

Reply to Reviewer #2:

Major comments:

1. “For the revised version of this submission the authors have tried to implement my suggestions to the extent possible, which is highly appreciated. I compared the new PDF to the former one and recognized that large parts of the text have been rewritten, in part also as a result of the improved dataset. In my view the text is now more to the point, the methodology better explained, the categorization of different surge-types more consistent and the comparison to other datasets completer and better understandable. Of course, the specific thresholds used for the classification can be discussed, but in my view the authors provide a reasonable starting point. The same applies to the combination of the results from two points in time and with other criteria or studies for the verified, probable and possible assignment. Also here the choices of the authors can be discussed, but it is likely impossible to find a ‘one fits all’ solution. As the authors acknowledge, this study will not be the end of the story, but I think they have done what is currently possible with the datasets available.”

Reply: [Thanks for your approval of our efforts in revising the manuscript.](#)

2. “I have also checked the revised dataset and think it is much completer and more usable now. The extra effort the authors spent on separating outlines of surging tributaries from often much larger trunk glaciers is highly appreciated. I think this will serve the community much better than currently available datasets and hope this dataset can be integrated in a future update of the new RGI7. Of course, there are now assignments where I would disagree and some glaciers that have obviously surged in the past are not included (e.g. Halong glacier in Tibet described by Wenying (1983) in doi.org/10.3189/S0022143000030306). Hence, also the here presented method (elevation change patterns) has its limitations and further improved and completer results can be obtained when further methods (length and velocity changes) and datasets (literature) are used. As the authors have demonstrated this with a direct comparison to several other datasets, I would leave it with this. The surges that have only be identified in some of these studies are certainly the most interesting, as they will help defining the thresholds needed to distinguish them from other (e.g. just advancing) glaciers.”

Reply: [Thanks for your encouraging comments on our work. We admit that this inventory does not incorporate all surges during the observation period. Further improvements can be achieved by combining other observations.](#)

3. “My most severe objection at this stage is the often wrong English grammar. To get this right, a careful check of the entire text by a native speaker is required. The text is mostly readable, but the wrong grammar is distracting. It seems as if the authors have the usual problems with using ‘a’, ‘the’ and the singular or plural form. In many cases they write it just the wrong way round although there are simple rules that can be applied. For example, one should use ‘the’ when the following is something specific and not use it when it is not (e.g. L113/115 should be ‘the COP30 DEM’ as the COP30 DEM is something specific and L55 should be ‘As for surge-type glaciers, which refers to glaciers that possibly surged ...’ as ‘surge-type glaciers’ are unspecific). But as I am not a native speaker, please give the complete manuscript a check. The points listed below (specific comments) are only a sub-sample. I also suggest to change the wording from ‘surging glacier inventory’ to ‘inventory of surging glaciers’ and to use ‘HMA DEM’ instead of ‘HMA8m DEM’ and ‘NASA DEM’ instead of ‘NASADEM’.”

Reply: [Thanks for reminding. We have employed the English-editing service to improve the language of our manuscript, and have changed the terminologies following your suggestion.](#)

Specific comments:

4. L9: (and elsewhere): ‘... ice flow and inventories of surging glaciers are important for correctly interpreting regional mass balance’

Reply: Thanks for reminding. We have replaced the expression of ‘surging glacier inventory’ with ‘inventory of surging glaciers’ throughout the manuscript.

5. L10: How can an inventory of surging glaciers help ‘assessing glacier-related hazards’? The inventory itself does not indicate anything and even after a hazard has happened, how can the inventory help to assess it? I suggest to remove or explain.

Reply: Thanks for reminding. We have removed related expressions following your suggestion .

6. L12: I suggest writing ‘In this study ...’

Reply: Thanks for reminding. We have rewritten it following your suggestion.

7. L16: I suggest writing ‘and 336 probably or possibly surging glaciers’. A ‘surge-like glacier’ can be something very different.

Reply: Thanks for your suggestion. We have rephrased it in the abstract and conclusion sections. In the Results section, we have clearly clarified it to avoid confusion and repetition.

8. L17 and elsewhere: I suggest writing ‘previous inventories of surging glaciers’

Reply: We have replaced the expression throughout the entire manuscript following your suggestion .

9. L18: ‘excluding glaciers smaller than’

Reply: We have corrected it.

10. L20: ‘...uneven. They are ...’

Reply: We have corrected it.

11. L24: have steeper slopes

Reply: We have corrected it.

12. L26: ‘those with severe mass loss’

Reply: We have corrected it.

13. L39: ‘impact the regional mass balance’

Reply: We have corrected it.

14. L40: investigation and requires to first identify the glacier surges.’

Reply: We have rephrased this sentence following your suggestion.

15. L42/43: insert missing spaces (4 in total)

Reply: Thanks for reminding. We have corrected it.

16. L44: ‘To support related investigations the distribution of surging glaciers is needed as a starting point.

Reply: We have rewritten this sentence following your suggestion.

17. L45: 'studying the internal dynamic processes' For this, also a glacier surge must happen. Just knowing where surges have occurred does not provide anything. I would delete this part or better explain the context.

Reply: Thanks for reminding. We have rephrased this sentence. We wanted to clarify that such inventory is needed to provide various surging glacier samples for studying the internal mechanism of glacier surges.

18. L45: glacier surges

Reply: We have corrected it.

19. The Shugar et al. (2021) paper is not related to a surge.

Reply: Thanks for reminding. We have deleted this citation.

20. L48: 'A complete inventory of ...' Not really. For a hazard assessment you need a hazard. An inventory alone does not help in assessing the hazard nor does it allow to determine where the next hazard will happen.

Reply: Thanks for reminding. We have deleted this part.

21. L51: The 'normal conditions' for a surge-type glacier that is not surging is close to being stagnant, at least its lower parts. This is not a good reference to determine flow acceleration. Maybe refer to the usual flow of glaciers that do not surge.

Reply: We have rephrased this part to 'compared to the usual flow of non-surging glaciers'.

22. L52: A medial moraine is common to many glaciers, it is not indicative of surge behaviour. Maybe write 'deformed medial or looped moraines'? As a note, a looped moraine is indicative of a tributary glacier that has surged into a (larger) trunk glacier. In other words, the glacier with the looped moraine is likely not the glacier that surged.

Reply: Thanks for your notes. We have corrected it.

23. L52: Maybe add 'shear margins' to the list?

Reply: Thanks for reminding. We have added it.

24. L55: As for a surge-type glacier, which refers to a glacier

Reply: We have corrected it.

25. L58: of supraglacial moraine deformation ... To recognize sudden changes

Reply: Thanks for reminding. We have modified this sentence .

26. L59: It can also be detected with the change in normalized backscatter from SAR sensors (doi.org/10.5194/tc-15-4901-2021).

Reply: Thanks for reminding. We have added the citation of this paper in the text.

27. L60: The image sources ...are limited, the strong changes in glacier motion might be missed. The Shugar et al. (2021) paper is not related to a surge.

Reply: Thanks for reminding. We have corrected it.

28. L61: I think here you mean: 'In contrast, the recognition of a specific surface elevation change pattern is a more

reliable way to identify surging glaciers, as it will be visible for many years before and after a surge (... , Zhou et al. 2018). Accordingly, its source datasets (DEMs) can satisfy the required spatio-temporal coverage with ... fewer datasets.

Reply: Thanks for reminding. We have rephrased this sentence following your suggestion.

29. L66: but most effective

Reply: We have corrected it.

30. L67: 'as a criterion and to combine this information with other observations if possible ...'

Reply: We have corrected it.

31. L70: as well as the differing glacier mass balance.

Reply: We have corrected it.

32. L73: '2020) and Tien Shan'

Reply: We have corrected it.

33. L74: inventory of surging glaciers

Reply: We have corrected it.

34. L75: spatio-temporal coverage

Reply: We have corrected it.

35. L78: '2020), i.e. not all glaciers that surge do also advance.'

Reply: We have added it in the text.

36. L81: long-repetition cycles

Reply: We have corrected it.

37. L82: surging glaciers.

Reply: We have corrected it.

38. L83: elevation changes

Reply: We have corrected it.

39. L84: from multiple DEMs

Reply: We have corrected it.

40. L96: Glacier elevation changes across HMA were found.

Reply: We have corrected it.

41. L98: positive or close to zero changes.

Reply: We have corrected it.

42. L106: The NASA DEM serves as

Reply: [We have corrected it.](#)

43. L107: with a moderate

Reply: [We have corrected it.](#)

44. L113 of the COP30 DEM

Reply: [We have corrected it.](#)

44. L115: therefore the COP30 DEM

Reply: [We have corrected it.](#)

45. L116: of the product

Reply: [We have corrected it.](#)

46. L119: from very high-resolution

Reply: [We have corrected it.](#)

47. L132: Why 48 m and not 30 or 60?

Reply: Processing the KH-9 images covering HMA glaciers is quite time-consuming. To accelerate the computation, a DEM of coarse resolution (48m, with a down-sampling factor of 2) was generated through the stereo processing. Due to the limitations of computation resources, we can only generate the coarser DEMs (lower than 30 m) at this stage. However, the resolution and quality of this DEM should be sufficient for identifying surging glaciers.

48. L134: include the most recent surges (Brun et al., ...).'

Reply: [We have corrected it.](#)

49. L138: detected and removed.

Reply: [We have corrected it.](#)

50. L141: 'to capture morphological changes.' I suggest inserting here: 'We acknowledge that due to the 30 m spatial resolution not all details of a changed glacier surface are visible.' Or something similar.

Reply: [Thanks for your suggestion. We have clarified this limitation here.](#)

51. L143: from the USGS

Reply: [We have corrected it.](#)

52. L149: as a template for the inventory of surging glaciers

Reply: [We have corrected it.](#)

53. L151: by also excluding rock outcrops, seasonal snow and shaded

Reply: [Thanks for reminding. We have modified this sentence.](#)

54. L169: such as the polynomial fit ... that were operated

Reply: We have corrected it.

55. L172: high-mountain regions

Reply: We have corrected it.

56. L173: 'geolocation shift' The method corrects both horizontal and vertical shifts, which one is meant here?

Reply: Both kinds of shifts were corrected through this method. We have clarified it.

57. L189: 'through a Fast-Fourier-Transformation.'

Reply: We have corrected it.

58. L192: through a 3-sigma threshold criterion.

Reply: We have corrected it.

59. L195: and potentially lead to false values.

Reply: We have corrected it..

60. L328: glacier area.

Reply: We have corrected it.

61. L339: Is it sure that Siachen Glacier surged? In my understanding this is a fast flow glacier such as Baltoro or Biafo that does not really surge.

Reply: Thanks for reminding. In the last round of revision, we carefully checked the identification results of huge glaciers. In periods of 1974-2000 and 1980-2000, the Siachen glacier has showed obvious thickening in the tongue (up to 50 m), and slight thinning in the upper reaches. We thought this could be the signal at the late stage of a previous surge, or possibly a mini surge. According to our identification criteria, we finally decided to classify it as surging.

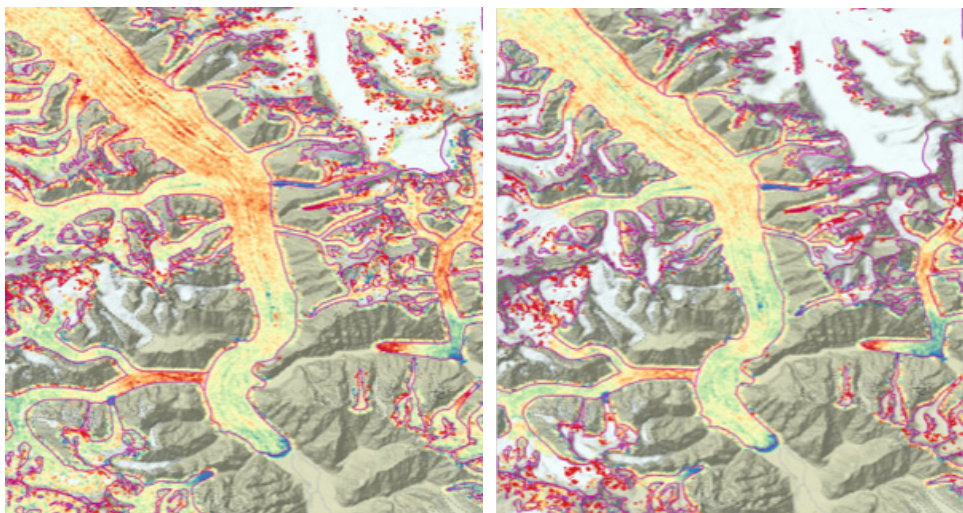


Fig.1 Elevation changes of the Siachen glacier during periods 1974-2000 (left) and 1980-2000 (right).

62. L349, L363, L365, L368: in the reference group

Reply: We have corrected them.

63. L352ff: please remove 'the' before north, northwest, north east

Reply: We have corrected it.

64. L371: with glacier area, length and elevation range as these are auto-correlated.

Reply: We have corrected it.

65. L372: By contrast, glacier median elevation has little correlation with these parameters.

Reply: We have corrected it.

66. L383: tiles

Reply: We have corrected it.

67. L390: where surges occur

Reply: We have corrected it.

68. L422: our results highlight ... aspects is slightly

Reply: Thanks for reminding. We have corrected it.

69. L424/5/9: facing north/towards north/facing north (or 'facing to the north')

Reply: We have corrected it.

70. L428: north-east facing glaciers have a higher chance to be surging glaciers

Reply: We have corrected it.

71. L445: positive elevation changes, which is known as one part of the 'Pamir-Karakoram-West Kunlun' Anomaly (as a note: the other two parts are advancing glaciers and stable or even decreasing summer temperatures).

Reply: Thanks for your note. We have corrected it.

72. L485: internal glacier surges that did not result in a terminus advance.

Reply: We have corrected it.

73. L495: observations after 2000 were used

Reply: This study has utilized multiple elevation change observations covering the periods both before and after 2000. Here we are trying to say that the elevation change observations before 2000 used by them only cover a small part of the Western Pamir, which could lead to fewer identified surges before 2000. We have rewritten this sentence to make it clear.

74. Frank Paul

Reply: We are sorry about the carelessness. We have corrected it.

75. L729/30: remove capitalization

Reply: We have corrected it.

76. L759: '(only glaciers larger 0.4 km² are considered)'

Reply: We have corrected it.

77. L773: 'The number and area ratios of surging glaciers for different area classes.'

Reply: We have corrected it.

Figures:

78. Fig. 1: I suggest making the (a), (b), etc. annotations on the figure a bit larger. Fig. 1c indicates that the KH-9 coverage is a bit incomplete, in particular in the Tien Shan. Can you add somewhere in the text how many surging or surge-type glaciers have thus no elevation change information for the first period?

Reply: Thanks for your suggestions. We have modified the label size in Fig.1. The incomplete coverage of usable KH-9 images led to 103 surging glaciers having no observations during the period of 1970s-2000. We have clarified this at the beginning of the results section.

79. Fig. 2: As for Fig. 1, I suggest that you first start with the reference to the figure panel and then describe the contents, i.e. '... change maps during (a) 1970s-2000, (b) 2000-2020 and (c) the corresponding surge classification. The subset selected for visualisation is fine but I miss the link to the classification scheme.' I suggest to annotate panels (a) and (b) with the class derived from the criteria for the glaciers possible. For several of them the assignment to the 'verified' class is not very obvious from the elevation difference maps.

Reply: We have added annotation to panels (a) and (b) with the classes derived from the identification criteria and modified the caption here. This study has utilized multiple elevation change observations covering the periods both before and after 2000. However, only one elevation change observation during periods both before and after 2000 was illustrated in this figure, and therefore the final identified class may not correspond to the elevation change pattern. In view of this issue, we have also added a subscript to note that elevation change observations of other periods were combined to determine the surging class.

80. Fig. 3: I suggest using much smaller circles (40% of current size) and more distinct colours to code glacier area (e.g. black, blue, red and yellow). Maybe the sub-regions can be numbered for a quick identification?

Reply: Thanks for reminding. We have modified the circle size and color following your suggestion. We have added the names of sub-regions in the figure.

81. Fig. 4: The dark red used to illustrate the percentages is a bit too dark to see the numbers on top. Please use a lighter colour.

Reply: We have changed the dark red to a lighter color following your suggestion.

82. Fig. 5: I think the panels are too small to see anything and suggest to show all 4 on top of each other with a width close to page width. I also suggest to use more distinct colours, at least for the probable and possible classes. As mentioned for Fig. 2, please move the panel identifier before the text, i.e. 'identification in (a) the Pamirs, (b) central Tien Shan, ...'

Reply: The size of this figure has been increased. We also changed the color and modified the caption following your suggestion.

83. Fig. 6: Maybe use white for the (a) and (b) annotation, it is a bit difficult to see. As for Fig. 2, I suggest to annotate the 'Surging glacier' class in the panel with the result of the classification. When it is not purely the elevation change

pattern, please add with an index letter or number (to be explained in the caption) which other criteria have been used.

Reply: After many times of test, we found that adding a background to the annotations is a better way to make them clearer. We have added the annotations of the surging class following the way in Fig. 2. Thanks for reminding.

84. Fig. 7: Instead of coloured bars you might use two different shades of grey. Please also add minor tick marks on the y-axis and consider using dotted grid lines for the major tick marks of the y-axis. I also suggest to get the inset-table out of the figure and show (and cite) it as a regular table.

Reply: We have modified this figure following your suggestion. The inset table has been taken out and turned to Table 3 in the revised manuscript.

85. Fig. 8: Caption: 'in eight aspect sectors'. As all six panels have an identifier, I suggest repeating it for the column description, e.g. 'Left column (a) and (d): distribution of ...'

Reply: We have modified the caption following your suggestion.

86. Fig. 9: Please add minor tick marks on the x-axis and consider using different shades of grey instead of colour for the plots. Caption: use commas as separators '... area, (b) elevation range, (c) natural logarithm ...'

Reply: We have modified the figure and caption following your suggestion.

87. Fig. 10: I suggest filling the foreground dots with a lighter colour or even white to better see the differently sized circles and to add minor tick marks on all x-axes.

Reply: We have modified the color and added the minor ticks following your suggestion.

88. Fig. 11: I suggest using major tick marks every 2 m, insert minor tick marks and dotted major grid lines (or tick marks also at the upper x-axis. Instead of colour, different shades of grey can be used. Please annotate the x-axis with 'NMAD (m)' instead of just 'Meter'.

Reply: We have modified this figure following your suggestion .

References mentioned above:

Dehecq, A., Gardner, A. S., Alexandrov, O., McMichael, S., Hugonnet, R., Shean, D., and Marty, M.: Automated Processing of Declassified KH-9 Hexagon Satellite Images for Global Elevation Change Analysis Since the 1970s, *Front. Earth Sci.*, 8, 566802, doi:10.3389/feart.2020.566802, 2020.

Reply to Reviewer #3:

Specific Comments:

1. L37: Please refer to the specific inventory you have compared?

Reply: Thanks for reminding. We have rephrased it to clarify that the number was concluded based on the comparison with the most recent study, which refers to the inventory presented by Guillet et al. (2022).

2. L19-L22: The regions listed in the bracket have been directly described in the result and discussion sections. So, you can remove these sentences to keep the abstract brief.

Reply: Thanks for reminding. We have modified it as you suggested.

3. L44: Replace “accurate” with “direct” or “clear”? Because the “distribution” cannot be quantitatively described.

Reply: Thanks for reminding. We have rephrased this sentence to ‘the distribution of surging glaciers is needed as a starting point’.

4. L56: I would say that less calculation does not mean the visual interpretation of glacier surface morphological changes is “easy to operate”. Please rephrase it.

Reply: Thanks for reminding. We have modified this expression to ‘less calculative’.

5. L85: “The preliminary identified surging glaciers were divided into...”.

Reply: Thanks for suggesting. We have modified it.

6. L130: There should be a comma after “Alaska”.

Reply: We have corrected it.

7. L133: Put the “(See Fig. 1c)” at the end of previous sentence.

Reply: Thanks for reminding. We have modified it.

8. L212: “were” → “was”.

Reply: We have corrected it.

9. L215: Delete the redundant blank between “the” and “false”.

Reply: We have corrected it.

10. L259: “small” → “slight”.

Reply: We have modified it.

11. L299: “all” → “most”? In fact, your elevation change results do not have 100% coverage, especially for the period of 1970s.

Reply: Thanks for reminding. We have modified it to ‘most’. Besides, we have added a sentence to demonstrate the coverage of KH-9 DEMs here.

12. L381: I would say the NMAD “can be deemed as a better proxy of uncertainties in dH than STD”.

Reply: Thanks for your suggestion. We have rephrased it.

13. L390: “top” → “head”?

Reply: We have corrected it.

14. L453: The expression of “809 if RGI6.0 was used” is ambiguous. Maybe you can rewrite it to “809 if represented by RGI6.0 polygons”?

Reply: Thanks for reminding. We have modified the expression following your suggestion.

15. L767: Figure 6: if the surging glaciers were identified through multiple criteria and multi-temporal changes, then I can understand that why some glaciers (e.g. the largest one in panel a) are classified as surging. But you should clarify that more clearly in the caption text.

Besides, please use a thinner line of the surging glaciers to make this figure more readable.”

Reply: Fig.6 has been redrawn with a thinner line to indicate identified surging glaciers. After that, we also added a label to annotate the specific identified class of the surging glaciers. Since only one frame of elevation change during each observation period was illustrated in this figure, the final identified class may not correspond to the elevation change pattern. We have also added two subscripts to demonstrate that dH of other periods or morphological changes were combined to determine the surging class, respectively. We have added the explanation in the caption.

References mentioned above:

Guillet, G., King, O., Lv, M., Ghuffar, S., Benn, D., Quincey, D., and Bolch, T.: A regionally resolved inventory of High Mountain Asia surge-type glaciers, derived from a multi-factor remote sensing approach, *The Cryosphere*, 16, 603–623, doi:10.5194/tc-16-603-2022, 2022.