Reply to Reviewer2:

The authors have investigated glacier elevation changes in High Mountain Asia (HMA) derived from digital elevation models (DEMs) acquired over a period of 50 years to obtain information about surge type glaciers. For this purpose they make use of the usually very typical elevation change pattern that result from the mass transfer of a reservoir zone to the glacier terminus during a surge and the subsequent down-wasting of the tongue and build-up of new mass after a surge. Thereby, the observed elevation changes usually reach several dozens of metres so that the obtained signal is generally much higher than DEM uncertainties. The new assessment is then analysed in terms of topographic glacier characteristics, to extract possible differences between surge-type and other glaciers.

Major comments:

1. "As a general feedback to the terminology, I would say this (and several of the recently published previous studies) presents an inventory of surging glaciers rather than surge-type glaciers. The authors look at real surges that happened rather than investigating surface features (looped moraines etc.) that hint to possible (unobserved) previous surges. This differentiation of terminology should be clearly stated and applied here as it could explain a part of the differences among different inventories."

Condensed summary: Please use proper terminology, distinguishing surging from surge-type

Reply: Thanks for reminding. We have carefully read the previous studies (Goerlich et al., 2020 and others) and learned the definition difference between surging and surge-type glaciers. We agree with you that our study aiming to present a surging glacier inventory. We will modify all related statement in the text and added a brief definition to distinguish surging glaciers from surge-type glaciers.

2. "I think this is about the third or fourth study creating an inventory of surge-type glaciers in HMA, so there is obviously a need for such information. It also seems that it is important which team identified the largest number of 'new' surges. However, as for the previous studies using the RGI6 to mark these glaciers, there is a severe backdrop of the inventory presented here: The authors have not separated the surging glaciers from their trunk glaciers they are connected to in RGI6. This might only be an issue for a smaller portion of glaciers (a few dozens?), but it has to be done. Now the really huge glaciers Baltoro, Biafo, Fedchenko and Siachen are surge-type glaciers although they are not. They are just connected to often much smaller tributaries that have surged. To study these, they have to be separated, maybe just with a straight line to start with (and in the accumulation area). As the authors correctly describe (L325ff), it is clear that in many cases a separation in the ablation region will be difficult, as some surging (tributary) glaciers might contribute substantially to the flow of a trunk glacier or even form a joint tongue with other tributaries. I suggest skipping these complicated cases and focus on the clear ones, e.g. separate Bivachny from Fedchenko, Drenmang and Chiring from Panmah, Maedan from Chiring and Panmah from Choktoi with a straight line."

Condensed summary: Please separate tributaries connected to a larger trunk glacier to the extent possible.

Reply: Thanks for your suggestion. We have noticed that the tributary or tributary-induced surges would bring biases to the present inventory and result in misleading. To address this problem, we will separate surging tributaries from the stable trunks. A tributary will be considered as a surging glacier if it meets the following criterions. First, the dividing line of contrasting elevation change locates within this tributary. Second, the volume of mass contributed by this tributary to the glacier trunk is relatively small. We have found that many large glaciers are not surging glaciers, and have found about 200 tributary surges in about 100 glacier complexes.

3. This separation is not only important for glaciologic studies, but also because the authors analyse here topographic characteristics, size being one of it. When the very large glaciers listed above are in the sample instead of the 10 to 100 times smaller glaciers that really surged, it is not surprising that the result is always that the surge-type glaciers are (on average) larger and longer than the other glaciers. Although this general result might not change after separation, the proper separation is mandatory for a sound assessment of related characteristics. So there is no way around it. A different issue but leading to the same bias is the use of RGI6 for the analysis. There are many smaller glaciers missing in RGI6 and a large number has been manually digitized to the effect that partly huge areas with rock outcrops are included in the glacier outline. This leads to glacier extents that can be too large by 50% or more. Please use for the analysis the outlines provided by the GAMDAM2 inventory(doi.org/10.5194/tc-13-2043-2019).
Condensed summary: Please use GAMDAM2 instead of RGI6
Reply: Thanks for reminding. The tributary surges will be separated from the glacier complex, and the topographic characteristics of surging glaciers will be reanalyzed based on the new inventory.

We agree with you that the RGI6 inventory has some deficiencies in glacier number and outlines. We will regenerate the surging glacier inventory based on GAMDAM2 inventory from the very beginning of DEM differencing. Since the GAMDAM2 inventory does not includes the geometric and topographic parameters of glaciers, we will firstly calculate the geometric and topographic parameters of each glacier.

4. “I had a look at the outlines presented here and compared them to the inventories by Bhambri et al. (2017) for the Karakoram, Goerlich et al. (2020) for the Pamir and Guillet et al. (2022) for entire HMA. Of course, there are differences between the inventories due to different methodological approaches (elevation changes, velocities, length changes), time frame considered or inclusion of surge-type rather than surging glaciers (see above). However, it is argued that the inventory presented here should be more complete as it considers a longer time frame for the analyses. As described in Section 6.3 and confirmed by an overlay of datasets, many glaciers that have been identified as surging in the Guillet inventory are not included here. The authors explain this difference by possibly diluted elevation differences when observed over a longer period of time. I can live with this explanation, but how can this inventory then be more ‘complete’? Completeness is mentioned as a key argument for this new survey at many places (L9, 11, 44, 66 and 73). But why should I favor this inventory over the other when obviously so many ‘verified’ surging glaciers are missing here?
To get the dataset presented here more complete, the authors should at least perform a back check for the glaciers classified as surging in the Guillet et al. inventory but not in this one. A comparison to very high-resolution imagery (e.g. ESRI Basemap) sometimes shows impressively surging glaciers or distorted moraines at these locations. Also a visual inspection of the KH-9 images might reveal that glaciers have surged back then. Some more details about why these glaciers have been missed would be helpful to provide a better insight into the limits of the various approaches. Vice versa, glaciers identified as surge-type here but not by Guillet at al. should also be double-checked. When mass balances are slightly positive and surge marks are missing, it is also possible that glaciers just advance.”
Condensed summary: Please double-check and correct the present inventory with Gilles et al. and satellite images
Reply: Thanks for your suggestion. We will double-check the present inventory with respect to the inventory of Guillet et al. (2022), and update the inventory by introducing the morphological features as an extra criterion. Firstly, the surging behavior will be identified through the multi-temporal and multi-source elevation change maps covering periods of 1970s-2000 and 2000-2020. In this stage, the “surge-like” glaciers will be classified with three level of possibility indicators. After that, we will utilize the long-term Landsat series images (1986-2020) to investigate the morphological feature changes of the “surge-like” glaciers. We will identify the changes of terminus position, looped

moraine, and medial moraine. Also, we will assign a possibility index regarding the strength of morphological feature changes(e.g. "I" for obvious change and "II" for slight change). Then the inventory based on dH will be merged with the one based on morphological change. Finally, we will utilize the very-high-resolution images (Google/ESRI/Bing, etc.) to check the updated inventory. This procedure aims to exclude the false identifications, such as the severe lower-thinning in a lake-terminated glacier, and find more surging glaciers.

5. "Related to the above, the criteria presented for surge identification in Section 4.3 seem to be unbalanced. For example, terminus thickening is included as criterion I-1 but thinning is only in class IV-1, i.e. strong (post-surge) thinning does not have the same weight as thickening. Given that glaciers showing only thickening might just advance rather than surge (creating false positives), I would even argue that strong thinning (see L35) is the better indicator and should at least also be listed in category I. For example, in Figure 2a one can see the strong down-wasting of both Western Kunlun glaciers (just below the last zero of the '2000' annotation) and in Figure 2b the re-advance of its eastern branch, whereas the western branch is still thinning. Indeed, this part is now also surging again and the assignment 'non surge-type' is obviously wrong."

Condensed summary: Please shift class IV-1 'only down-wasting' to class I-4 and re-check then classes I-1 & I-4

Reply: Thank for reminding. We will recalculate the changes in glacier surface elevation and refine the surge identification criterions following your suggestion. The identification criterion based on the elevation change results will be changed into:

I) "verified":

- a) obvious thickening in lower reaches;
- b) contrasting upper-thinning and lower-thickening;
- c) contrasting upper-thickening and lower-thinning, which is much stronger than the elevation change caused by normal mass gain/loss;
- d) severe thinning in the lower reaches (two time stronger than that of the normal glaciers, or comparable to the ablation of adjacent "verified" surging glaciers);

II) 'probable':

- a) moderate upper thinning and lower thickening;
- b) only the moderate thickening in the middle reaches;

III) 'possible':

- a) only moderate thickening at the terminus;
- b) only strong thinning in the lower reaches (one time stronger than adjacent normal glaciers);

Since serious melting can also occur in lake-terminated glaciers, we will remove the lake-terminated glaciers from class "III-b".

6. "Finally, I suggest removing the climatic interpretation in L342 to 366. We have recently learned that ESSD will refocus on publishing dataset descriptions. This part (although interesting) goes clearly far beyond this. Maybe you can just cite here some studies looking at the interpretation in more detail. Below is a condensed summary of the general points above."

Reply: Thanks for reminding. We will delete the climatic interpretation here.

Specific comments:

7. L35: 'melts fast' this is certainly correct in a relative sense, but still it might take 20 to 30 years or even longer. So maybe write 'relatively fast'.

Reply: Thanks for reminding. We will rephrase this statement following your suggestion.

8. L41: ‘However, a glacier surge’ (or use plural: glacier surges are’)

Reply: We will rephrase this statement following your suggestion.

9. L43: When speaking of contemporary glaciers, I suggest writing ‘glacier hazards’ or maybe even better ‘glacier-related hazards’

Reply: We will revise the terminology following your suggestion.

10. L44: Glacier-related hazards are certainly an important point for studying surge-type glaciers, but an inventory has no prognostic characteristics and does thus not help to solve the problem. By knowing where these glaciers are, one does not know where the next hazard will occur. I would thus better argue here with the importance of having such an inventory when studying climate change impacts on glaciers, e.g. mass balances or length changes. For such studies it is of high importance to distinguish the two samples.

Reply: Thanks for reminding. We will rewrite this part following your suggestion.

11. L67/70: Both studies identified surging glaciers (i.e. surges were observed) rather than surge type glaciers (which might have surged in the past). Please adjust the terminology.

Reply: Thanks for reminding. We will revise the terminology.

12. L73: I would write ‘In this study’

Reply: We will revise this sentence following you suggestion.

13. L77/78: Such analyses are not allowed in ESSD.

Reply: Thanks for reminding. We have noticed the requirement of ESSD publishment. We will remove the unnecessary analysis. We will only take the geometric characteristics for statistically comparison, and will not discuss why they are different.

14. L124: Please use GAMDAM2 instead, RGI6 has quite a lot of issues in this region.

Reply: Thanks for your suggestion. We will use GAMDAM2 instead.

15. L172: Please also explain in this section how glaciers that are just advancing were distinguished from glaciers that are surging (when criterion I-1 is used).

Reply: To take your comment into account, we will establish a new suit of identification criterion which includes the different strength levels of elevation change and morphological feature changes. Please see the replies to comments 4 and 5 for details. Referring to previous studies (Lv et al., 2020; Goerlich et al., 2020), we think the advancing glaciers usually have such features: 1) only thickened in a small area near the glacier terminus, without contrasting upper thinning; 2) the advancing distance is relatively short. These features are corresponding to the “III-a” type of elevation change, and “II” type of terminus advance. Therefore, if a glacier only shows these two kinds of changes, it will be deemed as an advancing glacier, rather than a surging glacier.

16. L182: Please shift the class IV-1 ‘Strong thinning only’ to class I (e.g. as I-4) and get the currently surging west Kunlun Glacier included.

Reply: Thanks for your suggestion. We will refine the surge identification criterion following your suggestion. Please refer to the reply to comment 5 for details.

17. L218: Please revise Section 5.2 after small (part-time) tributary glaciers have been separated from the much larger trunk glaciers. Neither Fedchenko, nor Siachen, Baltoro or Biafo (and several others) are of surge type.
Reply: Thanks for reminding. We have generated an updated surge-type glacier inventory with tributary surges separated from the glacier complex, see reply to comment 2. In the later stage, we will re-conduct the statistical analysis on surging glacier distribution and geometric characteristics difference.

18. L242: See comment to L218, this applies also to Section 5.3
Reply: Thanks for reminding. We will reconduct the analysis as suggested.

19. L296: See comment to L218
Reply: Thanks for reminding. We will reconduct the analysis as suggested.

20. L298: This might change a bit when separating small surge-type tributaries from their trunk glaciers. Please get at least the largest ones out of the sample.
Reply: Thanks for reminding. This part would be revised accordingly during revision, and now we have separated the surging tributaries from the glacier complex with a unified criteria (see reply to comment 2).

21. L332: Yes, fully agreed, it can be difficult. But it has to be done anyway. It makes no sense to present a topographic analysis for the glacier complex when it is 100 times larger than the glacier that is actually surging.
Reply: Thanks for reminding. We have separated the surging tributaries from the glacier complex with a unified criteria in the updated inventory, please see reply to comment 2 for details.

22. L356/7: I would not draw such a conclusion when surge cycles are longer than the observation window. This observation can still be by chance.
Reply: Thanks for reminding. We will remove this conclusion.

23. L396/397: Please clearly separate surge-type glaciers from glaciers with observed surges to get the numbers correctly interpreted.
Reply: Thanks for reminding. We will recheck the Goerlich's inventory and only take the identified surging glaciers for comparison.

24. L400/1: I do not understand this calculation: When Goerlich et al. reports 176 surging (not surge type!) glaciers and the present inventory includes 156 of them, why is this 126 more rather than 20 less? Please better explain what has been calculated and compared here.
Reply: We meant 156 of 176 surging glaciers in Goerlich et al.'s inventory were included by our presented inventory. In Pamir, our inventory recorded 282(200+67+15) surging and surge-type glaciers, and 126 of them were not included by Goerlich et al.'s inventory. However, the inventory will be updated following your and the other reviewer's comments. This comparison will also be revised. We will rephrase these sentences to make them clearer.

25. L426: Please provide the final selection of glaciers also as point data and in shape file format.
Reply: Thanks for reminding. We will provide the identified surging glaciers as point data and in shape file format.

26. Figs. 2 & 5: The orange to red colours are too close to properly separate them. Please use more different colours.

Reply: Thanks for reminding. We will revise these two figures following your suggestion.

27. Fig. 3: The circles can be a bit smaller to see more details

Reply: Thanks for reminding. We will revise Fig. 3 following your suggestion.

28. Fig. 5: Please revise after glaciers have been separated. Fedchenko, Biafo, Baltoro and Siachen (among many others) are not surge-type glaciers. This is highly misleading information that can not be used for anything.

Reply: This figure will be revised according to the updated inventory.

29. Figs. 6 and 7: Please use more distinct colours, they are too close.

Reply: Thanks for reminding. We will use more distinct colors.

30. Fig. 9: Make circles smaller to see something. The foreground data could also be dots only.

Reply: Thanks for reminding. We will revise this figure following your suggestion.

References mentioned above:

Bhambri, R., Hewitt, K., Kawishwar, P., and Pratap, B.: Surge-type and surge-modified glaciers in the Karakoram, Scientific Reports, 7, doi:10.1038/s41598-017-15473-8, 2017.

Goerlich, F., Bolch, T., and Paul, F.: More dynamic than expected: an updated survey of surging glaciers in the Pamir, Earth Syst. Sci. Data, 12, 3161–3176, doi:10.5194/essd-12-3161-2020, 2020.

Lv, M., Guo, H., Yan, J., Wu, K., Liu, G., Lu, X., Ruan, Z., and Yan, S.: Distinguishing Glaciers between Surging and Advancing by Remote Sensing: A Case Study in the Eastern Karakoram, Remote Sensing, 12, 2297, doi:10.3390/rs12142297, 2020.