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Natural Hazards and Earth System Sciences
Discussions

Interactive comment on "Glacier detachments and rock-ice avalanches in the Petra Pervogo range, Tajikistan (1973–2019)" *by* Silvan Leinss et al.

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Dear Reviewer 1,

We highly appreciate your constructive review and thank for the quick response allowing for an interactive discussion. In this interactive response, we like to clarify the key points adressed by you. We will provide a more extensive answer in final comments at the end of the discussion phase.

General Comment 1: "this paper lacks key information on the methodology used to identify and classify detachments and other mass flows".

Answer: In section 3.1, we wrote: "To identify and characterize detachments and

ice avalanches we analyzed [list of sensors] (. . .). To characterize (. . .) we compared consecutive images or images from different years acquired during the same time of the year".

Though we roughly explained what we did, we agree that the information *how* detachments and ice avalanches were identified and *how* they were classified is missing. Below we provide this information:

We did all detection and classification based on manual inspection of coregistered image series. The scale of identifiable events was given by the sensor resolution, but we considered only events, which showed a total length of at least 2 km length.

We identified events by looking for obvious traces of large mass flows, like clearly visible avalanche patterns in the valleys, removal of vegetation, and changes in surface color indicating overtopping of landscape by mass flows.

After identification of such an event, we inspected the release zone for local losses of ice or rock volumes. Despite using mainly optical imagery, we identified volume losses in a qualitative way by the clearly visible holes in the mountain slopes, often casting shadows, which were not visible a few days before (or on a similar day in the year before). In some cases, we identified glacier detachments by a sudden, significant loss of ice cover.

For classification of the events, we followed the description of Evans and Delaney (2015) as outlined in the introduction section. We classified events as glacier detachment when we could clearly identify a hole in a previously glaciated valley showing the newly exposed glacier bedrock which remaining after the loss of ice masses. In addition, we checked whether the avalanche debris showed considerable amounts of ice. We classified events as ice avalanches when the detached ice was not located in a clearly visible valley or when no exposed bedrock was visible. To distinguish the events from other types of avalanches, we checked whether the avalanche debris con-

tained large amounts of ice (the infrared channel allows for separation of snow and ice). We classified events as ice-rock avalanches when the release area was at least partially ice covered, the avalanche deposit showed traces of ice and rock, and when the release area was not located at a valley bottom. We classified events as rock-ice avalanches when satellite imagery indicated that rock fall run over an at least partially glaciated area.

General Comment 2: "(. . .) the conclusion about climate change and temperature are largely unsubstantiated given that the inventory of detachment events was collected from data with varying resolution and quality, and may be biased towards more detections with higher quality (recent) images".

Answer: We fully agree that the inventory is very likely biased towards more recent events where a larger number of different satellites are available and where a much higher spatial, radiometric and temporal resolution is available. However, we like to stress that we think to *compensate for this bias*, when comparing in Fig. 9 the temperature of the year of the event with the *linear trend* of the temperature in the past 46 years and find that most events happen in years with *above-trend* temperatures.

Because of the observation bias, we *do not intend* to draw any conclusion from the fact that the more frequent observation of more recent events shows a (very likely pseudo-)correlation with warming temperatures due to climate change.

Specific comments:

Comment 1): Usage of terminology.

Answer: We fully agree. Though we start the introduction (1st paragraph) with a definition of glacier detachments and also of ice avalanches, we will try to make the difference more clear (-> add dichotomy of event types to introduction). Will refer to

this section when describing how we classification the different events (See general comment 1).

Comment 2) Improve description of method, scale, classification.

Answer: We agree with all suggestions. We will consider them as suggested in the answer to general comment 1.

Comment 3) Bias of inventory.

Answer: We fully agree with the fact that the inventory is biased toward more events in recent years. However, as detailed in general comment 2, we think that our conclusion is not biased because of the comparison to the temperature trend.

Comment 4) Improving structure of method and result section.

Answer: Thanks you very much for your constructive suggestions. We will try to structure the method section according to data attribute collection. In the results, we will try to shorten the sections about the smaller events where possible and will refer instead to table 1. We might provide more details about streamlining the structure as soon as we have received the second review.

Comment 5) Emphasize analysis of detachments in relation to surging glaciers, bedrock geology, glacier slope.(. . .) Expand your discussion to other documented events.

Answer: We would like to point to the following, recently published discussion paper (Kääb 2020) which provides a large review, comparison and analysis of most detachment events identified up to date: https://tc.copernicus.org/preprints/tc-2020-243/. As we consider our paper as an inventory and documentation of the events, which hap-

pened in the Petra Pervogo Range in Tajikistan, we think that a larger comparison would be beyond the scope of our paper.

Technical correction + comment 6:

Answer: We absolutely appreciate the detailed feedback and especially the constructive suggestions. We will consider all technical corrections in the revision.

With best regards, The authors,

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