Review of: 'Brief Communication: Mass Balance of Glaciers in the Eastern Hindu Kush from 1979 to 2002 using KH-9 Panoramic and SPOT-5 stereo imagery'

The study of Ramzan and Ghuffar presents a set of geodetic mass balance estimates for glaciers in a sub-region of the Hindu-Kush in High Mountain Asia, over the period 1979-2002. They use declassified American spy satellite imagery (acquired by the Hexagon KH-9 panoramic camera) and more contemporary SPOT-5 images to generate a pair of DEMs, from which they derive surface elevation change estimates and subsequent mass balance data. The methods they have followed to undertake these analyses are robust and follow best practice established by previous studies. Consequently, I trust that their results are robust and have captured the mass change rate of the studied glaciers accurately. Their findings are highly relevant to the journal and the field and extend our view of the multi-decadal evolution of glacier mass balance in a part of High Mountain Asia where data coverage is currently sparse.

I believe the analyses and presentation of the results could be improved. At the moment, the paper presents mass balance estimates for a subset of the local glacier population, which is considerably larger than indicated by the figures in the paper. The paper doesn't describe how or why the subset was chosen or what portion of the local glacier population it represents. The size of individual glaciers covered by the sample of mass balance data is only briefly mentioned at the end of the discussion (2-89 km^2). The characteristics of the glacier sample are important because the reader needs to know whether they can make a fair comparison between the results of this study and other studies which likely *have* generated results for glaciers of a diverse size. I would therefore encourage the authors to update their manuscript to include this information, along with a justification of why they have selected the glaciers they present results for.

Aside from this main point, there are several other areas of the manuscript where I think more clarity is needed. These are mainly related to the more concise description of the results, and I have made some suggestions about how this could be achieved below.

Abstract:

I'm missing a clear statement within the abstract which describes how these findings advance our knowledge of glacier behaviour in the region. If these are the first observations prior to the more contemporary period, I think it's worth stating so.

Introduction:

L13: I'd suggest adding a brief description of where these studies based on historical images apply to. The previous sentence cites global studies, but I believe those cited on L13 apply to HMA.

L16: Again, if this discussion is focussed on HMA, this should be emphasised.

L25: Would suggest rewording 'the melting period' to 'ablation primarily occurs'.

L26: (Scher et al., 2021) in brackets.

L33: I think ASTER (Advanced Spaceborne Thermal Emission and Reflection Radiometer) needs defining on first use. Same for Digital Elevation Model (DEM).

Fig. 1: I think all RGI7 outlines should be shown on this Figure. I think I would probably also suggest the use of true colour optical imagery as the background for the figure, which would provide more information about the different glacier types present in the study region.

L36: I think it would be useful to state the ranges of elevation change values Wang et al. (2017) measured if they are markedly more variable over shorter timeframes than the other studies cited in this section.

Data and methods:

L50: Suggest stating clearly at the beginning of this section that the KH-9 panoramic camera imagery is of significantly higher resolution than either the alternative declassified images (KH9 mapping camera) used in previous studies mentioned above – this is an improvement on previous work.

The post-processing approach applied to the derived elevation change data is consistent with previous studies and applies robust techniques to remove potential biases and anomalies stemming from area of lower image quality.

L50: A clear omission from this method section is information about the subset of glaciers that the elevation change data (and therefore mass balance) covers following post-processing. RGI7 contains many more glaciers over the study region than the authors present mass balance data for (~1500 in RGI7 over the extent of Fig.2? see below) so I feel the authors should present information on the portion and number of the local glacier population their data covers. It would also be useful for the authors to provide information and/or an illustration of the range of glacier areas that their mass balance estimates cover. If the sample of mass balance data is biased towards larger/smaller glaciers, the calculated regional mass balance signal may not reflect the mass loss rate of *all* glaciers. This should be made clear to the reader.

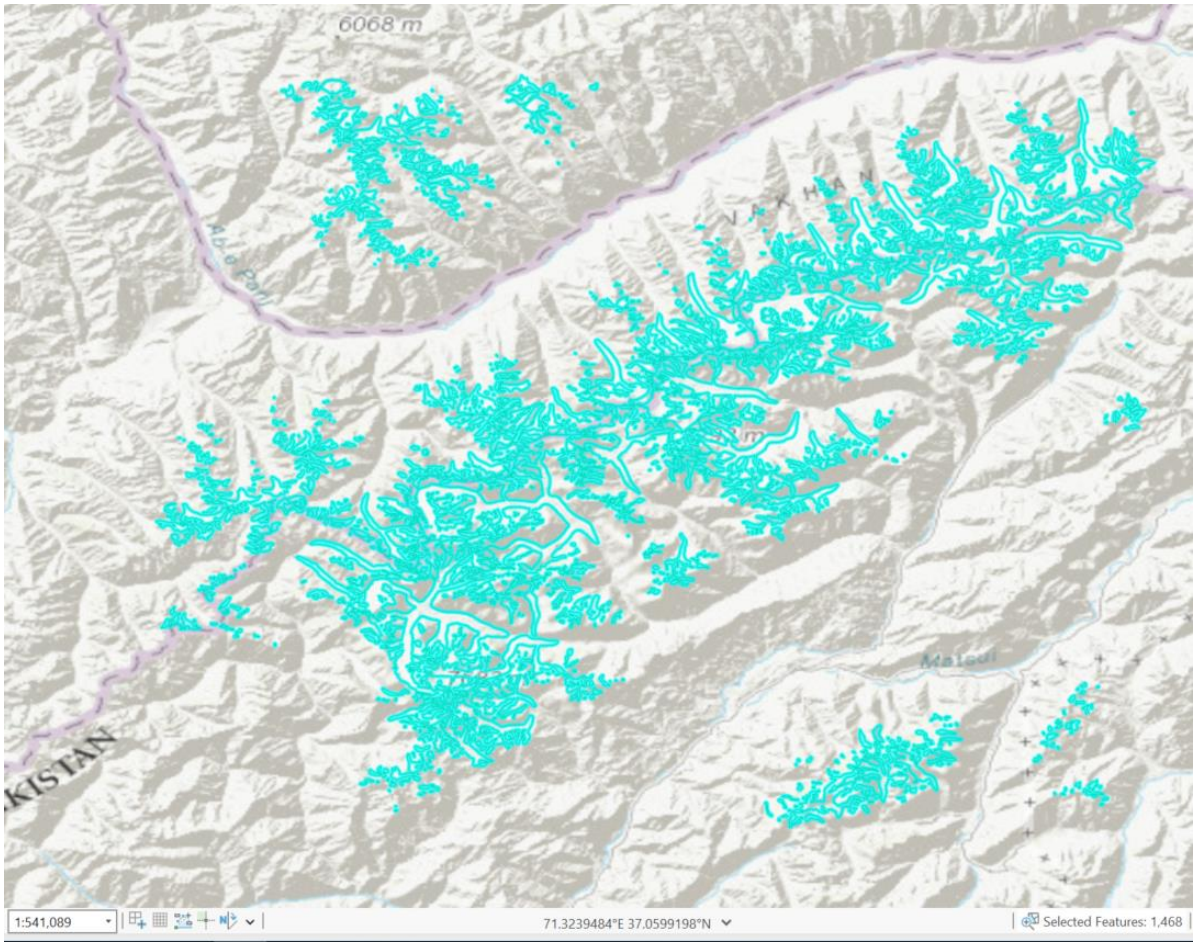

Fig.1. Subset of RGI7 approximating the extent of Fig.2 in Ramzan and Ghuffar, including 1468 glaciers.

I'd also suggest showing the full coverage of RGI7 on Figures 1 and 2, which currently suggest that glacier over in the region is fairly sparse compared to my Fig.1 above. The RGI7 outlines could be shown as thinner outlines and the glaciers for which the authors have mb data could have thicker outlines?

Fig.2: I'd really like to see elevation change data over the full extent of the figure, rather than over glacier surfaces from which the authors have derived mass balance estimates. The absence of elevation change data over stable areas (off-glacier) would illustrate the success of the methods applied, which is common practice in most geodetic studies. This is shown in the supplement (over a very large range of values) but would be useful here.

I'd also suggest tweaking the colour ramp slightly to have a broader range of values illustrating no/little change as white (+/- 0.5 m/yr perhaps?). This would help separate and illustrate the opposing signals of thinning/thickening associated with surging slightly better.

In the 4x4 grid at the bottom (b and c), I think panels III and IV could be combined to show the outlines from different time periods over the dHdT data. The two IV panels should use the same colour bar and range of values as the main panel A in my opinion, also showing off-glacier data.

Results:

L97: Would suggest just shortening this first sentence to 'During the period 1979-2002, the mean mass balance of glaciers we studied was -0.13….'

L99: More detail required here. Which post-2000 dataset did the authors use and what was the mean mass balance (with uncertainty)?

L101: Are the highest thinning and retreat rates associated with surging glaciers? If so, I'd signpost this at the start of this paragraph to clarify the point and then present your observations.

L111: I'd suggest removing this last sentence citing Sarikaya et al. (2012), I'm not sure it adds a great deal.

L112: Do they really influence the mean mass balance significantly as it is only two out of the full glacier sample (the total size of which remains unknown without discussion in the methods section). I can see how their mass balance would influence the total mass loss budget, but would only impact the mean mass balance if the sample size was very small.

L111: The paragraph from L111-L127 contains a lot of information but it's hard to place these in the context of the wider. The paragraph begins by mentioning two of the larger glaciers in the sample – are the rest of the glaciers in this paragraph also of a larger size? A sentence signposting the characteristics of the glaciers discussed in this paragraph in particular would help better understand these results (as the next paragraph does about surging glaciers).

L144: I think it's unlikely that the lower parts of Noroghikun Glacier would experience heightened ice loss in response to surge activity, when ice mass gain normally occurs over the lower parts of the glacier. I'd agree that the glacier would experience higher ice losses at low elevation *after* a surge, simply due to a large volume of ice sitting in higher temperatures.

L149: I think this sentence needs some clarification. I don't really follow 'Most of the retreating glaciers in the region are debris-free and range from slight to above 1 km2 of the retreated area.'.

Fig. 3: This is a nice figure. I think it could be presented as one row with three sub-panels. This would suite the journal format better and avoid so much white space.

Alternatively, you could add a fourth panel showing the mass balance contrast between debris-covered and debris-free glaciers?

Discussion

L165-169: I think this paragraph could be reworded to state the overarching results with more clarity. As I see it, the main points are that the results capture glacier mass loss rates over a period where observations are scarce. The results suggest that glacier mass loss rates have remained steady over at least the last 50 years in this part of the Hindu Kush, with this studies results being very similar to those of the Brun/Shean/Hugonnet studies.

As the discussion is currently rather short, the authors could tie these main points to supporting information that might show a record of climatic variability over a similar period, which could indicate why mass balance has remained relatively stable?

L171: It's not clear what 'overall moderate conditions' are to me.

L171: This is the only information I can see on the size of glaciers examined in the study. Was 2 km^2 a minimum area threshold set at the beginning of the work or is it an arbitrary number which happens to be the size of the smallest glacier with suitable data coverage?

L177: Discrepancies in glacier outlines from different sources were mentioned at the beginning of the discussion and they are again highlighted here, but I don't think I've seen a clear comparison between area change rates calculated as part of this study against those from the literature. I think the paper could be strengthened by calculating area changes rates for this earlier study period and comparing them specifically against any more contemporary results that area available. This would support the statements that are made about improving the record of glacier area change here which are currently not substantiated.

Conclusions:

I think the final line of this paragraph is another missed opportunity to place the results in the context of other studies and express how they expand our understanding. The authors state that the results are in line with those of more contemporary studies but don't describe how it indicates sustained mass loss over a considerably extended time period. I think this would be worth describing here.