

The Cryosphere Discuss., referee comment RC2  
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## Comment on tc-2021-303

Anonymous Referee #2

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Referee comment on "A regionally resolved inventory of High Mountain Asia surge-type glaciers, derived from a multi-factor remote sensing approach" by Gregoire Guillet et al., The Cryosphere Discuss., <https://doi.org/10.5194/tc-2021-303-RC2>, 2021

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### Overview

Overall, this paper provides a useful inventory of surge-type glaciers across all of High Mountain Asia based on a comprehensive analysis of changes in glacier velocity, surface elevation and surface crevassing. It is the most comprehensive such inventory of its type for this region, and the topic is of direct relevance for *The Cryosphere*. Overall the paper is well written and well illustrated, and I believe that it is worthy of publication. However, there are many smaller items that need to be addressed, as detailed below. The most significant of these is the use of inconsistent regions in different parts of the text, tables and figures; for example, Table 1 lists 22 regions, Fig. 7 uses 6 regions, Fig. 9 uses 8 regions, and Table 4 uses 4 regions. Insufficient information is provided to understand how these relate to each other, which makes it difficult to follow the arguments and statements in the paper. I also don't believe the statement in the abstract that this study newly identified 491 surge-type glaciers, particularly when this seems to directly contradict what is shown in Table 4.

### Detailed comments

L30: it would be useful to describe more explicitly as to which '*combinations of regional... and local... factors encourage instability*', and in particular whether these are found in HMA

L43: change to '*distribution of surge-type glaciers...*'

L45: it's a bit debateable to state that '*no HMA-wide inventory of surge-type glacier exists*', as one is already encompassed within the global study of Sevestre and Benn (2015). So I would refine the wording to say something like no '*dedicated*' HMA-wide inventory currently exists.

L46: state which hazards are being referred to here – e.g., ice-dammed lakes? Perhaps also ice avalanches?

L60: change to '*studies **have** documented...*'

L75: you say here that you identify surge-type glaciers from distinct widely used criteria, but the studies that you quote all use the presence of looped surface moraines as a major criteria, whereas it seems that you don't. It would be useful to add a sentence to make this clear, and to explain why you don't use this criteria.

L78-80 (and elsewhere, e.g., L85): specify the time period that you're referring to for '*substantial and spatially concentrated surface elevation changes*' and '*substantial variations in a glacier's velocity field*' to be classified as indicative of surging

L97: I believe that the measurement periods for Hugonnet et al. (2021) are 2000-2004 and 2005-2009 (also check caption for Fig. 1, which should be 2010-2019, and elsewhere throughout your paper). See: <http://maps.theia-land.fr/theia-cartographic-layers.html?year=2021&month=09&collection=glaciers>

Fig. 2a: I assume that Fig. 2a shows the velocity patterns for a non-surging glacier, so make this clear in the caption. It would also help to highlight the positive heavy tail in Fig. 2b if you used a symmetrical x-axis scale for Fig. 2b (e.g., -150 to +150), to match the symmetrical scale already used for Fig. 2a

L139: provide the resolution in m that defines VHR

L140: capitalize Bing Maps (and elsewhere, such as L161)

L140: I don't know what '*infirm*' means in this context; do you mean '*infer*'?

L163: you provide the resolution of the velocity data here (240 m), but this should also be

mentioned in Section 2.2

L173: to avoid any potential ambiguity, I would suggest modifying this sentence to say something like '*at least 2 of 3 proposed identification criteria of rapid changes in surface elevation, surface velocity and surface crevassing*' (assuming that these are the criteria that you're referring to here!)

L11 and L184: I'm not convinced by the statement that you newly identified 491 surge-type glaciers as it seems that you're only making comparisons with the RGI here? After working with the RGI myself, I know that their inventory is incomplete for their designation of which glaciers are surge-type. Rather, you need to make comparisons with other previously published studies to obtain an accurate number of which glaciers you've newly identified as surge-type, as you already do in Section 4.2 and Table 4. Indeed, Table 4 suggests that you haven't identified many new surge-type glaciers in some regions such as the Karakoram, and may have actually missed large numbers of them in the Pamirs.

L199: to reinforce the point that there is high correlation between the geometrical parameters, it might be useful to state how longer glaciers by definition have shallower slopes if they cover the same elevation range as smaller glaciers.

Fig. 5: please include part labels (a, b, c, d) for these figures, and indicate in the caption as to which geometrical attribute each figure part shows. It's currently a bit cryptic to try and figure out what `log_range` refers to, for example. Also provide units for each x-axis.

L235: I dislike sentences with clauses in brackets as it makes them difficult to follow, particularly when there are multiple such sentences back-to-back. It takes about the same amount of space to write out the sentences properly, but makes them easier to understand: e.g., 'We however note that balance distribution for surge-type glaciers in the Karakoram is positively skewed with  $g = 1.1$ , and negatively skewed with  $g = -1.4$  for non surge-type glaciers.'

L238: I don't follow the comment that the Himalayas are not representative with  $<10$  surge-type glaciers, as Fig. 7 specifies that the Himalayas has  $n=13$  surge-type glaciers, and Table 1 suggests  $n=14$  (unless Himalayas is defined in a different way in Fig. 10 than in other figs and tables, which relates to my comments below)

Fig. 7 and 8: please clarify how the six regions here compare to the HIMAP regions listed in Table 1 (perhaps by adding an extra column to Table 1?). For example, I can't figure out which of the six regions the Gangdise Mountains fits into. Some numbers also seem to be inconsistent between Table 1 and Figure 7: e.g., Central + Western + Eastern Himalaya = 14 in Table 1, but  $n = 13$  in Fig. 7. Also present the figure parts in the same

order in each figure so that it's easier to compare them (e.g., Tien Shan is shown first in Fig. 7, but Tibet is shown first in Fig. 8)

Fig. 9 and 10: these use 8 regions, compared to the 6 regions in Figs. 7 and 8, and 22 regions in Table 1. This makes it essentially impossible to make comparisons between the different figures, and makes it even more confusing as to which regions in Table 1 are included in which regions in the figures. Please be consistent throughout, and clearly define how the regions relate to each other.

L242 (and elsewhere): formal glacier names should be capitalized when referring to a single glacier: e.g., Khurdopin Glacier, Hispar Glacier

L244: add superscript -1 at the end of: '-0.22 - 0.3 m w.e. a<sup>-1</sup>'

Table 2: define in the caption as to whether these values are for the entire basin of each glacier?

Fig. 11: I don't follow the x-axis label for parts a and b: how can the units be both dimensionless and in m yr<sup>-1</sup>?

L260: I've read little, if anything, about previous surges lasting for 18 years in the HMA, so it would be useful to expand on this to provide more information about the location and characteristics of these, and how you can be sure that they surged for that entire time. Presumably it would also be more accurate to say '**at least** 18 years', since this is the maximum length of your record?

L261: Is the equation reference here correct? IPR is defined in Equation 3, while Equation 4 defines the surge index.

L271: 'active phase' is repeated twice here

L278: change to 'prevents **identification of** active phases...'

L286-7: this statement is a bit meaningless without anything to back it up; instead, it would be useful to provide some specific numbers here to convince the reader that the patterns you measured are real. For example, provide an average value for the quoted

elevation uncertainty in the Hugonnet dataset, and state what the average elevation changes were that you measured on surge-type glaciers. Same for velocity changes.

L296: remind the reader here of what the discriminatory criteria are, so that they don't have to go searching back through the previous sections

L302: change to 'certain level **of** certainty'

L315: you also need to make comparisons with the inventory of Sevestre and Benn (2015) here. You currently do this in section 4.3, but that text would be better moved to here. It would also be helpful to discuss why Sevestre and Benn (2015) identify so many more surge-type glaciers in the Pamirs than you, even after removing their duplicates.

L322: you're missing the inventory of Copland et al. (2011), who identified 90 surge-type glaciers in the Karakoram

L350: change to 'up to 45% of **total** glacier area...' to make it clear that you're referring to the entire glaciated region here, and not just the proportion impacted on each individual surge-type glacier

L372: seem to be missing some words here? 'in mass balance a single...' doesn't make sense as written