

Department of Environmental Science  
Niigata University  
8050 Nino-cho, Ikarashi,  
Nishi-ku, Niigata 950-2181,  
Japan

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Dear Editor,

We are pleased to submit our answers to the Reviewer's comments of nhess-2017-228 "Large drainages from short-lived glacial lakes in the Teskey Range, Tien Shan Mountains, Central Asia" article. We would to thank all referees for their valuable comments and have implemented all of them as detailed below. We restructured and changed in discussion part.

Yours sincerely,

Chiyuki Narama

(on behalf of co-authors)

## Reviewer 1

line 95. ... in the interior ... Better "... in the inner Tien Shan ..."

✓ We changed it.

line 145. ... decides. Better ... determines

✓ We changed it.

line 159. Better 2005 and remains the same by 23 May 2006

✓ We changed it.

line 167. ... volume of 163.000 m<sup>3</sup>

✓ We changed it.

line 187-188. ... we observed 300 m long ice tunnel with ...

✓ We changed it.

line 192-193 Karateke lake also was formed at an empty lake-basin depression, but without glacier contact.

✓ We changed it.

End of section 4.2. Dense debris flows could be quite mobile too. During the experiments in Kazakhstan in 1972-73 mean density of highly mobile debris flow reached 2200 kg/m<sup>3</sup> and water content was less than 10%

✓ We added this sentence. However, we do not know this reference. Please tell me the references. This reference is Evans and Delaney, 2015; Baimoldaev and Vinohodov, 2007?

line 241 ... had no such barriers.

✓ We changed it.

line 268. ... short-leaved water bodies (do not use "glacial lakes" twice in one phrase

✓ We changed it.

line 269. ... revealed that water discharged ...

✓ We changed it.

line 273-274 . ... or by deposition of ice and debris ...

✓ We changed it.

line 294 and 534. may be Shatravin?

✓ We changed it.

line 346-348. As these deposits have characteristics of both matrix support and clast support, we treat the flow as viscous.

✓ We changed it. We changed to the classification of debris-flow and water flood including text and figure 10.

line 365-366. ... because banks of the channels in the study area are composed of loose material.

✓ We changed it.

line 386 Many lake-basin depressions are of stony type. It is unclear how they can retain lakes - stony banks and bottom must be permeable.

✓ We changed to the classification of debris-flow and water flood including text and figure 10. About stony and viscous flows, we added “Many short-lived lakes change from water flood to debris flows, involving debris entrainment (stony flow or viscous flow), due to the channel wall having looser material (including composition of material; fragmented rock or surficial materials; Evans and Delaney, 2015).”

lines 402-403 - unclear statement.

✓ We changed the sentence to “Among 23 valleys in the study area in the northern-western part of the Teskey Range (Fig. 1), 14 valleys are of valley landform (Karateke case) and 9 valleys are of alluvial fan type (Jeruy case).”

Figure 4. What is 4/1, 5/1 ...month/day? better to indicate directly.

✓ We changed the form.

Figure 6. I do not see dashed region mentioned in the caption.

✓ We deleted the sentence in the caption.

Figure 8. You indicate "lake-basin with large lake", But only its area is large while volume is small.

- ✓ We added an explanation in caption of Fig.9. Depression A has a lake area of more than 30% of the maximum filling area possible.

## **Reviewer 2**

Review to the manuscript ‘Large drainages from short-lived glacial lakes in the Teskey Range, Tien Shan Mountains, Central Asia’ submitted by Chiyuki Narama et al. to the Natural Hazards and Earth System Sciences. I’m convinced that this manuscript might be of interest for readers of this journal.

General comments:

1) Structure of the study. Authors present original field data, analysis of RS data and outline implications for RS-based hazard identification. In order to make the manuscript more readable, I suggest to clearly separate: (i) descriptive part (past events; detection of potential lake basins, ...); (ii) implications for hazard identification and monitoring (geomorphological criterias for hazard identification, recommendations for monitoring, ...). These are mixed up in the current version of the manuscript.

- ✓ In the result, we show the area changes of three short-lived glacial lakes using satellite data. In second chapter, we show the geomorphological evidence of short-lived lakes. Third, we describe depressions where the short-lived glacial lakes appear.
- ✓ In the discussion part, we write about drainage and repeatable characteristics of short-lived glacial lakes, comparing with Himalayan cases. In the second chapter, we write about geomorphological locations where short-lived glacier lakes appear. In the third chapter, we describe the flood type and transition in the study region. In the four chapter, we discussed about differences in flood damage based on land-use and landforms.

2) Terminology and language. Some of the terms used sound bit unusual / clumsy to me, e.g., ‘ice-containing debris-landform’ – in this case I suggest to use ‘ice-cored moraine complex’. Similarly, ‘glacier-contact type’ might be replaced by ‘proglacial’ and ‘without glacier contact’ by ‘glacier-detached’ (see also Emmer et al., 2015a); ‘lake-basin depression’ also sounds weird, what about to use ‘potential lake basin’ or simply ‘depression’ or ‘hollow’; see also my specific comments; this should be unified within whole manuscript. Also, check correct use of present and past tense. Overall, language need some polishing (see also my specific comments).

- ✓ We could not classify debris-landforms into moraines and rock glaciers, also because there is likely a fuzzy transition between both. So, we changed to debris-landform with ice (ice-cored moraine complex). We simply used “with glacier-contact” and “without glacier contact”, because “proglacial” is not exactly, or not only, “with glacier-contact”. There are many small lakes without glacier contact, but at the glacier front. We used “potential lake basin” to describe “depressions”. We changed lake-basin depressions to depressions.

Specific comments and technical notes:

L18-L19: change wording to ‘Four lake drainages from glacial lakes have occurred in the western Teskey Range, Kyrgyzstan, during 2006 and 2014’; check and edit similar cases in whole manuscript

- ✓ We changed it.

L19: damages

- ✓ We changed it.

L22-23: four events are mentioned at the beginning of an abstract and three are mentioned here; this is bit confusing and should be edited

- ✓ We showed one reference in the Introduction and Method such as “Among them, the drainage from the western Zyndan lake was examined in Narama et al. (2010a).”

L27: late summer

- ✓ We cannot say “late” of summer, because the drainage occurred at the end of July and beginning of August. So, we prefer to leave the sentence.

L29: freezing of outflow tunnel

- ✓ We changed to “The blocking is caused either by the freezing of stored water inside of the outflow tunnel during winter, or by deposition of ice and debris by collapse of the ice tunnel.”

L64-66: formation and sudden drainage of supraglacial ponds were also documented from the Cordillera Blanca, Peru (see Emmer et al. 2015b)

- ✓ We used this sentence in the Discussion 5.1., because we distinguish between short-lived lakes and supraglacial lakes in the Introduction.

L67-69: in my understanding, the term ‘proglacial’ fits there well (e.g., short-lived proglacial lake)

- ✓ We avoid to use proglacial, because in our study the classification of the lake types between “glacier contact” and “without glacier contact” for the short-lived lake (depressions) is important. The term ‘proglacial’ would summarize both types.

L87-104: please add some info on geological / geomorphological setting of the study area

- ✓ We added geological and geomorphological information of the Teskey Range as “Tien Shan is a reactivated area of Paleozoic deformation. Although this region had a low-relief surface following the Paleozoic orogenies, Late Cenozoic deformation has resulted in this surface being warped across a series of mountain ranges cored by crystalline basement and previously deformed Paleozoic sedimentary and metamorphic rocks (Abdrakhmatov et al., 2001; Burgette et al., 2017). The Issyk-Kul basin is bounded to the south by the actively growing the Teskey Range.”

L114-L117: what is the resolution / accuracy of these measurements

- ✓ We obtained a positional accuracy of within 10 cm through differential post-processing of our GPS data using data from the Kyrgyz GPS reference station.

L118-119: please, provide more details on this investigation – what has been done and how ??

- ✓ We investigated clast diameter, sedimentary facies, and spread area of flood sediments, and observed eroded channels.

L137-138: these images are 7+ years old; considering high dynamic of studied entities, potential outdated should be discussed

- ✓ These DSM data were produced from satellite data of around 2010. Large drainages occurred in 2006, 2008, 2013 and 2014. In the Discussion 5.2, we discuss lake and lake-basin conditions of around 2010. Glacier recession was small in the study area.

L149-150: please, provide more details on this investigation in methodology

- ✓ We changed to “In addition, we classified lowland landforms at 23 valleys into valley and alluvial fans in the northern part of the western Teskey Range (Tong region) using satellite data.”

L158-162: this is hard to follow; please consider graphical representation of these data

✓ We showed lake area in figure.

L165: replace 'lies' by 'is located' in entire manuscript

✓ We remained it, because it is the same meaning.

L166: replace 'undiscernible' by 'not recognisable' or something similar

✓ We changed it.

L167: volume 163,000 m<sup>3</sup>

✓ We changed it.

L169: consider replacing 'non-glacier-contact' by 'glacier-detached' (see Emmer et al., 2015)

✓ We simply used "with glacier-contact" and "without glacier contact". Please see above.

L183: adjacent landform

✓ We changed it.

L184: was found

✓ We changed it.

L188-189: how do you know that ?? please provide more info on that

✓ We changed the sentence to "No surface channels were visible, but we observed a subsurface channel that developed inside of the debris landform. It was a 300-m-long ice tunnel with a water-stream from the lake to the tunnel outlet."

L191: delete 'much'; how much ice ?? please provide more info on that

✓ We changed to "We observed exposed ice and ice tunnels on similar debris-landforms in front of the Jeruy and Karateke Glaciers (Fig. 5A, B). Both debris-landforms contain buried ice. Jeruy lake appeared on the depression of a basin with glacier contact."

L202-203: considering the growth of the lakes

✓ We changed it and moved this sentence to in 4.1.

L202-204: these growth characteristics better fit in 4.1

- ✓ We moved this sentence to in 4.1.

L208: ... those that discharge following different mechanism (e.g., dam failure)

- ✓ We changed it.

L217-220: how was the flow speed in this case ?? please provide more info on that

- ✓ Local people say that the Jeruy flood was slow. However, we could not define the mobility.

L222: how much ?? please provide more info on that

- ✓ We cannot know amount, but we showed potential flow in Fig. 10.

L227-228: this is not understandable, please reformulate

- ✓ We changed to “Above the highly eroded-section, drainage water, which does not include much debris has a high mobility (lower density). A steep slope starts at the end of the flat valley and there the flood-wave is able to incorporate debris, transforming to a debris-flow. “

L235: why to compare with Himalayas ?? examples from Tien Shan are more reasonable here

- ✓ We deleted Himalayan size and showed the lake sizes of Tien Shan as “Of the 160 glacial lakes over 0.001 km<sup>2</sup> in the Teskey Range, 68% of them are less than 0.01 km<sup>2</sup> (Narama et al., 2015).”

L263: does

- ✓ We changed it.

L266: why is this sub-chapter placed in discussion section ??

- ✓ In this sub-chapter, we summarize results to then discuss them.

L280-282: what process ?? please reformulate / explain

- ✓ The drainage from supraglacial lakes occurs on debris-covered glaciers, due to connectivity between them through englacial conduits. Opening of such tunnels represents the same drainage process as found for short-lived lakes.

L286: replace 'here' by 'in this study'

✓ We changed it.

L287-288: this might be due to the small events are not documented from Himalayas; please discuss that

✓ The damage in this region is similar to that in the eastern Himalaya (Introduction). In this part, we explain the characteristics of short-lived lakes comparing with ones in the eastern Himalaya.

L288-289: this is not necessarily true; e.g. in the Cordillera Blanca, most of the lakes which produced GLOF by moraine dam failure still exist

✓ We improved the sentence as “Such a lake typically does not refill to the same level it had before failure. However, the lake area might expand again backwards due to glacier recession, or the water level might increase due to blockage of an outlet channel when a large-scale failure occurs at the moraine's inner slope (Ageta et al., 2000) or the dam opening is blocked by snow and ice (Huggel et al. 2003).”

L286: replace 'like' by 'similar to'

✓ We changed it.

L294: this implication is not clear to me, please explain

✓ We improved sentences as “For example, at Angisay Glacier in the Teskey Range (Fig. 1), several floods occurred from the same glacial lake in 1974, 1975, and 1980 (Kubrushko and Staviskiy, 1978; Kubrushko and Shatravin, 1982). The repeated floods indicate that the lake water refills at the same lake basin due to a repeated closure of the ice-tunnel.”

L302: delete 'much'

✓ We deleted it.

L304: Bolch et al. (2011) estimated ??

✓ We changed it.

L311-312: check wording

✓ We changed it as “Among the 60 depressions (> 0.01 km<sup>2</sup>) we examined, 38 of them had glacier contact and thus can get melt water directly from glacier termini.

The remaining 22 depressions had no glacier contact, but could also accumulate water type such as the Karateke lake (Fig. 3C). “

L312-314: this is not understandable, please reformulate

- ✓ We changed these sentences as “Among the 60 depressions ( $> 0.01 \text{ km}^2$ ) we examined, 38 of them had glacier contact and thus can get melt water directly from glacier termini. The remaining 22 depressions had no glacier contact, but could also accumulate water type such as the Karateke lake (Fig. 3C). As another geomorphological feature to rule out potential hazardous cases, we exclude basins with surface outflow channels from the depressions. As a result of these two restrictions, 53 depressions among 60 depressions are found to be potential basins for a tunnel-type, short-lived glacial lake.”

L319-312: is this shown ?? at the same time, proglacial lake are also turning to glacier-detached phase (see also Emmer et al., 2016); please explain and discuss

- ✓ We deleted this part, because we did not include this data in this paper.

L348: replace ‘treat’ by ‘classify’

- ✓ We changed it.

L362: ‘debris-free drainage water’, please explain

- ✓ We changed as “As another indication of drainage water without debris we consider grass flattened by water in the riverbed after drainage from the western Zyndan lake (Narama et al., 2010a)” and “For lakes of tunnel type, the flood wave without moraine deposits can transform into a debris flow where the channel gets steeper and the wall-material erodible.”

L363: delete ‘the’ before observed

- ✓ We changed it.

L348: replace ‘materials’ by ‘material’

- ✓ We changed it.

L380-382: discussion or results ??

- ✓ We remains in the same chapter, because we discussed using the basic information.

L383-391: discussion or results ??

- ✓ We also discuss the debris flow type here. We changed to the classification of debris-flow and water food including text and figure 10.

L395: what is meant by ‘monuments’ ?? please explain

- ✓ We changed monuments to many tombs.

L400: term ‘landform’ is not fitting here well, please reformulate

- ✓ We changed to “The degree of flood damage is related to the local land-use and the landform type at the valley mouth such as alluvial fan.”

L406: replace ‘within’ by ‘up to’

- ✓ We changed it.

L410-11: term ‘one package of river basin’ please reformulate

- ✓ We changed to “However, for risk mitigation, drainages from short-lived lakes should become an integral part of river basin management in the region, considering in particular depression volume, flood type, land-use and landforms potentially affected.”

L418-419: ... tunnels, as a result of winter freezing ...

- ✓ We changed it.

L425: (iii) no visible outflow channel

- ✓ We changed it.

L435-447: these are implications / recommendations, not conclusions, please replace

- ✓ These are important recommendations from our suggestions. So, we changed the paragraph.

Fig. 4: please replace the description of x (e.g., April, May, ...)

- ✓ We changed it.

Fig. 6: please check figure heading (there are no red arrow or dashed region on my figure)

- ✓ We deleted the sentence from the caption.

Fig. 8: replace ‘prebious’ by ‘previous’

- ✓ We changed it.

Fig. 10: replace ‘current’ by ‘existing’

- ✓ We changed it.

### **Reviewer 3**

General comments:

Dear Editor, thank you for allowing me to comment on this manuscript. The Authors proposed the manuscript “Large drainages from short-lived glacial lakes in the Teskey Range, Tien Shan Mountains, Central Asia”. The paper is interesting, but Authors have to go through all the text because some sentences are not clearly understandable and need to be reformulated. I recommend it for publication after some medium revision.

- ✓ We improved and restructured in our paper based on reviewer’s comments.

Main comments:

Line 18-23: you first mention four drainages from glacial lakes, but only three are named in the abstract. This happen again further below in the manuscript. That is confusing, please correct it.

- ✓ We showed one reference in the Introduction and Method such as “Among them, the drainage from the western Zyndan lake was examined in Narama et al. (2010a).”

Line 72: need more references.

- ✓ We added references.

Line 153: same as line 18-23.

- ✓ We changed the sentence to “In the following, we consider the area changes of the Kashkasuu lake in 2006, Jeruy lake in 2013, and Karateke lake in 2014. (The western Zyndan lake is described in detail in Narama et al., 2010a). Figure 3 shows their changes observed from satellite images, Fig. 1 shows their locations.

Line 155-156: not clear sentence, please rephrase.

- ✓ We separated into two sentences.

Line 158: “(left column)” it is not necessary.

- ✓ We deleted it.

Line 196: “250 m long”.

- ✓ We changed it.

Line 209-220: same as line 18-23.

- ✓ The content of line 209-220 is not the same as line 18-23. We described the flood type and damages of the two floods in more detail in line 209-220.

Line 245-246: where are from the data about “four large drainages: : . and lake-basin depressions”? Provide references please.

- ✓ We divided these lakes and depressions and changed to “we added four large drainages of Kashkasuu, w-Zyndan, Jeruy, and Karateke glacial lakes, depressions in the Tong region (this study), and six lakes from previous studies in the Kyrgyz and Ili Ranges (personal communication of I. Severskiy; Janský et al., 2010).”

Line 247: replace “relational line” with “regression line”.

- ✓ We changed it.

Line 249: replace “figure” with “data” (I can not see it from the figure).

- ✓ We changed it.

Line 254-255: merge these two sentences, it look like a repetition.

- ✓ We deleted this sentence.

Line 257: “0.01”. I suggest to use the same decimal precision (0.015 in other parts of the manuscript).

- ✓ We changed the sentence in 4.3 as “The Karateke lake drainage had a volume of 169,000 m<sup>3</sup>, the smallest of the four large drainages we studied, and the lake had an area of 0.015 km<sup>2</sup>. Thus, we recommend to monitor depressions with area exceeding 0.01 km<sup>2</sup>, thus taking also into account moderate future expansion.”

Line 262: not clear sentence, please reformulate (and replace “dose” with “does”).

- ✓ We changed to the classification of debris-flow and water food including text and figure 10.
- ✓ We changed to “The depressions without glacier contact are of water accumulation and non-accumulation types. The depressions of water accumulation type can get melt water from the glacier because the depression is connected to it via one or more subsurface channels. In contrast, the non-accumulation type is not connected to a water channel and cannot get substantial amounts of water within short time. We found 22 depressions of the water accumulation type, and each may become a short-lived lake such as the Karateke lake (Fig. 3C).”

Line 267: “As shown in Fig. 3, consecutive: : :”.

✓ We added “such as the Karateke lake (Fig. 3C)”

Line 310: “2.5 m”.

✓ We changed it.

Line 311-312: not clear sentence, check wording.

✓ We changed to “The remaining 22 depressions had no glacier contact, but could also accumulate water type such as the Karateke lake (Fig. 3C).”

Line 315: replace “conditions” with “characteristics”.

✓ We changed it.

Line 336: please explain (iv).

✓ We added this sentence in the same paragraph : “In the study area, the lake water of the western Zyndan glacial lake overflowed before a large drainage, due to high snow/ice melting rate (Narama et al., 2010a). Late opening of the ice tunnel leads to filling the depressions with water. In contrast, early opening of the ice tunnel or small melting rates in the upstream area might cause only a partial discharge.”

Line 343: “maximum Discharge ( $Q_{max}$ )”.

✓ We changed it.

Line 356-357: replace “the characterization” with “this classification”.

✓ We changed it.

Figure 6: there are no dashed region or red arrows in the figure (maybe white).

✓ We deleted the sentence of caption.