Reply to Reviewer #1:

The manuscript presents a new inventory of surge-type glaciers in High Mountain Asia, derived from glacier surface elevation changes computed from various DEM sources, between the 1970's and 2010's.

The manuscript tackles an important topic which is the identification of surging behavior over a large spatial and temporal scale using remotely sensed glacier observables and thus aims at proposing an updated inventory by incorporating historical data absent from other studies.

This problem is of significant importance or the community and the proposed paper is of overall good quality.

Major comments:

1. "The authors here rely solely on anomalous surface elevation change pattern to identify surging behavior. This can lead to false identifications of glaciers present similarly altered surface elevation change signal (See specific comments for more). Some of the widely known shortcomings of the datasets used in this study, as well as the existing corrections (SRTM C-Band penetration correction) are not accounted for in this study, which may lead to further false positive identifications."

Reply: Thanks for reminding. Considering the two error sources you mentioned, we will update the flow chart of data processing and correct the inventory. We believe the newly generated inventory of surging glacier will be more convincible. More details of the revision plan on the false identification handling were listed in the responses for specific comments 13 and 14.

2. "The authors rightfully propose a classification that assigns a level of certainty over the potential surge behavior of each glacier. This is a valid approach since the authors only have one identification criterion and I commend them for doing so. However, when analyzing, discussing and presenting their results, the authors seem to forget that surge-type behavior is uncertain for some glaciers and consistently mention 1015 surge-type glaciers while "only" 704 present indications of surge-type behavior."

Reply: Thanks for reminding. Indeed, speaking of surge-type glacier, only the 'verified' ones should be analyzed and discussed. We will classify the identified glaciers into the "Surge-type" and "Surge-like" categories like Bhambri et al (2017). The uncertain classes ("probable" and "possible") will be classified as "Surge-like" glacier. In the Result section, we will refer to the glacier types more explicitly. Also, only the confirmed surge-type glacier will be taken for characteristic discussion and comparison with previous studies.

3. "Finally, some of the Introduction and Discussion lack context and an adequate description of the state of knowledge of what are glacier surges and the processes that govern glacier instabilities."

Reply: Thanks for reminding. We will elaborate the knowledge of what are glacier surges and the processes that govern glacier instabilities in the Introduction and Discussion.

4. "I want to restate my support for this manuscript and the work it presents. Given its current state however, I

suggest that the authors make major additions and changes to both their methodology and results before this manuscript can be considered for publication.
As an example, adding more than one identification criterion would strengthen the confidence in the presented results. The authors could for example use available satellite images to visually investigate changes in surface and geomorphological features like crevasses, supraglacial ponds or looped moraines."

Reply: Thank you for your affirmation. We will modify our methods and results following your suggestions. In particular, we will add criterions based on morphological feature change. Please see the detailed revision plan for each specific issue listed below.

Specific comments:

5. L15-16. This statement is misleading as your classification is based on the confidence degree you have over certain surge events - all the glaciers in your inventory have different level of confidence.
This directly differs from the methodology used in Guillet et al, which I assume is the work you refer to, which used different identification criterion to investigate surges.
Reply: Thanks for reminding. We will categorize the updated results into the "Surge-type" ("verified" class) and "Surge-like" ("probable" and "possible" classes). To avoid confusion, both of them will be clearly stated in the text, especially in the comparison with others results.

6. L23. This relationship was actually first described in the enthalpy balance theory of glacier surges proposed by Benn et al 2019. Please rephrase this statement.
Reply: Thanks for reminding. We would rephrase this statement into "Based on a larger number of samples within HMA, this inventory further confirmed that the glaciers surge activity is more likely to occur for larger and longer glaciers…"

7. L27. Isn't that just because of a sampling bias, as a longer observational period allows to identify more surges?
Reply: Thanks for reminding. We have realized this statement is not rigorous. Since Reviewer #2 also doubt this statement and recommend to remove it, we will remove this statement from our manuscript.

8. L32. Please describe what do those phases entail and how do they differ.
Reply: Thanks for your suggestion. We will add a clear definition of glacier surge to clarify the differences in different surge phase.

9. L34. While I agree that the physics governing the unstable flow exhibited by surge-type glaciers requires a better understanding, I also think that speaking of 'enigma' disregards the substantial efforts made in the recent years to further our understanding of glacier surges.
The authors should here at least refer to the works of Sevestre and Benn (2015), Benn et al (2019), or Thøgersen et al. (2019) (among others) in order to provide an up-to-date synthesis of the state of knowledge on the physics of surge-type glaciers.
Reply: Thanks for reminding. We will rephrase this part and introduce more related works.

10. L35. Please be more specific in this statement. 'Fast' is very vague without a reference. This sentence is not easy to read and could benefit from being segmented and more detailed.

Reply: Thanks for your suggestion. We will rewrite this sentence following your suggestion. We will add more specific number to describe the "unstable flow" and "severe post-surge down-wasting".

11. L46. Not all surging glaciers show terminal advance. I suggest reading through the works of Paul et al. (2017) and Steiner et al. (2018, already cited in your work).
Reply: Thanks for reminding. We will modify the statement to "a surging glacier could exhibit either one or several drastic changes, including…"

12. L58. Contrasting elevation change signal is indeed a powerful tool to identify surge-type glaciers when it is associated to other remotely sensed observations (surface velocity, changes in crevasse pattern etc.). However, the statement made here is misleading as both Lv et al (2019) and Guillet et al (2022) also changes in surface velocity to identify surges. Furthermore, Viay and Braun (2017) focus on the early 21st century - a period of 12 years - not necessarily what could be called a 'long temporal scale'.
Reply: Thanks for reminding. We will alter the references cited here and rephrase the statement. Taking the elevation change as the only criteria to identify surge is indeed not rigorous. We will use more criteria to identify glacier surges following your suggestion (see reply for comment No. 14).

13. L92: As mentioned, the NASADEM used in this study originates from a reprocessing of the C-band SRTM. This data is however known for suffering from important radar penetration. This is more than likely to create spurious elevation change signal in the upper reaches of glaciers which can then lead to false identification of build-up phases, for example. This has to be addressed here, since the NASADEM is extensively used throughout this study.
Reply: Thanks for reminding. We will carefully address the errors caused by radar penetration. We will follow a two-step procedure to reduce the radar penetration bias in the final elevation change results. First, we will difference the NASADEM with the SRTM-X DEM. The elevation differences over glacierized area will be regarded as the penetration difference between X-band and C-band. Secondly, for each 3×3 grid, we will fit a 3rd polynomial function between the penetration differences and altitudes. Then, the bias in the glacier dH results (NASADEM minus TanDEM-X DEM) caused by radar penetration will be removed by taking the glacier elevation as input for the function. For the dH results calculated by differencing NASADEM and optical DEMs (HMA8m and KH-9 DEM), the penetration difference between X-band and C- band will be multiplied by 2 to represent the absolute penetration depth of C-band (Fan et al., 2022; Jaber et al.,2019). Also, the uncertainties in the penetration estimation will be included in the analysis of uncertainty of dH.

14. Sec 4.3: This is my main concern with this manuscript. Surge-type glaciers are mainly identified using only surface elevation changes. To me, this approach is a bit hazardous, as many processes can cause altered glacier surface elevation changes compared to what would be deemed as "normal" or "standard". I am here typically thinking about glaciers affected by landslides for example (Hewitt, 2009, Van Wyk de Vries et al., 2022) for example. This needs to be further investigated, including the possibility of using additional criteria to validate the identified surges. Such criteria would typically be morphological (Looped moraine or changes in crevasse patterns) as I doubt of the availability of glacier surface velocity datasets for the 1970s-2000 period.
Reply: Thanks for your suggestion. We have realized that taking the elevation change pattern as the only criteria to identify glacier surges is inadequate. Following your suggestion, we will establish a new workflow to identify surging glacier, which would produce a more reliable inventory. The new workflow is as follow:

1) Firstly, three types of surging glaciers (I-"verified", II-"probable", and III-"possible") will be identified based on

the "abnormal" glacier elevation changes. In particular, glaciers with one of the following four kinds of elevation change features will be identified as "verified" surging glaciers: 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 down-wasting in the lower reaches (as suggested by reviewer 2), which should be either two time stronger than that of the normal glaciers, or be comparable to the strength of adjacent "verified" surging glaciers. Within each observation period, each glacier will be labeled with its possibility level of surging and elevation change pattern (which was missed in the presented inventory).

2) Secondly, long-term Landsat series images (acquired between 1986 and 2021) will be utilized to investigate the morphological change features of the three types of surging glaciers identified from elevation change. For each year, about 2 cloudless Landsat images will be selected. With each Landsat image acquisition frame, images of different dates will be merged into an animated image. Base on the animated image, we are able to identify the morphological feature changes, such as terminus position change, looped moraine changes, and medial moraine changes. Also, we will assign an index of surging possibility for each kind of morphological changes. For example, when the terminus has advanced by over 500m, the glacier will be labeled as "I" type, and as "II" type for less than 500m. Glaciers with clear formation of a new looped moraine or the dramatic shape-change of old looped moraine will be also labeled as "I" type, and those with slight shape-change of old looped moraine will be labeled as "II" type. The treatment of changes in medial moraine is similar to that of looped moraine. The crevasse changes will not be included because the moderate resolution of Landsat images don't allow the identification of crevasse changes.

3) Thirdly, the inventory based on elevation change will be merged with the one based on the morphological change.

4) Finally, we will utilize the very high resolution images (Google/ESRI/Bing, etc.) to check the updated inventory.

This procedure aims to exclude some potential false identifications, such as the severe lower-thinning in a lake-terminated glacier and remarkable surface heightening caused by nearby landslide.

15. L208: Again, this statement is extremely misleading. Glaciers that are considered as "Possibly" or "Probably" surge-type cannot be considered as such. There is no clear surge signal in the elevation change of those glaciers over the studied time periods, otherwise they would be qualified as "verified". In total, you have identified 704 surge-type glaciers at most.

Reply: Thanks for reminding. We will rephrase this sentence. We will clearly differentiate the identified "surge-type" glacier from "surge-like" glaciers in the text, and only refer to the "verified" surge-type glaciers when analyzing the result and making comparison with other studies.

16. L240: Please show examples of these glaciers as well as their elevation change signal for all considered periods.

Reply: We will add the elevation change maps of these identified glaciers for all considered periods.

17. Sec 6.2: This section is very qualitative and provides very few quantitative information. Please provide estimates of the quantities you are referencing.

Reply: Thanks for reminding. We will rewrite this part and incorporate more quantitative information from our results and other studies.

18. L308: You mention randomness, where I believe you mean variability. I do not understand the point made

between L311 and 314. Please clarify.

You further mention that glacier median elevation is "irrelevant" for other topographic parameters. Again this statement is pretty hard to understand, even though I assume you here mean "correlated". A glacier's median elevation is however very correlated to its elevation range. Similarly glacier are is most likely correlated to glacier elevation range (as glaciers are relatively elongated features) so I do not really understand the point of this statement. If I misunderstood your point here please correct me and clarify.

Reply: Yes, we meant the average slope of small glaciers varies widely, and we will modify this statement.

In L311-314 we tried to clarify that, for small glaciers there is no clear relationship between the length and mean slope, because the average slope of small glaciers varies widely. We will modify this statement to make it clearer.

Likewise, we also tried to explain the reason why the distribution of median elevation of surge-type glaciers is similar to non-surge-type glaciers (Fig. 8e). We agree with you that the median elevation is highly correlated to the absolute elevation. However, the elevation range we mentioned means the difference between the maximum and minimum elevation, rather than the absolute maximum and minimum elevation. The median elevation is an absolute value, while the elevation range is a relative value. We will modify this statement to make it clearer.

19. Sec 6.3: This section is a bit problematic at the moment for several reasons. First, the authors propose an inventory based on only one identification criterion and compare it to the one of Guillet et al 2022, which only comprises glaciers for which two criteria of active surges could be observed. Apart from the intrinsic methodological difference, this comparison makes little sense, as the inventory proposed here also comprises glaciers for which surging behavior is uncertain.

This comparison should only target 704 glaciers in the inventory proposed here - which then lowers the difference with Guillet et al (2022) to 38. This in turns leads to several questions, most notably on the length so-called cycle of surging glaciers (assuming that there are no false positives in any of the inventories). Second, the authors mention that with 349 glaciers more (1015-666), they only observe a small (4%) increase in the glacierized area covered by surge-type glaciers in HMA and that, hence, the newly identified ones are relatively small.

This is in stark contrast with previous studies documenting surge-type glaciers as systematically bigger than non-surge type glaciers (Jiskoot et al., 2011, Sevestre and Benn, 2015, to cite a few) as well as what is predicted by the enthalpy balance theory (Benn et al., 2019) and needs further investigation.

Reply: Thanks for reminding. We have realized that the present comparison with other studies is improper. The comparison will be conducted after excluding the uncertainly identified glaciers.

During the past days, we refined our identification strategy by taking your comments into account. We have found some nonnegligible problems in our previous results that were due to the careless check of small glaciers and the underutilization of multi-temporal DEMs (KH-9 and HMA8m). The updated inventory has documented more surge-type glaciers with specific surging features that are mentioned in comment 14. The new inventory should be more reliable. Thanks for your constructive comments. The datasets will be shared soon after the final check and manuscript revision.

References mentioned above:

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Abdel Jaber, W., Rott, H., Floricioiu, D., Wuite, J., and Miranda, N.: Heterogeneous spatial and temporal pattern of surface elevation change and mass balance of the Patagonian ice fields between 2000 and 2016, The Cryosphere, 13, 2511–2535, doi:10.5194/tc-13-2511-2019, 2019.