al. reference.	We corrected the reference. *"Balco, G: Contributions and unrealized potential contributions of cosmogenic nuclide exposure dating to glacier chronology, 1990–2010. Quat. Sci. Rev. 30, 3–27.* https://doi.org/10.1016/j.quascirev.2010.11.003. *2011"*
Ln 202-205	You use three statistical tests to identify outliers, but it sounds like you are only using the third method by Batbataar to reject samples? Did the methods come up with different answers? First, I think you need to explain the methods a bit more in detail, how are they different and which one is preferred? What do you do if the methods give different results?	We added some brief explanation for each method. In the result part, we wrote that which one is preferred to reject outliers. See the reply on Ln 227 *"We tested the boulder populations for finding outliers using the Chauvenet and Pierce criterion and normalized deviation methods (Ross, 2003; Chauvenet, 1960, Batbaatar et al., 2018) before we assigned deglaciation ages of moraine sequences. The idea behind Chauvenet's criterion is to find a probability band centered on the mean of a normal distribution containing all n samples. And any data points that lie outside this probability band can be considered to be outliers. In contrast, Peirce's criterion is based on Gaussian distribution, and data point is rejected if its deviation from the mean exceeds the maximum allowed deviation (calculated from standard deviation of the group and Peirce's criterion table). For the normalized deviation, a sample in groups was rejected if its normalized deviation from the group mean (excluding tested sample) was greater than two (Batbaatar et al., 2018). The sample was excluded from the group if its exposure age was recognized as an outlier in any of these three methods."*
Ln 206-207	Specify, whether you include or exclude the outliers in the standard deviation of the samples.	The reduced chi-square values and relative uncertainties were calculated from the group ages with no outliers. *"We also calculated the reduced chi-square value and the relative uncertainty of the group (Balco, 2011) after rejecting outliers."*
Ln 207	You assume zero erosion but you don't actually test what varying boulder erosion rates does to your ages? Consider adding a discussion on boulder erosion checks.	We performed the boulder erosion rate sensitivity test on our exposure ages. *"We presented minimum exposure ages assuming zero erosion because it has been negligible (at least for the sampled surface) since the boulders were deposited based on field observations and considering almost negligible erosion of arid regions. We performed boulder erosion sensitivity tests on our exposure ages, using erosion rates of 1-4 mm kyr-1 (Blomdin et al., 2018)."* *For erosion rates of 1-4 mm kyr-1, an exposure age of 10 ka calculated assuming zero erosion would underestimate the true age by 1-4% and an age of 20 ka by 2-7%. Samples with longer exposures (boulders with inheritance) older than 100 ka, were increasingly sensitive to erosion; i.e., JAM10 (123.8 ka) had an impact, increasing ages with 12-125% for 1-4 mm kyr-1 and JAM03 (636.2 ka) was saturated even for 1 mm kyr-1boulder erosion rate."*
Ln 212	The result section misses a sub section describing the mapped moraines and proper maps showing how they were mapped. (See my comment on Figure 5)	- Since it is a hummocky moraine with low relief, 12.5 m resolution DEM was insufficient to show moraine morphology. We made an additional panel using oblique aerial imagery and cross-profiles to identify moraine sequences instead of DEM. - We visualized the moraine ridges with separate color (only inner and distal moraines are distinguished with color) and moraine limits with dashed lines (inferred or uncertain limits) and bold lines (certain limits). - Sorry for confusion. We should have to add more content about moraine morphology. It is a hummocky moraine; hence we took samples from uneroded moraine surfaces (flat ridge-like top) rather than terminal or lateral ridges. - In the field, we matched the uneroded surfaces with the similar elevation and

		hypothesized them as an individual moraine sequence. Also, age dating result with large inheritance could not help with the moraine limit confirmation. See the 'Result' part (4.1).
Ln 213	This could be illustrated on a map. Also, I'm not sure the reason for making this ELA reconstruction—is it used to compare with the model or other sites? Or is it linked to paleoclimate? Or do you simply make the ELA reconstruction to say that paleoglaciers did not behave in the same way in the two catchments? Consider clarifying the purpose with the ELA reconstructions.	- The ELA reconstruction is for simple comparison of different behaviors of two glaciers. We illustrated ELA estimations of two catchments on the Fig. 10. *Ikh Bogd massif is unglaciated today. Furthermore, the nearest modern glaciers are glaciers in Otgontenger (Khangai), Sutai (Mongolian Altai), which are approximately 350 to 550 km north and west of the study area. Thus, we could not calculate present ELAs or ELA depression; hence only ELAs for former glaciers were estimated for comparing glacier behavior of Ikh Artsan and Jargalant glaciers.*
Ln 223	According to the map in Figure 5 it's not clear that this is the most distal ridge. It's in fact, impossible to see this.	We are not sure for Jargalant distal moraine. However, it seems to maximum extent based on the moraine size and 2D ice surface model. *"Under the same temperature and different insolation, glaciers on the south- and north-facing slopes across small regions behave almost synchronously. Both of Ikh Artsan and Jargalant glaciers reached their maximum extent near 20.2 ka and abruptly retreated to the cirque headwall. Also, their changes in glacial dynamic were almost the same (See supplementary 2 file). However, there was no glacier stagnation observed in the Jargalant valley around 17 ka (i.e., this result does not match our exposure age dating). We sampled from possible most distal moraine from Jargalant valley to avoid sampling from of reworked boulders in steep slope. Likewise, we could not find any other evidence that the Jargalant glacier reached the trunk valley of Bituut river. If we consider both glaciers moved synchronously, the most distal moraine must locate more downvalley from the ~17 ka culmination. In this case, the geological evidence (terminal moraine) near 20 ka must have been degraded by Bituut mainstream or/and reworked with the mass movement."*
Ln 227	You should specify which rejection method was used to reject the outliers.	See the reply on Ln 202-205. And below. Result: ***"Ikh Artsan valley:*** *seven granitic boulders (IAM001–007) collected from the most distal moraine ridge ranged in age between 21.2 ± 1.5 to 19.1 ± 1.3 ka. ^{10}Be exposure ages from this moraine sequence were well-clustered, and none of the three methods (Chauvenet, Pierce, and standardized deviation) detected outliers. A group mean was 20.1 ± 0.7 ka, Rχ2 was 0.29, and group relative uncertainty was calculated as 4% (Fig. 7)."* ***"Jargalant valley:*** *twenty-one granitic moraine boulders on the four moraine sequences were collected. Five to seven boulders from each moraine crest were sampled. Outliers were detected and rejected by Pierce and normalized deviation criterions. Because, the results from Pierce and normalized deviation methods were consistent, however, Chauvenet method could not recognize some outliers which were recognized by Pierce and normalized deviation criterions."*
Ln 247	I think this structure is unnecessary. Why don't you include the methodological explanations for the 2d model together with the other methods in one chapter?	Yes, we separated 'Method' and 'Result' part of 2D ice modelling. This structure moved to method section.
Ln 241-245	You should clarify that this you interpretation of the too old ages.	We revised like below. *"These unusually old boulders are pieces of the summit plateau that were transported onto the glacier surface by rockfall, which seems to happen in the recent times as well. For temperate glacier, rock fracturing occurs not only on the headwall above the glacier, but also within the bergschrund (bottom of the headwall) by ice segregation. This kind of undermining (sapping) process, would drive consequent upper headwall collapse and give large amount of rock supply to the glacier (Sanders et al., 2012)."*
Ln 251	Oh, I see; you are going for some sort of chronological structure of events. I actually can't see why this is necessary. Please consider moving the methods part of this section to the methods. I would rather see that you treated he modelling stuff in the methods.	We moved this content into 'Method part'
Ln 260	What is the resolution of increments along this profile? Is it the same as the cell size of the DEM?	We added the information. *"The elevation of the profile was taken from DEM with 12.5 m of spatial resolution in 5 m intervals."*
Ln 264	I think you need a few sentences in the beginning of this section linking back to your aim. Why exactly are you including the "potential clear-sky	We revised the text based on your comment. *"We assumed that the topography (aspect and slope) is main factor producing difference in daily incoming solar radiation on south- and north-facing slopes. The earth surface receives*

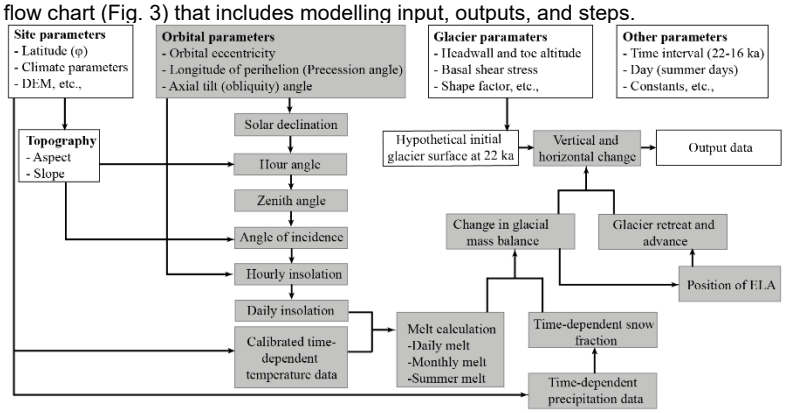
	direct solar radiation method"? I assume it is to see how different incoming insolation is between the two catchments but I can't find any statements mentioning this.	*more energy as the solar altitude angles (α) is high (zenith angle and angle of incidence is low). The earth's rotation around its axis causes the diurnal changes in solar altitude angle; which is different from morning to evening. Solar altitude angle is 0 degree at sunrise and sunset, reaches its maximum value at noon. Accordingly, in the mountainous area of northern hemisphere, south-facing slope receives highest energy at noon, however, north-facing slope receives less or no energy due to topographic shading effect (Fig. 2e). In a long-term scale, such diurnal cycle of insolation would result in significant difference in annual or long-term mass balance of mountain glaciers (by surface melt) flowing on south- and north-facing slopes."*
Ln 276	"Further" is the wrong word I think.	Oh yes. It is a mistake. We removed "further" from a sentence.
Ln 278	See my comment on ln 264. I think this must come much earlier.	We moved the phrase to the head and revised.
Ln 328	This section would benefit from having it's own headline.	We added some headline on it. *"Calculating time-dependent temperature"*
Ln 360-362	Consider elaborating on this.	We added more explanation on it. *"Jargalant glacier is 2.7 times larger in area than Ikh Artsan and twice as long in glacier length, forming a large, deep, and well-developed cirque. The cirque and valley dimensions reflect the glacier size (including thickness), as well as intensity of former glacial erosion. The normal stress acting on the glacier bed is mainly a result of the weight (thickness) of a glacier. According to the glacial valley size, we chose the higher basal shear stress of initial glacier for Jargalant valley (200 kPa) and the smaller value for Ikh Artsan valley (100 kPa)."*
Ln 392-398	This is a recurring problem in this manuscript. Frequently methods and results are mixed up in the different sections which makes it hard to get a complete overview of what has been done. This would have been useful information earlier during the methods. Additionally, I think it would have been helpful if you created a flow chart of the modelling part to better have an overview of the steps in your approach and the input data and how it applies to you paleoglaciers.	We revised the text. And separated method and result part. Also, we created a new flow chart (Fig. 3) that includes modelling input, outputs, and steps.  **Fig. 3.** Source code structure diagram of 2D ice surface modelling
Ln 421-427	Isn't it more interesting to explore whether there are similar differences in timing across water divides for these ranges? Currently, you are simply stating when glaciers advanced? But you do not discuss any spatial patterns in asynchrony? Or do you simply mean asynchrony in terms of "glaciers reached their maximum during different time periods"?	Our model presents the vertical and horizontal changes in glacial ice. But currently we concentrated on horizontal changes (changes in glacial toe location) in order to link with age dating result.
Ln 538	I miss some statement regarding the geomorphology of the summit plateau and what you observed while mapping and sampling it. Was there no evidence of glacial erosion here?	Actually, we could not explore the summit plateau due to lacking of time. Our samples are not the real ones (see the interpretation of them in the 'Method' and 'Result' part). The satellite images and DEM provides only the flat surface of it. However, Vasallo et al. (2011) and Jolivet (2007) who had been on the summit plateau suggest that the absence of Quaternary glacial landforms on the summit plateau. That is why we could not suggest about ice cap erosion on the summit with full confidence. However, our age dating results (with high inheritance and old exposure ages of 636.2-35.9 ka) from Jargalant inner moraines suggest the ice-free condition at least during LGM.
Ln 561-572	These ages are not even presented in the exposure age results? I have to admit that this section regarding the summit samples, their erosion rates and relationship to the boulders in the moraines comes a bit odd here at the end. I think they need to be emphasized more clearly in your previous results.	Our summit samples are not the real ones, hence, we explained this in the 'method part'. Although they are not real samples, we reported their result in the 'Result part'. This whole part (Ln 561-572) is the summary of the previous studies. It is little bit awkward to use age dating results from previous studies in my result section. That is why I compiled and cited them at this end.
Figure 1	Include units for the elevation ramp in "b".	We added the ramp.

Figure 5	The inferred moraine limits obscure the possibility for the reader to judge the imagery. I suggest making additional panels using the 12m resolution DEM you used and to show the moraines using a hill shade version of this one. Best would be to make a proper geomorphological map showing mapped ridge crests and perhaps moraine limits in various colours with topographic information. It's but unclear to me what the limits represent. Also, the samples rarely align with the limits, so it seems like you have sampled random boulders in the ground moraine rather than "on the" terminal or lateral ridges. Do you see what I mean? Apart for the lateral limits you have drawn, I do not think the inferred terminal limits match what's in the imagery. In the methods section you state that you are sampling moraine crests although it's clear from the map that the samples are a bit scattered from "within" the deposit. This must be explained.	- Since it is a hummocky moraine with low relief, 12.5 m resolution DEM was insufficient to show moraine morphology. We made an additional panel using oblique aerial imagery and cross-profiles to identify moraine sequences instead of DEM. - We visualized the moraine ridges with separate color (only inner and distal moraines are distinguished with color) and moraine limits with dashed lines (inferred or uncertain limits) and bold lines (certain limits). - Sorry for confusion. We should have to add more content about moraine morphology. It is a hummocky moraine; hence we took samples from uneroded moraine surfaces (flat ridge-like top) rather than terminal or lateral ridges. - In the field, we matched the uneroded surfaces with the similar elevation and hypothesized them as an individual moraine sequence. Also, age dating result with large inheritance could not help with the moraine limit confirmation. See the 'Result' part (4.1).
Figure 6	You need to increase the resolution of this image. I also think it's more justified to use the internal errors when calculating the KDP.	We re-calculated kernel density using internal errors. And external error is used to calculate total uncertainty of the group age.
Figure 7	You need to indicate the units in the maps for the colour ramps. Panel d needs to be change to planar view instead. Otherwise, it's impossible to compare this to the insolation maps. The resolutions also need to increase. I suggest making two maps of each catchment, zoomed in to show the tree distribution.	We added units in the color ramp. Actually, the panel d and e are not from study area (Ikh Bogd). Ikh Bogd is a unforested mountain due to its aridity. Panel d and e are from Khangai mountains. We brought them as an evidence of incoming solar radiation diversity between southern and northern slope of the midlatitude regions with arid and semi-arid climate of northern hemisphere.
Figure 8	You need to explain the box and whisker plots. Shouldn't the median be indicated? And also why do some miss error bars?	Median is indicated and box and its upper, lower limits, whiskers, and the "+" (miss error bars) symbols are explained. *"On each box, central mark indicates the median, and the bottom and top edges of the box indicate the 25th and 75th percentiles, respectively. The whiskers extend to the most extreme data points not considered outliers, and the additional outliers were detected from the effective ages and plotted individually using the '+' marker symbol".*
Figure 9	I do not understand what the red dashed lines represent? Are they the original 2d profile-and then the blue shaded ice extents, where you have to add the "m" from the mass balance calculations	Red dashed lines are the profile of the retreating glaciers from its maximum extent to the headwall. We revised the figure and some additional explanation in the caption.
Technical corrections	I haven't had time to list all technical corrections but there are many of them. I suggest the authors go over language and sentence structures one more time before sending in a new version of the manuscript.	Thanks again. All authors read through the manuscript and corrected all typos and other matters as much as we can. In addition, an Indian PhD proofread the manuscript as well.