Overall comments

This paper effectively utilizes a wide variety of remote sensing datasets and methods to enhance our understanding of the dynamics and surge history of the NKG basin in the Eastern Karakoram. It effectively demonstrates a novel application of Jason-3 altimetry data to measure elevation changes of glaciers and glacial lakes, as well as a new approach for automatically mapping glacier extents and terminus positions using Sentinel-1 SLC images. These methods have potential for widespread application within High Mountain Asia and other glaciated regions, increasing our ability to efficiently monitor glacier change over time.

The authors provide a detailed description of surges in NKG I and NKG V, employing sound methods that are generally well described. However, I believe the uncertainty analysis requires more detail, particularly regarding the uncertainties in the ITS_LIVE glacier velocities used in this study. I recommend that the authors describe these uncertainties more transparently, offering specific uncertainty ranges for each dataset, where possible. Additionally, some sections of the text and certain figures could benefit from modifications to enhance clarity and interpretability. Suggestions for these improvements are provided in the specific comments below.

Once these minor revisions are addressed, I believe this paper will make a valuable contribution to our understanding of glacier surging in the Karakoram and offer important insights into the mechanisms driving glacier dynamic changes in this region.

Specific comments

Abstract:

- L10: “Increased occurrence” is a bit ambiguous. Please specify what the increase is relative to, such as whether surging occurrence is higher in this region compared to other glacier regions or whether the occurrence of surging has recently increased.
- L11–12: I would not say that observations are particularly limited in this region, as several studies have reported on glacier surging in the Karakoram and HMA. I therefore suggest to change this sentence to “However, more observations are needed to further our understanding of surging dynamics and their underlying mechanisms”.
- L21: Change “and raising its surface elevation by ~ 180 m” to “and raising the glacier surface elevation by ~ 180 m”.

Introduction:

- L29–30: Consider revising to: "Frequent glacier surges and slight mass gains **over recent decades** are defining characteristics of Karakoram glaciers (Farinotti et al., 2020; Bazai et al., 2021), collectively known as the Karakoram Anomaly (Hewitt, 2005; Berthier and Brun, 30 2019; Bolch et al., 2012)."
- L33: Change "up to 10 to 100 times of the normal (Guo et al., 2022)" to "increase to 10 to 100 times the normal rate (Guo et al., 2022)".
    - Also consider revising the 10 to 100 times figure to 10–1000 times, a more widely accepted range, as some glaciers have been seen to accelerate well over 100 times above background levels, such as Variegated Glacier in its 1982–83 surge (Kamb et al., 1985).
- L46–48: Since you mention "mass-energy balance", which is based on the idea of the enthalpy balance theory of surging, you should cite this paper by Benn et al. (2019): https://doi.org/10.1017/jog.2019.62.
- L69: Specify which "key variables" you are referring to here.
- L85–86: The coordinates seem to be reversed; they should read "34.823°N, 77.863°E" instead.
- L91: It would be useful to also mention mean annual air temperatures in this sentence.
- L110: Synthetic aperture radar should not be capitalised.

Methods:

- L142–143: How did you determine that longer intervals resulted in underestimated velocities rather than shorter intervals overestimating velocities if you did not have independent data to validate the ITS_LIVE velocities? Smaller time intervals in the ITS_LIVE image pair data, such as the interval that you used for this study, can be more noisy and have higher errors. Therefore, it would be important to properly quantify uncertainty estimates for the ITS_LIVE data that you used in this study (see other comment for L262–270 below).
- L145: Change "Give" to "Given".
- L153: Specify the resolution of the DEM.
- L156–157: Consider adding this DOI for the Theia data portal, where the Hugonnet et al. (2021) data can be downloaded: https://doi.org/10.6096/13.
- L189: Small typo: Change "Jaosn-3's" to "Jason-3's"
- L262–270: It is good to know that the velocities derived from these different satellites tend to agree well with each other. However, you did not give any estimated uncertainty value (i.e., in m yr^{-1}). The ITS_LIVE dataset provides GeoTIFF files of estimated velocity errors. It would be good to mention typical error values over the glacier from the velocity maps that you

downloaded over the specific time periods that you analysed. At the very least, you could quantify velocities over unglaciated terrain to give an estimate of uncertainties.

Results:

- L299–300: “A notable increase was observed in June 2015”: please quantify this velocity increase.
- L301–302 and L326–328: Once again, it would be helpful to provide specific values for these velocity peaks to clarify their magnitude and improve the interpretability of the text
- L352–354: While the elevation change rates are shown in Figure 6d, I suggest also mentioning them in the text for increased clarity.
- L376: Change “taking” to “taken”.
- L376–377: Please specify uncertainties for the terminus position changes (i.e., 43 ± ?? m and 180.3 ± ?? m).
- L398–400: In terms of glacier extent changes, have you quantified glacier area changes (with associated uncertainties)? If so, please mention these estimates and associated uncertainties here.
- L427: Change “has commenced” to “had commenced”.

Discussion:

- L513: Change “data-scare” to “data-scarce”.
- L537–538: Either state the revised glacier volume changes here or direct the reader to Table 2 for details.
- L564–565: Briefly explain how enhanced the steeper surface slope and erosion from the former proglacial lake would have contributed to NGK V surging first.
- L565–566: “Historical climate records indicate that from 1977 to 1980, temperatures in the NKG region were higher than average”: 1980 appears to have been a relatively warm year, but 1979 was one of the coldest years according to Figure 13a. Therefore, from looking at the graph qualitatively, I would not say that 1977–1980 temperatures were higher than average, unless you can quantitatively prove that.
- L581–582: “This transition could lead to reduced surge magnitude, shorter return periods, and greater instability in glacier structure”: While a transition to surging controlled by hydrological processes would not in itself cause reduced surge magnitude (hydrologically-regulated surges are often more intense than thermally-regulated ones, for instance), I believe you are referring instead to more negative mass balance conditions and a reduced ability of the reservoir zone to build up

mass between more frequent surge events causing this decrease in surge magnitude. Please ensure to clarify this in your text.

- L606: Replace “remaining” with “maintaining”.

Figures and tables

- Figure 4: Mention how the extent of the black rectangle was determined. For example, “The two black rectangles highlight the extents of the identified glacier surges, showing where velocities increased by an order of magnitude over quiescent rates”.
- Figure 5: For easier comparisons between the four graphs, I would suggest using the same y axis value range (i.e., 0–1400 m yr^{-1}), or to at least inform the reader that the y-axis scales differ between the graphs.
- Figure 7: Elevation change data in Figure 7e look rather noisy, especially in higher elevation areas. I recommend mentioning uncertainty estimates for these results in the text.
- Figure 7: The colour bar, running from -25 m to 50 m of surface elevation change, is asymmetric. It would be better if it were around 0 (e.g., -50, -25, 0, 25, 50). This adjustment would make it easier to directly compare the intensity of elevation gains and losses through time, and would ultimately improve clarity and visual interpretation of the figure.
- Figure 8: Why did you choose to display changes in the longitude of the terminus position on the y-axis? Displaying changes in terminus position in meters or kilometers would be much easier to interpret.
- Figure 10: In line 434 of the figure caption, change “insert map” to “inset map”.
- Figure 12: This is a nice figure, but as with Figure 7 (see previous comment), it would be better to center the surface elevation change scale on 0 with the following labels: -100, -50, 0, 50, 100.

References

Benn, D. I., Fowler, A. C., Hewitt, I., & Sevestre, H. (2019). A general theory of glacier surges. *Journal of Glaciology*, *65*(253), 701–716. https://doi.org/10.1017/jog.2019.62

Kamb, B., Raymond, C. F., Harrison, W. D., Engelhardt, H., Echelmeyer, K. A., Humphrey, N., ... & Pfeffer, T. (1985). Glacier surge mechanism: 1982-1983 surge of Variegated Glacier, Alaska. *Science*, *227*(4686), 469–479. https://doi.org/10.1126/science.227.4686.469