

The Cryosphere Discuss., author comment AC2  
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## Reply on RC2

Philipp Bernhard et al.

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Author comment on "Assessing volumetric change distributions and scaling relations of retrogressive thaw slumps across the Arctic" by Philipp Bernhard et al., The Cryosphere Discuss., <https://doi.org/10.5194/tc-2021-137-AC2>, 2021

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We thank the reviewer for the detailed and constructive comments. We considered each comment carefully and address them point by point below. We hope that our modifications will make the manuscript clearer and more complete.

In the following we abbreviate: RC1 (Reviewer 1 Comment), RC2 (Reviewer 2 Comment) and AC (Author Comment).

**RC2:** Line 18: Only 15% of the Northern Hemisphere is underlain by permafrost. Please correct accordingly. Explanation for why one quarter is not the correct value can be found in this publication: <https://doi.org/10.1029/2021JF006123> . I would also suggest adding it as a reference.

**AC:** We implemented the correction and added the reference.

**RC2:** Line 54: "only remote sensing techniques are feasible": I would argue that other techniques are not impossible to perform. Consider changing to "more feasible" or similar.

**AC:** We changed this part to "remote sensing techniques are the most feasible".

**RC2:** Line 55: The sentence is not clear.

**AC:** We omitted the term "supra-regional" and changed the sentence to: "Digital elevation models (DEMs) that cover the pan-Arctic permafrost terrain with a high enough resolution to study RTSs became only available in the last few years."

**RC2:** Lines 110-112: "It is difficult to assess RTS delineation procedure based only on this text. I suggest adding examples of RTS delineation from each site to the supplement."

**AC:** We added four examples of RTS delination of different sizes with additional false-color optical Sentinel-2 images to the supplement. (See Supplement to this reply)

**RC2:** Lines 117-118: It is not clear for reader at this point what "shoreline" and "hillslope" relate to.

**AC:** We added some clarifications: "Additionally, the location of the RTS in terms of "shoreline" (located close to a waterbody) or "hillslope" (located at trenches or riverbeds)

was noted."

**RC2:** Line 120: From the text, one could assume that you only delineated RTS according to the active elevation change occurring at headwall. Substantial area of RTSs is a zone where material is transported and no significant elevation change occurs.

**AC:** Yes we only delineated RTSs according to the active elevation change. In the DEM difference images only this part is clearly visible. To make this distinction more clear we specify the zone we delineate as primary scarp zone and explicitly exclude the debris tongues. We added to Section 3.3 RTS attributes the sentence:

"For all calculations we used the area outlined by the polygon indicating the areas showing an elevation change and thus a net volume loss. It is to note that this area can also be a zone of deposition, especially for small and low-relief RTSs or if the time between observations increases. Areas such as the debris tongues or zones of alluvial deposits can not be accurately detected by the DEM difference data and are not included."

**RC2:** Lines 168-177: This part would be more suitable for the methods section. Consider moving it.

**AC:** We assume that the reviewer refers to the sentence: "Due to the low density of RTSs in Yamal and Gydan and the two study regions in Taymyr we combined these to one study region (in the following "Yamal/Gydan" and "Taymyr") according to their geographical and geophysical proximity." We think that there is no clear section in the methods where we could add it and think that the decision to merge them are motivated by the results and could stay there.

**RC2:** Line 189 and other sentences describing figures before and after: It would be more appropriate to refer to the figure inside the text, instead of writing separate sentences just for that purpose. I would suggest extending these sentences to describe the main results shown in these figures.

**AC:** We changed the manuscript to the reviewers suggestions and rewrote and removed several sentences.

**RC2:** Line 204: Is there an established methodology on how to quantitatively discriminate megaslumps from slumps? Otherwise I would suggest avoiding this term.

**AC:** The term "mega slump" is relatively new but has been used in several recent publications (e.g. Lacelle et al. 2015, Kokelj et al. 2015, Jones et al. 2019). The exact definition varies slightly but generally includes RTSs with an area larger than 20 ha ( $2 \times 10^5 \text{ m}^2$ ).

**RC2:** Line 254: The correct would be "relict ice". Since not all of the relict ice is necessarily excess or massive ice, using "massive" or "excess" would be more appropriate.

**AC:** We changed the term to massive ice.

**RC2:** Lines 296-297: This statement might be too general. Differences between the aspects according to solar radiation might be relatively small in the high Arctic, where also north-facing slopes receive quite some solar radiation during the Arctic summer. Given that RTS headwalls are close to vertical, relatively low sun angles might still be efficient in melting ice.

**AC:** We think that the aspect factor does indeed play an important role in RTS activity. We agree with the reviewer that in the case of vertical headwall the impact reduces, but considering that our study areas are located at 60-75 degree latitude and that RTSs initiate

and grow at slope angles of 15-25 degree the difference in the energy availability due to solar irradiation plays an important role. See for example Figure 3 in Ohmura et al. 2012 for the hourly ration measured during summer at Summit (Greenland) at 72.6 degree latitude.

### **Corrected typos**

Line 20: Missing comma after "Furthermore".

Line 29: You probably meant nutrient cycles.

Line 54: "Arctic RTSs": Are there any RTSs outside the Arctic? Consider omitting "Arctic"

Line 132: You probably meant "than" instead of "then".

Line 137: Missing comma after "For this computation"

Jones, M. K. W., Pollard, W. H., and Jones, B. M.: Rapid initialization of retrogressive thaw slumps in the Canadian high Arctic and their response to climate and terrain factors, *Environmental Research Letters*, 14, 055 006, 2019.

Kokelj, S., Tunnicliffe, J., Lacelle, D., Lantz, T., Chin, K., and Fraser, R.: Increased precipitation drives mega slump development and destabilization of ice-rich permafrost terrain, northwestern Canada, *Global and Planetary Change*, 129, 56–68, <https://doi.org/https://doi.org/10.1016/j.gloplacha.2015.02.008>, 2015.

Lacelle, D., Brooker, A., Fraser, R. H., and Kokelj, S. V.: Distribution and growth of thaw slumps in the Richardson Mountains-Peel Plateau region, northwestern Canada, *Geomorphology*, 235, 40–51, <https://doi.org/10.1016/j.geomorph.2015.01.024>, 2015.

Ohmura, A.: Present status and variations in the Arctic energy balance, *Polar Science*, 6, 5–13, <https://doi.org/https://doi.org/10.1016/j.polar.2012.03.003>, special Issue: The Second International Symposium on the Arctic Research (ISAR - 2), 2012.

Please also note the supplement to this comment:

<https://tc.copernicus.org/preprints/tc-2021-137/tc-2021-137-AC2-supplement.pdf>