Nat. Hazards Earth Syst. Sci. Discuss.,
https://doi.org/10.5194/nhess-2020-252-AC2, 2021

Natural Hazards and Earth System Sciences
Discussions
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EGU

Interactive comment on "Water storage and drainage of short-lived lakes in the Teskey Range, Central Asia" *by* Mirlan Daiyrov and Chiyuki Narama

Mirlan Daiyrov and Chiyuki Narama

narama@env.sc.niigata-u.ac.jp

Received and published: 19 January 2021

We thank you for their valuable comments, all of which helped to improve the manuscript. Our response to each comment is below. We showed our replay for reviewer comments.

General comments: This is an interesting study about ice tunnels of short-lived lakes in parts of the Tien Shan. A main problem with the paper is that it becomes not very clear over large parts what its focus is: Is it ice tunnels, is it Korumdu lake? Is Korumdu lake an example, or a main focus? Why Korumdu lake? The authors should at the beginning develop and explain the purpose of the paper, and then relate to this purpose

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throughout the paper more clearly.

[Response] Our paper focused on short-lived type of glacial lakes in the Teskey Range of northern Tien Shan, Kyrgyz Republic. The Korumdu lake is good example of short-lived type which we could collect field survey data in detail, because we cannot know which lake appear every year. For none of the case studies investigated by previous studies, neither geomorphological behavior of the ice-tunnel nor water level fluctuations were studied in detail. We succeeded to get water level data directly based on field survey.

We added the sentences about reason to choose the Korumdu lake in “Study area”. “As the reason why this lake was selected as a research site, (i) the lake is a short-lived type which appears every year, (ii) it is easy to access the field, and (iii) this lake is located at the Tong region where four large outburst floods occurred in the past.“

Specific comments: Abstract: [Comment 1] The abstract is unclear. Needs to be rewritten thoroughly. What is the relation of Korumdu lake with respect to the other lakes, not mentioned by name? Only later in the text it becomes clear that the paper is about Korumdu lake.

[Response] We improved abstract. Please see response comment for General comments.

Introduction [Comment 2] Well written, but I recommend an additional paragraph summarizing the previous findings from a number of papers of the authors about short-lived lakes, and how this paper relates and adds to these previous papers. Is it a new outburst, not covered in the previous papers? Why was it not covered in the previous overview papers? Something special with this lake? What new knowledge is expected compared to the previous papers? Is there a special focus of this study (on ice tunnels?), not covered in the other studies? Etc.

[Response] We added references and explanation in detail. We also showed subjects

in this study based on previous studies. In this study, the changes of water level were clarified by direct observation in field work. This is first results about short-lived lake.

Study area [Comment 3] This section suffers from the lack of clarity in the paper focus. You introduce the study region, not the lake Korumdu, but then you start investigating one specific lake. You need to introduce the region and the specific lake, and make clear why you investigate in detail lake Korumdu. What makes this lake particularly useful or necessary for ice tunnel investigations in addition to the ones studied earlier?

[Response] We added reason to choose the Korumdu lake in “Study area”.

Results [Comment 4] L189: too low for drainage? Do you mean the lake did not run over in 2016 and 2018? Where did the melt water from the basin go then?

[Response] The lake did not appear in 2016. Lake was empty at our visiting in 2018, But lake appeared in this year as shown by lake level data and time-lapse camera images (Figs. 4-6). This sentence is written about lake level and drainage during our visiting. We improved the sentences.

“During the fieldwork, we observed lake water leakage at an outlet point in 2015, 2017, and 2019, but not in 2016 and 2018. We argue that this might be due to the difference in relative elevations between the lake level and the outlet ice-tunnel entrance. 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 the water levels higher than the outlet ice-tunnel entrance at approximately 3,807.5 m a.s.l. 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 the water levels 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 during our visiting.”

Discussion [Comment 5] L250: deposition-closure type? This term/type was not introduced before. What is the difference to the deposition-freezing type?

[Response] We explained for these types in text.

Popov (1987) and Narama et al (2010a, 2018) have reported about the past drainages of short-lived lakes in the northern Tien Shan. Narama et al., (2010, 2018) documented that four short-lived glacial lakes which caused four large drainages appeared between May and June due to closure of ice-tunnel by freezing of stored water during winter or ice-debris deposition. This is “deposition-freezing type”. Our present study found many short-lived lakes including Korumdu lake appeared in July–August. The freezing is not reason in this season. During July-August, thermal erosion caused deposition of ice and debris which blockaded the outlet ice-tunnel at its entrance or interior. Therefore, we call this type as “deposition-closure type”.

“The timing of lake appearance suggests an ice-tunnel closure that is caused by the freezing of stored water during winter or deposition of ice-debris mixture (Fig. 11a). We call this the deposition–freezing type of ice-tunnel closure. 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. In the case of Korumdu lake, the tunnel closed in July–August of every year since 2014 (excluding the case of no lake expansion in 2016) based on our field surveys. As we observed changes in the lake basin on the ice-cored moraine complex caused by subsidence or downwasting (Fig. 9), the blockages of the outlet ice-tunnel at its entrance or interior were likely caused by deposition of ice-debris mixture due to thermal erosion. This type of blockage (deposition-closure type) is sketched in Fig. 11b. Looking at water level fluctuations of Korumdu lake gives further evidence for lake formation by deposition of ice-debris mixture.”

[Comment 6] L254-256: I don’t understand these sentences. “inevitable”? Do you say every moraine complex will lead to a short-lived lake? I don’t get the purpose of the last sentence.

[Response] Narama et al. (2018) and Daiyrov et al. (2018) found that short-lived

glacial lakes formed on the ice-cored moraine complexes under mountain permafrost zone. Because ice-tunnel has developed inside of ice-cored moraine complex. Not all moraine complexes lead to short-lived lakes in study area. However, our previous studies showed that four past drained short-lived lakes formed on these ice-cored moraines. Because these ice-cored moraine complexes within the mountain permafrost zone include stagnant ice, surface changes are caused the expansion of the outlet ice tunnel and formation of the depressions.

[Comment 7] L270: But what causes what? Does more discharge lead to larger tunnels, or do larger tunnels enable more discharge? I would expect that large discharge melts the tunnel walls and enlarges the tunnel. But you seem to argue that other way round? Further: what influence has the drainage catchment size and the amount of melt water available? Could it be that larger catchments produce more water which then causes larger tunnels?

[Response] This is drainage case of ice-tunnel. Dimension of ice-tunnel does not change suddenly. In the Korumdu lake, lake volume (234,000 m3) was larger than past large drainage cases in 2006, 2013 and 2014. However, this lake never caused hazardous floods before, because tunnel size related to discharge scale was too small. Our paper shows larger dimension of tunnel causes large discharge.

Discussion [Comment 8] Why don't you summarize your two types of tunnel closures? I think these are important to understand your conclusions of paragraphs 1 and 2. Last paragraph needs rewriting. Especially the conclusions regarding hazards are not well discussed and backed-up in the text.

[Response] We improved the discussion part more clearly.

Technical corrections [Comment 9] Line 49: "but this relationship was so far little studied with regard to proglacial lakes as of concern in this study." Or something like that.

[Response] We changed it.

[Comment 10] L54: supply “from”?

[Response] We changed it.

[Comment 11] L55: from the “lake” depression.

[Response] We changed it.

[Comment 12] L64: As changes “related to short-lived lakes” can occur...

[Response] We changed it.

[Comment 13] L74: clear -> clarify.

[Response] We changed it.

[Comment 14] L110: SA) Structure from Motion. Remove “of”

[Response] We deleted it.

[Comment 15] L131: does the lake need to “double”??? or just increase in area?

[Response] The lake increase in area.

[Comment 16] L155: lake is of flood-wave type. . . Do you want to say that the slope is too low that the flood would incorporate debris and become a debris flow?

[Response]

That is right. As shown in Narama et al. (2018), drainage water from short-lived lake is clean water without debris. So, after drainage, water is flood wave type (Huggel et al., 2004). However, most stream from glacial lakes changed the flow type to debris flows. The flood wave without moraine deposits can transform into a debris flow where the channel gets steeper and the wall-soft material erodible. The change occurs because banks of the channels are often composed of loose material (Haeberli, 1983; Clague and Evans, 1994; Breien et al., 2008; Evans and Delaney, 2015). When a steep slope starts at the end of a flat valley, the flood wave is able to gather debris, transforms into

a debris flow. In the case of the Korumdu lake, the water stream from lake flows on a gentle slope. This is flood wave type. It is important to understand which type of flow comes.

[Comment 17] Fig 5: can you remove the blue tone of the photos by improving the colour balance?

[Response] We already arranged color balance.

[Comment 18] Fig 7: there are no panels c and d as indicated in the caption, and I guess b is placed wrong.

[Response] We changed it.

[Comment 19] Fig 11: indicate that dark blue in the tunnel is frozen

[Response] We changed it.

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