

**Review by Mauro Fischer (Glaciologist at the Institute of Geography, University of Bern, Switzerland, mauro.fischer@giub.unibe.ch) of the manuscript „Water storage and drainage of short-lived lakes in the Teskey Range, Central Asia” submitted by Mirlan Daiyrov and Chiyuki Narama to Natural Hazards and Earth System Sciences (NHES)**

**Summary**

In their manuscript submitted to Natural Hazards and Earth System Sciences (NHES), Mirlan Daiyrov and Chiyuki Narama present their findings about the formation and drainage of short-lived glacial lakes occurring on or due to the presence of ice-cored moraine complexes (i. e. in permafrost zones) of the northern Teskey Range, Kyrgyz Republic (Central Asia). Based on extensive field surveys carried out during the summer months of 2014–2019 and use of various satellite imagery data, they show interesting results about the formation, evolution and drainage of Korumdu lake in the western part of the northern Teskey Range. They found that Korumdu lake appeared each summer (except in 2016) due to the blockage of a subsurface outlet ice-tunnel by deposition of debris and ice caused by thermal erosion (ice melt). Korumdu lake rapidly increased in volume and area each summer, but always drained within about one month due to the opening of its outlet ice-tunnel. Drainage rates from Korumdu lake were rather small, but could increase in future according to the authors due to climate change, increasing temperatures and enlarging of the outlet ice-tunnel. The behavior of and drainage from Korumdu lake was compared to four other short-lived glacial lakes of the northern Teskey Range, for which large drainage events and downstream flooding were reported in recent years. In addition, based on a series of satellite images from various sources, the authors detected 160 short-lived glacial lakes spread over the entire northern Teskey Range, and analyzed their timing of appearance during the summer months of 2013–2018. The authors show that insights from monitoring short-lived glacial lakes in permafrost zones are useful to better understand their characteristics and behavior, and therefore important for mitigation of glacier-related hazards in high-mountain areas of Central Asia.

## **General comments**

I want to thank the authors for their work and valuable scientific contribution. The study contains (partly) novel and interesting findings, the presented results seem solid overall and are of interest to the scientific community. I think that this work deserves to get published in *Natural Hazards and Earth System Sciences*. However, in my opinion, the authors still need to put quite some effort into improvement of their manuscript. As it is, it cannot be published. There are some important major and an extensive number of minor issues which definitely need to be addressed, corrected, clarified, extended and implemented prior to publication. I guess that – even if there are quite a few – the majority of the specific comments listed below are easy to implement, whereas some specific comments will maybe need some additional work and time. I hope that my work will help improving the paper, and I encourage the authors to implement and reply to all my comments as far as possible. Thanks a lot, all the best and kind regards.

### ***List of some general comments:***

- In general, linguistic and content clarity and correctness need to be substantially improved (see my introduction to the specific comments below)
  
- For some parts, the manuscript also needs major improvement in terms of content (see various specific comments thereupon below). For instance, the conclusions have rather “discussion character”. You need to add an introductory paragraph to the conclusions, elaborating the research questions and what you did in order to answer them (including a short summary about your study area and methods). Then you can summarize your results and contextualize the meanings of your findings
  
- You have used so many different satellite imagery data from various sources and for many different things. I think for the reader of your paper it would be beneficial to add a table containing sources or platforms (i. e. Landsat, Sentinel-2 etc.) of the satellite images used, also listing source dates, resolution and purpose (i. e. which satellite imagery you used for what). You could then refer to this table in the manuscript wherever needed instead of having to write long and rather choppy sentences
  
- Is there a reason why Korumdu lake was chosen for your extensive fieldwork?
  
- In 2018, there was no water leakage at the outlet point close to Korumdu lake, but the lake emptied anyway. Do you know how, through which processes, and why? – Would have been interesting to add in the discussion

- In my opinion, it would have been interesting to know why, in the Teskey Range, there are “so many” short-lived glacial lakes... is this mainly due to the presence of permafrost (ice-cored moraines)? It would have been interesting to elaborate “a list of geomorphological prerequisites or conditions” for the formation of the type of short-lived glacial lakes occurring in the northern Teskey Range (i. e. presence of sufficient debris, location in permafrost zone, retreating (debris-covered) glacier etc.). If possible, it would have been interesting to compare the spatial density or number of short-lived glacial lakes in the northern Teskey Range to other high-mountain areas...

### **Specific comments and technical corrections**

To facilitate the author’s correction of the manuscript I combined specific comments and technical corrections (including language and comprehensibility issues). Sometimes comments contain both specific comments and technical corrections, sometimes just one or the other. I took a lot of time to rephrase beforehand rather unclear text passages and tried to improve a lot of the manuscript. I hope that helps and that the authors appreciate my efforts in this regard. I would ask the authors to implement my comments and suggestions as far as possible.

### ***Title***

I think it would be more attractive, preciser and more transparent to change the title of the manuscript into “Formation, evolution and drainage of short-lived glacial lakes in permafrost environments of the northern Teskey Range, Central Asia”

### ***Abstract***

Ln 11f: Not clear to me if you refer to short-lived lakes in general here or if this sentence already refers to processes of drainage of the short-lived Korumdu lake. If the former applies, you have to write “Short-lived lakes grow rapidly and drain within a few months, due to...”; if you already refer to Korumdu lake here you would have to state this, e.g. “Korumdu lake, a short-lived glacier lake in the Teskey range surveyed in detail for this study, grows rapidly and drains within a few months, due to...”

Ln 12: “... in moraine complex...” → “...in **a** moraine complex at **the** glacier front.”

Ln 12f: This is a general statement → you have to write “Outburst floods of this lake type are a major hazard in this region and differ from many cases...”

Ln 14f: This sentence starts with a statement on the drainage of short-lived glacier lakes in general, i.e. it's not clear if you then write “..., we examined its recent changes...” → be precise and write “..., we examined recent changes of Korumdu lake in water level, area, volume and discharge...”, or if you refer to the whole sample of short-lived glacier lakes you analysed in the Teskey Range you have to write “..., we examined recent changes in water level, area, volume and discharge of short-lived glacier lakes in the Teskey Range with a field survey and satellite data analysis.”

Ln 16: “... during all summers during...” → “... during all summers between 2014 and 2019 except in 2016.”

Ln 14 vs. Ln 16: “water level” vs. “water-level” → be consistent and write “water level” everywhere in the manuscript

Ln 16f: How this sentence is written one would think that the sudden appearance and expansion of Korumdu lake took only place 2017-2019, not before, correct? Below in the methods section you write that you carried out field surveys from 2015 to 2019. So, during summers 2015 and 2016 there was no sudden appearance and expansion (and drainage) of Korumdu lake? I think it would be good to clarify/be more precise here.

Ln 17: “The timing...” which timing? – be precise in order to be clear → “The timing of lake appearance/lake formation indicates...”

Ln 18: “drain” → “drainage”

Ln 19: Here, the abbreviations “UAV” and “DSM” appear for the first time. I would write them out and put the abbreviations in parentheses, unless it's ok to do that in the abstract (but then you would have to write the terms out when they appear for the first time below in the manuscript. Moreover, a lake is per definition made of water → in my opinion you can just write “..., the lake's volume reached...”

Ln 22: “...that caused large drainages...” → “...that showed larger drainage rates...”

Ln 22f: This is a general statement → write “As a result, the dimensions of outlet ice-tunnels of short-lived glacial lakes...”. Moreover (for the entire manuscript), in my opinion “flooding scale” is a somewhat misleading and not very precise term... here you refer to discharge (rates) and of course smaller discharge over longer time means less hazard potential for flooding downstream... Be preciser/clarify!

Ln 24: “basin volumes” is again a bit misleading, I would just write “... both tunnel size and lake volume...”

Ln 24: I would replace “greater hazard” with “increased hazard potential”

Ln 24f: I think it's more clear to write “In addition to our field surveys of Korumdu lake, we investigated...”

Ln 25: It's clearer to replace “in this region” with “in the Teskey Range”

Ln 27: This is a general statement → write “The appearance of short-lived glacial lakes is inevitable in summer when the melting rate is high.” Moreover, I think this general statement is not clear enough yet! For which region, for which glaciers, for which type and composition of forefield characteristics does this statement/sentence apply? In my opinion you need to clarify this, otherwise you cannot just leave this as a general statement which could be interpreted as being “valid everywhere”...

Ln 27f: This sentence is not yet clear enough to me. Do you mean something like “Similar characteristics of short-lived lake formation and drainage through blockage and opening of subsurface channels might also be found in other mountain regions of (Central) Asia”? Moreover, this is “just a guess” and I think as a concluding sentence of your abstract I would try to be a bit preciser and clearer. You also mention the term “permafrost” for the first time here. Of course this is important for the short-lived lakes you're looking at (in terms of the frozen material, i.e. moraine complexes in the glacier forefield). So again, try “not just to guess” but try to say why and where in high-mountain (Central) Asia you would expect to find similar processes, lake types and characteristics of formation and drainage! Seems important and interesting to me...

## ***Introduction***

Ln 32f: clearer to write "..., rather small glacial lakes can be found close to the present termini of glaciers in the northern Tien Shan (Central Asia) (References)."

Ln 33f: I would write "...often produce hazardous debris flows and floods." Like this, the link/logical connection to the subsequent sentence is much better...

Ln 35: I would insert commas before and after "including casualties" or put "including casualties" in parentheses for better/smooth readability

Ln 36: Reference "Daiyrov et al., under review" → Please do only cite research articles that are either already accepted for publication or already published!

Ln 36: "Such short-lived glacial lakes...": Here you mention "short-lived" for the first time in the introduction. Above it's just about small glacial lakes. So I guess one could assume that all small glacial lakes are short-lived, which of course is not true. In order to be a bit clearer I would therefore add a sentence or a subordinate clause here to precisely state that some/a certain number of these small lakes are "short-lived" or "unstable" (or if you are sure about the percentage of small glacial lakes in the Tien Shan that are "short-lived" you can write "many/the majority of small lakes are short-lived"...), then you can add that "they grow rapidly and drain within a few months"

Ln 38f: "Such lakes drain through..." here you refer again to small and short-lived proglacial lakes dammed by ice-cored moraine complex, ok, but I think the clarity of the introduction (and the manuscript in general) would benefit from explaining your focus a bit in more detail (including further references), i.e. explaining in more detail which types of short-lived glacial lakes you're looking at/focusing on. – I mean, supraglacial lakes are often also "short-lived", i.e. appear and disappear over the summer season, but processes are different from short-lived lakes in the glacier forefield where frozen moraine material plays a role as well... Not all small glacier lakes in the glacier forefield are short-lived and not all short-lived glacier lakes show the same formation and drainage processes as the ones you're specifically focusing on... I would appreciate if you could elaborate these issues a bit more clear, precise and complete/holistic in the introduction (this would for instance also include an explanation which nonstationary lakes are short-lived and which have a longer lifetime and why (cf. Ln 39f). Partly this is already done further below in the introduction... maybe you could rearrange the different sections of the introduction a bit in order to avoid confusion about what you mean by "small lakes" or "short-lived lakes"...

Lns 40f: "A short-lived lake can be a severe hazard...", next sentence "The short-lived lakes are a major hazard..." → somehow a repetition, I think you could easily merge these two statements to avoid this

Lns 40f: About the use of the term "hazard" or "natural hazard". Please be aware that there is a difference between "hazard" and "risk"! As far as I understand these terms, "hazards" or "natural hazards" are just geomorphological processes which take place (naturally) and which can potentially be dangerous for people, infrastructure and goods. Important factors defining "hazards" are, for instance, duration, intensity/magnitude, spatial extent and return period of the respective geomorphological processes. "Risk" refers to the combination of the probability of occurrence and the damage potential of an event (whereas damage potential is a function of exposition and vulnerability). I was not always quite sure if you actually refer to "hazard" or "risk" whenever you use the term "hazard" in your manuscript. Please check if you use these terms correctly everywhere.

Ln 41: If you write "The short-lived lakes are a major hazard in this region...", this means "all short-lived lakes in the area" are concerned. I would just write "Short-lived lakes are a major hazard..." Moreover I would be precise again and replace "in this region" with "in the Teskey Range" or with "in northern Tien Shan".

Lns 41f: "..., and differs from the outburst which caused by..." → sentence ist not fully correct (English). I don't know if you refer to the differences in characteristics of lake drainage (i.e. processes) here or if you refer to the different damage potential/risk of the different lake types and outburst mechanisms here... Please clarify, write more precisely what you mean

Ln 44: "As such glacial lakes" → which glacial lakes? I know which ones you mean but I think it's important here to precisely write which types of glacial lakes you're talking about (→ "small and short-lived proglacial lakes which are dammed by (partially) frozen moraine material/sediments" would be clear, wouldn't it?)

Ln 44: "Small and short-lived proglacial lakes which are dammed by (partially) frozen moraine material/sediments drain through a subsurface outlet ice-tunnel. These lakes can expand rapidly when the outlet ice-tunnel..." I think it's better and clearer like this

Ln 46: "Some short-lived glacial lakes" → clearer if you write "Some of these/the aforementioned short-lived glacial lakes..."

Lns 46f: "..., which is behavior they share with supraglacial lakes on a debris-covered glacier" → not only the case for supraglacial lakes on debris-covered glaciers. See for instance "Gornersee" or "Lac de Faverges" on the (quasi debris-free) "Gorner-/Grenzgletscher" or "Glacier de la Plaine Morte" in the Swiss Alps in recent years... (e.g. Huss et al. 2007 in Journal of Glaciology (doi: 10.3189/172756507782202784) or Huss et al. 2013 in Geographica Helvetica (doi:10.5194/gh-68-227-2013) → I would just delete the "on a debris-covered glacier"

Lns 47ff: "Several studies have examined the relationship between supraglacial lakes and englacial conduit on a debris-covered glacier (Benn et al., 2000, 2017; Miles et al., 2016; Watson et al., 2016; Narama et al., 2017), but this relationship has seen little study for glacial lakes." → To me it's not clear what you want to say with this sentence... Please rephrase the sentence in order to be clear

Ln 50: "Short-lived glacial lakes" → again, it has to be clear which types of short-lived glacial lakes you're talking about... You could refer to the definition above (it's about "Small and short-lived proglacial lakes which are dammed by (partially) frozen moraine material/sediments"), maybe you could introduce an abbreviation for the types of short-lived glacial lakes you're investigating and use this abbreviation after having precisely introduced it in order to facilitate smooth reading and avoid misunderstandings, increase clarity...

Ln 50: delete "either"

Ln 51: better "... or on a depression formed by a surging glacier"?

Lns 52f: better and clearer → "Narama et al. (2018) showed that such short-lived glacial lakes typically exist where the three following geomorphological conditions apply: 1)..., 2)..., 3)..."

Ln 55: maybe more precise if you write "...the existence of a subsurface outlet ice-tunnel."

Ln 56: "...the recent expansion..." do you refer to the increase in number of glacial lakes or the growth of already existing lakes? – I guess rather the former, right? – If so you have to reformulate in order to be clear

Ln 58: "the large variability of glacial lakes" → large variability in terms of what? – Lake type? size? Formation/evolution/drainage? → please clarify

Ln 58: "...was not only related to..." → "...is not only related to..."

Ln 58: I would write "... of glacial lakes in the Issyk-Kul basin (Tien Shan) is not only related to the local climate conditions, but also..."

Ln 59: In my opinion it is less misleading if you delete the "regional" here

Ln 59: As you stated this before referring to the three geomorphological conditions for the existence of these short-lived glacial lakes (cf. Narama et al., 2018), I would rephrase the sentence as follows: "..., but also to geomorphological conditions in the glacier forefield as described above (cf. Narama et al., 2018)", I think this is easier to understand and clearer because it's not only about the closure and opening of an outlet ice-tunnel...

Ln 60: "such complex" → "such complexes"

Lns 60f: "Ice degradation within such complexes results in moraine formation"??? – I am not sure whether I agree here, I mean, you write about "ice-cored moraine complexes", which are also already moraine structures in my understanding (the word "moraine" is even already included...), just that they contain ice... I would delete this sentence and instead write what changes in terms of surface dynamics and landform processes when there is no more ice in the morainic material...

Lns 61f: "...were confirmed in the Jeruy Glacier front..." → you mean "...were observed in the forefield of Jeruy Glacier..." → change accordingly

Lns 62f: "..., and such changes likely affect the outlet ice tunnel and formation of the depressions." → ok, can you briefly state/write how? Seems important to me here...

Ln 64: "As changes can occur..." → new section, please specify what changes you're referring to here!

Ln 64: See comment above, I think using the term "flood scale" is not very precise here... do you refer to discharge (rates), range of the flood, or what? → please rephrase in order to be clear

Lns 65f: "...are confirmed in recent years in the northern Tien Shan" → "...have been observed in the northern Tien Shan in recent years, ..."

Ln 66: "...difference of..." → "...difference in..." or "...difference between..."

Lns 66f: "flood scale" → see comment just above

Lns 67f: "A lake's fate depends on..." → this is a very general statement and not true as such  
→ you again have to be precise about which lakes you mean, because, for instance, a rock dammed lake doesn't depend on the existence of ice or permafrost when it comes to GLOF's at all...., here again you talk about a very specific glacial lake and dam type!

Ln 68: "Such hazards" → "Hazards from abruptly changing discharge of glacial lakes can.. ."

Ln 69: I think "investigate" is more suited than "predict" here

Ln 70: I would add "...at the Korumdu lake (Teskey Range, Tien Shan, Kyrgyz Republic)..."

Ln 70: "...reason of..." → "...reason for..."

Ln 70: "flood scales" → see comment above

Ln 70: "shot lived lakes" → "short lived lakes"

Ln 71: "These new knowledges are important for glacier disaster mitigation" → "Findings from our study are relevant for glacier-related hazard mitigation."

Ln 72: "The paper is organized as following" → "The paper is organized as follows: ..."

Ln 72: "To understand the closure and drainage..." → The lake per se doesn't close! → "To understand the formation and drainage mechanism of..."

Ln 74: "To clear the reason how..." → "To find out how.../To investigate how..."

Ln 75: The outlet ice-tunnel is not "in" the Korumdu lake → rephrase

Ln 75: "...we examined the surface changes around the Korumdu lake in field survey." → "... we surveyed surface elevation changes around Korumdu lake in the field"

Lns 75f: "To clarify how the other short-lived lakes..." → which other short-lived lakes/where  
→ be clear, precise and rephrase accordingly

Lns 76f: "...we investigated the timing of appearance of short-lived lakes for the other lakes in this region were studied in 2015–2019" → "...we investigated their timing of appearance during summer months between 2015 and 2019 using..."

Lns 78f: "...we discussed..." → "...we discuss..."; "...the reason of..." → "...the causes of..."; "...at Korumdu lake including other lakes..." → "...for Korumdu lake and other lakes of the same type in the study area.", then start with a new sentence and rephrase as follows: "We also examine the relationship between outlet tunnel size and lake drainage rate under the influence of increasing air temperature."

### **Study area**

Lns 81f: "The study area is in the northern part of the Teskey Range and near the south shoreline of the Issyk-Kul Basin, Kyrgyz Republic (Fig. 1)." → "The study area is situated in the northern part of the Teskey Range south of Lake Issyk-Kul (Fig. 1)."

Lns 82f: "The glacier distribution in the western part of the range (3700–4200 m) is lower than the distribution in the eastern part (3800–4500 m)." → "There are less glaciers in the western part of the Teskey Range (3700–4200 m) than in the eastern part (3800–4500 m)."

Ln 83: "The difference is..." → "This difference is..."

Ln 85: "...of the western part is 255 mm, ..." → "...of the western part was 255 mm, ..."

Ln 85: "...whereas that at the..." → delete "that"

Ln 85: "...of the central part is 378 mm, ..." → "...of the central part it was 378 mm, ..."

Lns 85f: "..., and that at the..." → "..., and at the Cong-Ashu station (2788 m) of the eastern part it was 550 mm (Podrezov and Ryskal, 2019; Fig. 1)."

Lns 86f: "Their annual average temperatures are 0.1°C (1961–1988), –6.28°C (1995–2011; Kuzmichenok, 2013), and 0.27°C (1995–2005), respectively." → "Mean annual air temperature was 0.1°C (1961–1988) for Kara Kujur, –6.28°C (1995–2011; Kuzmichenok, 2013) for Tien Shan, and 0.27°C (1995–2005) for Chong-Ashu."

Moreover, unlike for mean annual precipitation, which you compare for the same reference period for the three weather stations (but unfortunately only over 9 years), you compare mean annual air temperatures for three completely different time periods for the three weather stations. In my opinion this makes not much sense (climate change and increasing temperatures!). If possible, you should take (both for mean annual precipitation and air temperature) reference periods of ca. 30 years (statistically significant) and you should compare values of mean annual precipitation and mean annual air temperature over the same reference periods for all weather stations!

Ln 88: "...has been smaller in the western than the eastern part..." → "...was less pronounced in the western than in the eastern part..."

Ln 90: "The glacier-moraine zones..." → This is not a technical term, or at least I haven't heard or read about "glacier-moraine zones"... What do you exactly mean here? Please rephrase and clarify, using correct technical terms

Lns 91f: "...the ice-cored moraine complex (debris landform including ice) at the glacier front developed during the Little Ice Age (Dikih, 1982; Shatravin, 2007)." → "...ice-cored moraine complexes (debris landforms including ice) at the glacier front developed during the Little Ice Age (Dikih, 1982; Shatravin, 2007)."

Ln 93: "recessions" → "retreat"

Lns 93ff: "Four large drainages occurred from short-lived glacial lakes that appeared on the ice-cored moraine complex; specifically, from Kashkasuu (2006), west Zyndan (2008), Jeruy (2013), and Karateke (2014) (Narama et al., 2010, 2018)." → "Four large drainage events occurred from short-lived glacial lakes that formed on ice-cored moraine complexes (Kashkasuu (2006), west Zyndan (2008), Jeruy (2013), and Karateke (2014) (Narama et al., 2010; 2018))."

Lns 96f: "The Korumdu catchment forms the largest tributary in the Tong River Basin." → "The Korumdu catchment gives source to the largest tributary in the Tong River Basin."

Moreover, from your figures I cannot really distinguish Tong River... If you name it (if this is important at all), you should indicate it on the map in Fig. 1...

Ln 97: “The Korumdu glacier occupies an area of 2.35 km<sup>2</sup>” → can you add in parentheses when the glacier covered 2.35 km<sup>2</sup>? Does this number come from a glacier inventory? – Source/Reference?

Lns 98f: “In addition, we investigated the timing of appearance for 160 short-lived lakes in this region (Fig. 1).” → see similar comments above, you should be more clear here and write if all these lakes are of the same type as Korumdu and also say how you chose these lakes (data source?, criteria?)

### **Methods**

Ln 100: “Method” → “Methods”

Ln 102: I would place “(Fig. 1,2)” after “...at Korumdu lake...”

Ln 103: “Aug” → “August”

Ln 104: “set” → “placed/installed”: “water-level” → “water level” (everywhere in the manuscript, be consistent how you write it, see respective comment above); “...and ground levels...” → I guess you mean “at water table level” here? – “ground levels” is not very clear to me..., maybe you can combine that in a short and easily understandable way with information given in the following sentence (Ln 105).

Moreover, I think it’s a bit misleading to start the sentence with “We also placed/installed water level data loggers...” because just above you already mention that, and then it’s confusing to read “We also placed/installed...” → please rephrase accordingly

Ln 105: “Water-level” → “Water level”;

Moreover, technically it is not very clear to me how you did this correction, because – depending on daily weather conditions – atmospheric pressure which you measured and used to correct your water level data varies as well (i.e. is not a constant)... maybe you can add some information oder reference here

Ln 106: “...was also set with an interval of 1 day.” → “...was installed as well and took one oblique image of the area per day”

Lns 108f: “Aug” → “August” (change everywhere)

Ln 110: "...with ground control points..." → "... and ground control points..." (because GCPs are logically independent of the Software you use but of course necessary to produce orthoimages)

Lns 110f: "We obtained the GCPs..." → "We collected/surveyed the GCPs..."

Ln 111: "...using the Trimble GeoExplore 6000..." → "...using a Trimble GeoExplore 6000"

Lns 111f: "The absolute positions were accurate to 30-40 cm at GCPs positions by post-processing with data from the Kyrgyz GNSS reference station..." → "The absolute positions of GCPs were corrected during post-processing using data from the Kyrgyz GNSS reference station and had an accuracy of 30–40 cm."

Lns 112ff: "We also investigated the surface changes in an ice-cored moraine complex around the lake by comparing DSMs obtained in 2015 and 2016 on ArcGIS 10.5." → "Surface elevation changes of an ice-cored moraine complex surrounding the lake were computed in ArcGIS 10.5 by comparing DSMs from 2015 and 2016."

Ln 115: "...in the summers..." → "...during the summers..."

Ln 116: "...on ArcGIS 10.5" → "...in ArcGIS 10.5"

Ln 116: "The daily volume..." → "The daily lake volume..."; "...(without water), combined with..." → delete the comma here

Lns 116ff: It is not clear to me how daily time-lapse images were processed and combined with DSMs of different summers/years to compute daily lake volumes. Did you somehow orthorectify the (oblique) time-lapse images? This is important in my opinion but not clear at all from your explanations here... → please add/write how you combined DSMs with daily time-lapse images to compute daily lake volumes

Ln 117: You write "(including amount of glacier recession)" → It is clear to me that you can compute glacier surface elevation changes and terminus retreat from DEM/DSM differencing, fair enough, but it is not clear to me how you included (annual, i.e. from summer to summer, i.e. from one UAV/SfM-derived DSM to the next) glacier surface elevation changes into daily lake volume calculations... or do you mean you just looked at glacier surface elevation

changes as well and just wanted to mention that? – This is not 100% clear to me, please rephrase accordingly

Ln 117: “water-level” → “water level”

Ln 118: “...time-lapse camera data based on UAV DSMs” → don’t you mean “...time-lapse camera data and/combined with UAV DSMs”?

Lns 118ff: “Using the same method, we also reconstructed...” → again, it’s not clear at all in my opinion how satellite images were “combined” with UAV DSMs to reconstruct water levels of Korumdu lake (see respective comment above) → you have to write how you did this  
Moreover, what is the benefit of using satellite imagery (of different resolution and quality) to reconstruct lake water levels compared to using your time-lapse camera images? – is it just to compare two or more different data sources to get the same results and compare the latter? – or is it to extend the temporal resolution of you lake water level data? – or does it have something to do with what you write below (“because we visited at the lake on 4 August 2019”)? – or is it to investigate whether satellite remote sensing data could (completely) replace in situ time-lapse camera data to calculate lake water levels using DSMs? – interesting, but not really clear to me here → can you add something on that, be clearer on that point?

Ln 120: “...because we visited at the lake on 4 August 2019.” → delete “at”

Ln 121: “We also investigated the changes in lake area during 2017–2019 using PlanetScope images.” → ok, I guess You just manually digitized lake areas from the satellite imagery and then compared lake areas? – maybe it would be clearer to write this

Moreover, I think it would be really good and more transparent for people who read your paper if you could add a table containing all different sorts and sources of satellite imagery you used, including columns with “resolution”, “acquisition date”, and information on how the different satellite imagery were used (i.e. for which type of analyses described in your methodology section you used which satellite images)

Ln 122: I think “meteorological” is the right term to use here instead of “climatic”

Ln 123: delete “resolution”

Ln 124: “...were calculated for 2016–2017” → whole year round or only during summer months? → please clarify

Ln 126: "...were identified using satellite images on ArcGIS 10.5" → "were identified in ArcGIS 10.5 using satellite images."

Lns 126ff: "In particular, 91 images from Landsat- 7/Enhanced Thematic Mapper Plus (ETM+, SLC-off) and Landsat-8/OLI, 31 images from Sentinel-2, and 16 images from PlanetScope acquired during 2013–2018. The resolutions of these images are 15 m (pan-sharpened images of Landsat-7/8), 10 m (Sentinel-2), and 3 m (PlanetScope)." → referring to my comment above, I think it would be very good to make a table with all satellite imagery data you used (including columns with "resolution", "acquisition date", and information on how the different satellite imagery were used (i.e. for which type of analyses described in your methodology section you used which satellite images)); because you worked with many different satellite images from different source dates, with different resolution, for various analyses etc. If you do that then you don't have to write all this information in Lns 126ff, but you can refer to the table and can rephrase these lines in a more descriptive manner...

Ln 129f: "As a definition of short-lived lake, we use that in Daiyrov et al. (2018), which is based..." → "We used the definition by Daiyrov et al. (2018) for short-lived lakes, which is based on seasonal changes in lake area over the summer months of each year"

Ln 131: "...that appears or doubles in area" → "...that suddenly appears and/or increases substantially in area" (I would write this like this because these lakes don't necessarily have to double in area, you just want to express that they often increase substantially in area)

Lns 131f: "We counted the number that appeared..." → "We counted the number of lakes that appeared..."

Ln 132: "In addition, the number was tracked..." → "In addition, the number of lakes was tracked..."

Ln 133: "extracted" → "digitized"

## **Results**

Ln 136: "Areal variations of Korumdu lake" → better: "Changes in area of Korumdu lake" or "Areal variability of Korumdu lake"

Ln 137: "It sits in a basin formed during glacier recession." → better: "It developed in a depression that formed during the retreat of the glacier."

Ln 138: "The basin developed..." → "The lake basin developed..."

Lns 137f: "At the front of the Korumdu glacier lies the Korumdu glacial lake (Fig. 2). It developed in a depression that formed during the retreat of the glacier. The lake basin developed inside an ice-cored moraine complex." → In my opinion these three sentences belong to the "Study area" section and it is not necessary to write that again here at the beginning of the results section...

Ln 138: Why "Although"? – Makes more sense to delete this

Ln 138: "...most of the basin area..." → "...most of the lake basin..."?

Ln 139: "...glacier, based on..." → delete the comma there

Ln 139: "...a basin length..." → "...a lake basin length..."

Ln 140: "...with total area of..." → "...and a total area of the lake basin of..."

Ln 140: "The basin volume..." → "The lake basin volume..."; "...from 264,000 m<sup>3</sup> in 2017 to 330,000..." → add "m<sup>3</sup>" after "330,000"

Ln 142: "basin" → "lake basin" (2x)

Ln 143: "..., but we found an outlet point..." → "..., but we found an outlet point where meltwater from the lake emerges from a subsurface ice-tunnel within the frozen moraine complex which is connected to the lake (Fig. 2)." → Then you can delete the whole next sentence as it's clear enough (i.e. delete "The existence of the outlet shows that lake water flows through an outlet ice-tunnel from the lake.")

Ln 145: "basin" → "lake basin"

Ln 145: "Drainage water was observed at the outlet point in 2015, 2017 and 2019, but not 2016 and 2018." → "Leakage of meltwater was observed at the outlet point in 2015, 2017 and 2019, but not in 2016 and 2018."

Ln 146: "...becoming large on 30 July" → do you mean "...reached its maximum on 30 July...?"

Lns 147f: "...of the changes appears in the images in Fig. 4..." → better "...of changes in lake size is shown with a sequence of PlanetScope satellite images in Fig. 4." (then you can delete "..., which are based on PlanetScope satellite data.")

Ln 152: "...and reached its maximum level.." → "...and reached its maximum size..."

Lns 152f: "In contrast, the lake area did not change dynamically in 2016." → ok, but what does that exactly mean? – the lake appeared but did not expand substantially? – not clear to me at all. Moreover, do you know this from field surveys, the on-site time-lapse cameras or satellite data? – not clear, either... → please clarify here

Lns 153f: "Based on Landsat-8/OLI data, we also found that the lake appeared in 2014 (May 5, June 27, and September 10)." → ok, does that mean it appeared (and thus also drained) three times or does that mean that you just found the lake on May 5, June 27, and September 10 2014 on the satellite imagery but do not know what happened in between? – this is not clear here → please rephrase and clarify, see also my comment just below

Lns 154f: "Although these images show rapid drainage, we did not find evidence that the drainage caused flooding during the survey period" → my comment here goes a bit in the same direction as my comment just above: How can you see on three single (and "point in time") satellite images that the lake showed rapid drainage? – in my opinion you cannot! – If you have field evidence or know from other sources that the lake drained ok, but then you have to write this more clearly → please rephrase and clarify

Also, you write "...we did not find evidence that the drainage caused flooding..." → evidence like what? – can you maybe be more concrete/precise here?

Lns 155f: "According to data in Narama et al. (2018), drainage from Korumdu lake is the flood-wave type in the downstream region because the water stream flows on a gentle slope." → ok, can you please connect this sentence a bit better to the precedent one in terms of logic and context?

Also, "...drainage from Korumdu lake is the flood-wave type..." → ok, but from the sentence just above (when you write "...we did not find evidence that the drainage caused flooding...") it seems that the lake can also drain without flooding, so these two statements are a bit contradictory... → can you please rephrase and clarify?

Ln 159: I would delete the first sentence (“Consider the properties of Korumdu lake from 2017 to 2019”), and then write.... (see comment just below)

Lns 159f: ... “Figure 6 shows the measured water level, lake area and volume, and inflow-outflow rate of Korumdu lake from 2017 to 2019” (→ I would not use the term “inflow-outflow discharge” because “inflow is not a discharge” → I recommend using “inflow-outflow rate”, you would also need to change this accordingly in Fig. 6d)

Lns 160f: “For 2017, we also show the water temperature (Fig. 6a). We also reconstructed the water level data between August 4 and 31 based on 10 satellite images (yellow points in Fig. 6a).” → better and clearer to shorten and write everything in one sentence: “For 2017, water temperature data were also recorded (Fig. 6a), and water level data between 4 and 31 August were reconstructed based on 10 satellite images (yellow points in Fig. 6a).”

Lns 161f: “We calculated volume and discharge using the water levels and the UAV DSMs.” → “Lake volume and discharge were calculated based on the water level data and the UAV DSMs.”

Ln 163: “...August 3...” → “...3 August...”

Lns 163f: “..., and then vanishes on 19 August (Fig. 6a).” → “..., and then the lake is empty on 19 August (Fig. 6a).”

Ln 164: Why “In the first 29 days...”? → write “Within 29 days, ...”

Ln 165: “The resulting rate of volume increase was 8,070 m<sup>3</sup>/day.” → “The resulting rate of lake volume increase was 8,1 m<sup>3</sup> per day.” (I think the uncertainty in the applied methodology to derive daily lake volumes is too high to write three decimal places → round to one decimal place)

Ln 165: “During discharge, 234,000 m<sup>3</sup> of water drains in 17 days, ...” → “During the emptying of the lake, 234,000 m<sup>3</sup> of water drain in 17 days, ...”

Ln 166: insert comma after “(Fig. 6b)”

Ln 167: “August 3” → “3 August”

Lns 167f: In my opinion it's a bit a pity to only mention the average recorded lake temperature here (referring to Fig. 6a). From your graph one can clearly see that if the water level is low, lake temperature is high, and vice versa, which makes absolutely sense (heating of shallower lake with less water by solar irradiance is stronger than cooling from inflowing ice meltwater) → I think it would be worth it to add some words about the observed variability in recorded lake temperatures (as well as about the reasons for these measured lake temperatures)

Ln 168: Insert "(Fig. 6a)" after "1°C"

Ln 169: "The first, on 25 July, reaches 3.5 m and a volume of 21,000 m<sup>3</sup> (Fig. 6a, b)." → "The first peak on 25 July, showing a lake depth of 3.5 m and a volume of 21,000 m<sup>3</sup> (Fig. 6a, b)."

Ln 170: "The second, the yearly maximum, on 11 August, reaches 6 m and a volume of 53,000 m<sup>3</sup>." → "The second on 11 August, with a lake depth of 6 m and a volume of 53,000 m<sup>3</sup>, which corresponds to the maximum values in 2018."

Lns 170f: "Finally, the third peak, on 17 August, reaches a level of 5 m and a volume of 39,000 m<sup>3</sup>." → "The third peak occurs on 17 August, showing a lake depth of 5 m and a volume of 39,000 m<sup>3</sup>."

Ln 172: "Compared to the case in 2017, ..." → "Compared to 2018, ..."

Lns 172f: "However, like that in 2017, the inflow rate is also intermittent in 2018." → "Similar to 2017, the inflow rate also clearly varies over time in 2018."

Lns 173f: "The three peaks indicate that closure of the tunnel occurred several times during the 1-month period." → "The three peaks in water level, area and volume of Korumdu lake indicate that closure of the ice-tunnel occurred several times during the one-month period."

Ln 175: "In 2019, the water level goes up and down until 22 July, when it rises sharply (Fig. 6a)." → "In 2019, the lake water level rises and falls before 22 July, when it rises sharply (Fig. 6a)."

Lns 175ff: "Then the level has a local maximum on 30–31 July, reaching 5 m and a volume of 53,000 m<sup>3</sup>, followed by a yearly maximum on 11 August, reaching 6.5 m and 74,000 m<sup>3</sup>

(Fig. 6 a, b).” → “Then, the water level shows an intermittent maximum around 30 – 31 July, reaching a lake depth of 5 m and a volume of 53,000 m<sup>3</sup>. 2019 maximum values were recorded on 11 August, with a lake depth of 6.5 m and a corresponding volume of 74,000 m<sup>3</sup> (Fig. 6a, b).”

Ln 178: Delete “Over these years, ...” and start with “Other differences include...”

Lns 179f: “...small discharge rates...” → “...small lake discharge rates...”

Ln 180: “..., consistent with the lack of reported flooding.” → “..., which is consistent with the absence of reported flooding.”

Ln 181f: “Concerning fluctuations, according to the water level data for 2017–2019, the level increased with repeated storage-drainage cycles.” → clearer: “According to the water level data of 2017–2019, the lake level rose and fell several times, indicating repeated storage-drainage cycles.”

Ln 182: “...small increases of water level...” → “...small increases in water level...”; “...with the level...” → “...with the lake level...”

Ln 185: “We observed drainage water at an outlet point...” → “We observed lake water leakage at an outlet point...”

Lns 185f: “The reason we argue is due to the relative elevations.” → “We argue that this might be due to the difference in relative elevations between the lake level and the outlet ice-tunnel entrance.”

Lns 186f: “The water levels were 3,810 m on 21 Aug 2015, 3,816 m on 6 Aug 2017, and 3,810 m on 4 Aug 2019, all of which are higher than the outlet point at the basin.” → “The water levels were at 3,810 m a.s.l on 21 August 2015, 3,816 m a.s.l on 6 August 2017, and 3,810 m a.s.l on 4 August 2019, thus always higher than the outlet ice-tunnel entrance at approximately 3,807.5 m a.s.l.”

Lns 187f: “However, we did not observe water drainage in 2016 and 2018 because the water levels were 3,806.5 and 3,807.5 m, respectively (Fig. 8a, c).” → rephrase to avoid repetition of what is written in Ln 185 → “In 2016 and 2018, lake water levels were at 3,806.5 m a.s.l and 3,807.5 m a.s.l, respectively, thus always lower than the outlet ice-tunnel entrance at

approximately 3,807.5 m a.s.l (Fig 8a, c). Therefore, no lake water leakage was observed at the outlet point of the ice-tunnel in 2016 and 2018.”

Ln 188f: “These results indicate that...” → following my rephrasing of the paragraph above, you can delete this whole last sentence!

Ln 191: “4.3 Surface changes around Korumdu lake” → more correct to write “4.3 Surface elevation changes around Korumdu lake”

Lns 192f: “Over a period of one year, how does the region near the entrance of the outlet ice-tunnel change? To answer this question, we compared UAV orthoimages with DSM data in 2015 and 2016 (Fig. 9).” → “To investigate annual surface elevation changes near the entrance of the outlet ice-tunnel, we compared UAV-derived orthoimages with DSMs from 2015 and 2016 (Fig. 9).”

Lns 193f: “A comparison of Fig. 9a, b shows debris sliding, with horizontal backwasting of an exposed ice ridge by 7m.” → “Debris sliding and horizontal backwasting by 7 m of an exposed ice ridge between 2015 and 2016 appear from the comparison of the orthophotos.”

Lns 194f: “The backwasting indicates melting occurred, which is supported by the UAV-derived DSMs in Fig. 9c).” → “The backwasting indicates that melting of debris-covered ice occurred, which is supported by comparing the UAV-derived DSMs from both years (Fig. 9c).”

Lns 195f: “In particular, along the profile (a–a’; Fig. 9b) of the landform between 2015 and 2016, the surface elevation decreases by about 5 m.” → “For instance, along a cross-sectional profile (see a–a’ in Fig. 9b), the surface elevation decreased by about 5 m (Fig. 9c).”

Lns 196f: “These results indicate that the surface motion and deposition of debris can cause closure of the outlet ice-tunnel during summer.” → I don’t think that this is really clear here. Do you have real evidence that debris from the surface of melting ice blocked the entrance of the outlet ice-tunnel? What is the diameter of the ice-tunnel at its entrance (i.e. can it easily/quickly be blocked by mobilized sediments?) And how are these sediments transported from the ice margin to the entrance of the outlet-ice tunnel where they cause blocking of the ice-tunnel? How close are the features shown in Fig. 9 to the entrance of the ice-tunnel? Are these processes really directly linked? And what is the grain size distribution

of the debris (I mean to block the tunnel entrance you need to have a mix of finer and coarser material so that lake water doesn't leak through the deposited debris material anymore)? And how does reopening of the tunnel entrance work after closure by debris deposition? I think you could very well be right with what you're saying but this is all not very clear from the information I have now from the text and the figures of the manuscript... → Please clarify, add on this

Ln 198: delete "mountain" or write "...discontinuous mountain permafrost..."; and write "3,100–3,200 m a.s.l."

Ln 199: "...in 2015–2017..." → "...between 2015 and 2017..."

Ln 200: "...in 2015–2019..." → "... during 2015–2019..."

Lns 201f: "...such as that for a supraglacial lake on a debris-covered glacier..." → "...comparable to supraglacial lakes on debris-covered glaciers..."

Moreover, I think that this sentence is kind of a repetition from the paragraph just above in the manuscript (Lns 192-197) → Maybe better to delete the sentence here and include the references in the paragraph above (Lns 192-197), would fit better...

Ln 205: "4.4 Comparison to other short-lived lakes in the area" → "4.4 Comparison to other short-lived glacial lakes of the Teskey Range"

Ln 206: "...had relatively little drainage..." → "...showed relatively little drainage during emptying..."

Ln 206: "..., whereas four other short-lived lakes..." → I would add the names of these lakes in parentheses here

Ln 207: "...caused large drainages..." → "...caused larger drainage..."

Ln 208: "...these appearance times..." → do you mean the (compared to Korumdu lake) earlier appearance times here → rephrase in order to be clear

Ln 209: "...short-lived lakes..." → "...short-lived glacial lakes..."

Ln 209f: You had a look at the months from June to September 2013–2018 to determine the appearance times of other short-lived glacial lakes, ok, but just above you refer to four lakes described by Narama et al. (2010, 2018) appeared from May to June... So why didn't you also consider May 2013–2018?

Ln 211f: "...such short-lived lakes during 2013–2018 (the total includes re-appearances of the same lake in different years) in the study area." → "...such short-lived glacial lakes in the northern Teskey Range during 2013–2018 (the total number of lakes includes reappearances of the same lake in different years)."

Ln 212: "In Fig. 10, we classify these by month of appearance." → "A classification of these lakes by month of appearance is shown in Fig. 10 for the six year period."

Ln 212f: "The appearance months with the most lakes are June, the snow-melt period, and July, the ice-melt period; specifically, 43 lakes in June and 90 in July." → "Most lakes appeared in June (43 lakes), the snow-melt period, and July (90 lakes), the ice-melt period." Moreover, you can also have snow melt earlier or later than June, and ice melt earlier or later than July. Would it make sense to write "...June (43 lakes), the period of maximum snow-melt, and July (90 lakes), the period of maximum ice-melt."?

Ln 214: "...in these two periods..." → "...for these two periods..."

Ln 214f: Would it be right to write "This large variability is related to different meteorological conditions during summer months of 2013–2018."? I think this would be clearer.

Ln 216f: "Concerning re-appearances, 81 lakes appeared only once for 6 years. Of the remaining, 19 appeared twice, 7 appeared 3 times, 2 appeared 4 times, and 2 lakes appeared all 6 years." → "Concerning reappearances, 81 lakes appeared only once during six years. Of the remaining, 19 lakes appeared twice, 7 lakes appeared three times, 2 lakes appeared four times, and 2 lakes appeared every year."

Ln 217: "indicating that tunnel closure occurred with a different month each year." → Does this refer to the two lakes that appeared every year? – not very clearly written, please rephrase

Ln 218: "Short-lived lakes that reappear many years likely have a tunnel condition in which closure occurs easily." → "Short-lived glacial lakes that reappear during many years likely

show geomorphological settings at the drainage tunnel entrance which favor tunnel closure and hence lake formation.”

### ***Discussion***

Ln 221: “5.1 Cause of outlet ice-tunnel closure at Korumdu lake” → “5.1 Causes of outlet ice-tunnel closure at Korumdu lake”

Lns 222f: “In the case of ice tunnel closure, the supraglacial lakes on the debris-covered Inylchek Glacier in April–May are likely to appear due to the closure of englacial conduits when stored water freezes (Narama et al., 2017).” → “In the context of ice-tunnel closure, Narama et al. (2017) report that the supraglacial lakes on the debris-covered Inylcheck Glacier appear in April–May due to the closure of englacial conduits by freezing of stored water.”

Ln 228: I would replace “...in the study region...” with “...in the northern Teskey Range...”

Ln 229: “...or by blockage by collapsing with deposition of mixed debris and ice...” → “...or by blockage with depositions of ice-debris mixture after roof collapsing...”

Lns 231f: “The short-lived lakes here that caused the four large drainages (2006, 2008, 2013, and 2014) appeared in May–June and expanded in June–July (Narama et al., 2010, 2018).” → “Four short-lived glacial lakes of the Teskey Range that caused four large drainage events (2006, 2008, 2013, and 2014) appeared between May and June and expanded in area until June–July (Narama et al., 2010; 2018).”

Ln 232: “The timing suggests a closure that...” → “The timing of lake appearance suggests an ice-tunnel closure that...”

Ln 233: Do you mean “We call this the deposition-freezing type of ice-tunnel closure.”? → I would rephrase this accordingly...

Ln 234: Do you mean “However, for none of the case studies investigated by Narama et al. (2010, 2018), neither geomorphological behavior of the ice-tunnel nor water level fluctuations were studied in detail.” → I would rephrase this accordingly...

Ln 235: "...excluding the case of no expansion..." → "...excluding the case of no lake expansion..."

Ln 236: I would replace "based on water-level of a data logger and time-lapse camera images." by "based on our field surveys." (smoother and the reader knows your survey methods from the parts of the manuscript further above)

Ln 236: "...changes in the basin..." → "...changes in the lake basin..."

Ln 238: "...likely was caused by..." → "...were likely caused by..." (plural because you write about "the blockages")

Ln 239: "Further evidence that Korumdu lake forms by the deposition process comes from consideration of water-level fluctuations." → "Looking at water level fluctuations of Korumdu lake gives further evidence for lake formation by deposition of ice and debris."

Ln 240: "The fluctuations of water level, such as spikes, reveal changes in the tunnel condition (Fig. 6d)." → I'd suggest "The fluctuations of lake water level and discharge spikes reveal changes in the ice-tunnel morphology (Fig. 6d)."

Ln 241: "...the water increase was..." → "...the water level increase was..."

Ln 242f: "...ice tunnel..." → "...ice-tunnel..."

Ln 243: delete "also"

Ln 244: "...to the water pressure..." → "...to changes in water pressure..."; I suggest replacing "...or thermal erosion." with "...or deposition of ice-debris mixture through melting processes."

Lns 245ff: "In 2017, the trend of water volume increase consisted of two parts: 5 to 25 July and 26 July to 3 August (Fig. 6b). The first period had sporadic fluctuations, indicating incomplete closure of the tunnel, but the second period had a smooth increase, indicating complete closure." → "In 2017, there were two periods of varying patterns of lake water volume increase (Fig. 6b). The first period (5 to 25 July) revealed sporadic fluctuations in increasing water volume, indicating incomplete closure of the ice-tunnel. However, the

second period (26 July to 3 August) showed a continuous and rapid increase in water volume, indicating complete closure of the ice-tunnel.”

Ln 247: delete “value”

Ln 248: “Longer closure periods...” → “Longer periods of tunnel closure...”; “...larger short-lived lakes...” → “...larger short-lived glacial lakes...”

Ln 249: “Thus, the period of closure might be determined by the condition of the tunnel.” → “Thus, the period of closure is likely determined by the morphology of the ice-tunnel.”

Lns 250f: “Many of the other short-lived lakes that also appear in the ice-melting period are likely to be the deposition-closure type, for the same reasons we applied to Korumdu lake.” → “As for Korumdu lake, many of the other short-lived glacial lakes in the northern Teskey Range which were detected based on satellite imagery are likely to belong to the deposition-closure type as well.”

Lns 251f: “For example, in Fig. 12, we show surface changes in the outlet ice-tunnel at the Jeruy glacial lake between 2014 and 2016.” → the observed surface changes are rather around the lake or above the ice-outlet channel I think, and not in the ice-tunnel itself → I would rephrase as follows: “For example, Figure 12 shows changes in surface elevation and the outlet ice-tunnel of the Jeruy glacial lake between 2014 and 2016.”

Ln 252: I would replace “large” with “distinct”

Ln 253: “...making closure likely” → “..., which likely led to tunnel closure.”

Lns 253: “Thus, the surface condition always changes...” → better: “Thus, morphology and surface characteristics of an ice-cored moraine complex within the mountain permafrost zone are prone to frequent changes, and...”

Ln 254: “...and the deposition-closure type is the major type in this region.” → clearer to write: “...and the deposition-closure type is likely the main type for drainage tunnel blockage and hence formation of short-lived glacial lakes in the northern Teskey Range.”

Lns 254f: “Thus, the appearance of a short-lived glacial lake is inevitable in summer when the melting rate is high.” → following my suggestions to rephrase the subsequent sentence, I

would rephrase this one as follows to make things clear: “If deposition-closure processes occur in summer when the melting rate is high, the formation of a short-lived glacial lake is highly likely.”

Lns 255f: “The characteristics of this lake disaster might be shown in another Asian mountain permafrost region.” → This sentence makes not much sense to me and is quite misleading, as you primarily write about geomorphological processes linked to short-lived glacial lake formation and drainage! You hardly say anything about risks or disasters related to the emptying of the studied lake type! I really think it’s better to delete this whole sentence.

Ln 258: “5.2 Relationship between outlet tunnel size and drainage scale” → “5.2 Relationship between outlet tunnel size and lake drainage”

Lns 259f: “...had large drainages.” → “...showed considerable drainage.”

Ln 261: “...with Jeruy’s outlet cross-section being...” → “...with a cross-section measuring  $8\text{m}^2$  at Jeruy...”; “... $4 \times 2 \text{m}^2$ ...” → was the tunnel width 2 m and the height 4 m? So a cross-section of  $8 \text{m}^2$  in area? → clarify

Ln 262: “...and Karateke’s about the same or larger (not shown).” → “...and a cross-section of about the same size or larger at Karateke.”

Lns 262f: “Earlier, back in 2008, the w-Zyndan lake of  $437,000 \text{m}^3$  had a discharge rate of...” → “In 2008, the w-Zyndan lake ( $437,000 \text{m}^3$ ) emptied at a discharge rate of...”

Ln 264: “...did not have a large drainage during...” → “...did not show as high drainage rates during...”

Ln 265: “...than those of...” → “...than those at...”

Ln 266: “...of the two large drainages...” → “...of the two large drainage events...”

Ln 267: “...with Korumdu lake...” → “...for Korumdu lake...”

Lns 267f: “..., which is behavior consistent with closure of a small channel caused by deposition.” → “..., which was related to closure of the small outlet ice-tunnel caused by deposition of and blockage by debris.”

Ln 268f: "...ensured a slower discharge even when it became full (300,000 m<sup>3</sup>). →  
"...resulted in slower lake discharge even when lake volume reached its maximum (300,000 m<sup>3</sup>)."

Ln 270f: "These results show that the lake size and the dimensions of the outlet ice-tunnel are related to the scale of discharge." → But above you just say that there was no clear relation between lake size and discharge rate for Korumdu lake during 2017-2019! → "These results show that, at least for Korumdu lake, the dimensions of the outlet ice-tunnel were the dominant factor controlling lake discharge rates."

Ln 273f: I would place "...enlarging the outlet ice-tunnel..." before the references here

Ln 274: "...although basin-size changes depend on the particular glacier landforms, the basin area in the case of Korumdu lake has increased each year due to glacier recession." →

"...although lake basin-size changes depend on the particular glacial landforms, the basin area of Korumdu lake has increased each year due to glacier retreat."

Moreover, I am not very sure what you exactly mean here... how do which glacial landforms exactly influence lake basin-size? → please clarify

Ln 276: "...in this region,..." → "...in the Teskey Range,..." ; "...during their discharge may increase in the future..." → "...during their discharge may become more frequent in the future..."

### **Conclusions**

Ln 278: "6 Conclusion" → "6 Conclusions"?!

Ln 279: "Our field survey found..." → "From our field survey we found that..."

Ln 280: delete "Later, ..."

Ln 281: "...the draining process was relatively slow..." → "The lake drainage was always relatively slow..."; "outlet ice tunnel" → "outlet ice-tunnel"; "...scale of discharge..." → "...discharge rate..."

Ln 282: "...sizes..." → "...size..."

Lns 282f: “We argued that predicting the scale of a drainage requires knowledge of the outlet ice-tunnel dimensions and the lake’s depression size.” → “We argue that predicting drainage rates requires knowledge about the dimensions of the outlet ice-tunnel and the size of the lake basin.”

Lns 283f: “Our research method of combination between water-level data and UAV DSMs could estimate the discharge and the approximate dimensions of the tunnel.” → “By combining water level data and UAV-derived DSMs from consecutive years, we were able to estimate daily lake discharge and approximate dimensions of the outlet tunnel.”

I am not sure whether it is clear enough from the manuscript that (and how) you could estimate the dimensions of the outlet ice-tunnel from DSM differencing, i.e. from interpreting surface elevation changes. – In my opinion you rather wrote about ice melt, changing surfaces of the ice-cored moraine, backwasting and debris sliding... I did not read really much about how you estimated approximate dimensions of the outlet tunnel in the results section (4.3). If you write this in the conclusions, you would have to elaborate and talk about that in the results chapter... You cannot bring up “new results” only in the conclusions section! → please add some text in section 4.3 accordingly

Ln 285: “During 2013–2018, satellite data showed this region to have 160 short-lived glacial lakes, ...” → “Based on satellite images from 2013–2018, 160 short-lived glacial lakes were detected in the northern Teskey Range, ...”

Lns 286f: “Four lakes that appeared a month earlier had large drainages, the only cases of large drainage in the study.” → “Four lakes that appeared a month earlier showed drainage rates which were significantly higher compared to the rest of the lakes.”

Lns 287f: “Nevertheless, with a warming climate, any short-lived glacial lake might cause large flooding if the outlet ice tunnel and basin size sufficiently enlarge.” → better and more specific: “However, with a warming climate resulting in enlarging outlet ice-tunnels and lake basin sizes, also other short-lived glacial lakes of the northern Teskey Range might cause large flood events.”

Lns 289f: “The glacial lake outburst floods (GLOFs) which caused by moraine-dam failure such as Himalaya and Andes are minor cases in this region.” → “Glacial lake outburst floods (GLOFs) caused by moraine-dam failure, as frequently observed in the Himalayas or the Andes, rather rarely occur in the northern Teskey Range.”

Lns 290ff: “Short-lived lakes which caused by closure and opening of an outlet ice-tunnel in moraine complex are a major hazard in this region, because the short-lived lake exists on an ice-cored moraine complex within geomorphological and climate conditions of the mountain permafrost zone.” → “Short-lived glacial lakes that form on ice-cored moraine complexes within the mountain permafrost zone through closure and opening of subsurface outlet ice-tunnels are a major hazard in the northern Teskey Range.”

Lns 293f: “These new knowledges are useful to understand the phenomena and behavior of the short-lived lakes and consider glacier hazard mitigation in the mountain permafrost regions of Asian high mountains.” → “Insights from monitoring short-lived glacial lakes in permafrost zones are useful to better understand their characteristics and behavior, and therefore important for mitigation of glacier-related hazards in high-mountain areas of Central Asia.”

Lns 294f: “A threat of the short-lived lakes increases for the residents since 2000s. This hazard case might be major in Asian high mountains in present.” → Apart from the fact that those two sentences would have to be rephrased in order to be clear, I would directly delete them because in your study you don’t really address risks from glacier-related hazards and you have not shown that such threats have increased for residents since 2000. Hence, this would be something totally new at the end of the paper, and in the conclusions you should not come up with something new!

### **Figures**

Figure 1: I would enlarge the figure if possible and also add names of specific glacial lakes or rivers that you mention by name in the manuscript (see also corresponding comments above).  
Figure Caption: “...located on the south shoreline of Issyk-Kul Lake,...” → “...south of Lake Issyk-Kul,...”; “Red circles are...” → “Red circles indicate locations of...”; “Green squares with checks are...” → “Green squares with checks show short-lived glacial lakes...”; “...caused large drainages...” → “...caused large drainage events...”

Figure 2: I think it would be beneficial for the reader of the paper to show locations of your time-lapse camera, water level measurement logger, water temperature logger, air and ground temperature loggers in Fig. 2 (see respective comments above referring to the methods section). Moreover, in my opinion, this is not really a “geomorphological map” (i.e. not really a map of landforms and processes) → I would just write “Overview of the Korumdu glacier front” in the figure caption instead of “Geomorphological map of the Korumdu glacier front”.

Figure 4, figure caption: "...of the Korumdu lake area during 2017–2019." → "...showing the evolution of Korumdu lake in (a) 2017, (b) 2018, and (c) 2019."

Figure 5, figure caption: I would rephrase as follows: "Evolution of Korumdu lake during 2017–2019 based on time-lapse camera images acquired in the field."

Figure 6: I would write "air temperature" for the labeling of the right y-axis in Fig. 6a; Labeling of the y-axes: write "lake volume ( $m^3$ )" and "lake area ( $m^2$ )" (Fig. 6b, c); labeling of the x-axes; Fig. 6d: labeling of the y-axis: better write "inflow-outflow rate ( $m^3/s$ )"? See my comments thereupon further above...

Figure caption: I would delete the first sentence and rephrase the figure caption as follows: "(a) Water level of Korumdu lake in 2017–2019 and air temperature in 2017. (b) Lake volume. (c) Lake surface area. (d) Inflow-outflow rate. These data from 2017 to 2019 are based on water level logger data, UAV DSMs, time-lapse camera images, and PlanetScope satellite images."

Figure 7: You have to add "(c)" and "(d)" to the right images and "(b)" has to be replaced to the second image I guess (otherwise it doesn't make sense with what you write in the figure caption).

Figure caption: I would write "...increase in water level of Korumdu lake."

Figure 8: Better write "maximum lake extension/area" in Fig. 8a instead of "basin line"; I would write "m a.s.l" instead of "m" wherever you refer to "elevation values"

Figure caption: write out the name of the months ("August", "July"); in addition, write "Orthoimages were acquired from UAV surveys."

Figure 9: write "Elevation (m a.s.l)" in the labeling of the y-axis of Fig. 9c;

Figure caption: better write "...of the debris-covered stagnant ice/dead ice at the entrance of...?"; write "...based on UAV orthoimages."; "(a) On 21 August 2015."; delete "line" after "exposed ice edge"; "(b) Same as (a) except on 12 August 2016."; "...show the new positions of the respective surface features after one year."

Figure 10: I would write out the names of the months in the legend of the graph.

Figure caption: I would add "...derived by Landsat-7/8, Sentinel-2, and PlanetScope satellite images." at the end of the sentence!

Figure 11: With the dotted black line you show the level of the lake-dam crest; I would write "level of lake-dam crest" in Fig. 11a instead of just "lake-dam"

Figure caption: write "The two types of ice-tunnel closure occurring in the northern Teskey Range."; better: "(a) Deposition-freezing type of closure in case of an outlet ice-tunnel being blocked by freezing of stored water or deposition of debris and ice."; "(b) Deposition-closure type of closure in case of an outlet ice-tunnel being blocked by deposition of debris and ice by thermal erosion (ice melt)."

Figure 12: I would add information about the width and height of the ice tunnel shown in Fig. 12b (2 x 4 m).

Figure caption: write "...which drained on 15 August 2013."; write "(a) Lake basin of Jeruy glacial lake on 9 August 2014. The white arrow shows the direction of lake drainage. (b) Insight into the outlet ice-tunnel on 9 August 2014. (c) The outlet ice-tunnel area on 9 August 2014. The white circles in (c) and (d) show the same location. (d) Same as (c) except on 9 August 2016."