

Answers to Review Comments #1 (RC... Reviewer comment, AC... Author comment)

The revised manuscript is much easier to read than the original manuscript and largely without methodological flaws that need to be corrected. I have only a couple of comments and several editorial suggestions.

Comments: On page 11 (l. 417-319), it is stated: "The reason for the large bias of the glaciological record of $-0.22 \text{ m w.e.a}^{-1}$ in regard to the geodetic record needs further investigation using a distributed mass balance model." This comment does not properly reflect the typical magnitude of the bias of conventional mass-balance measurements. Andreassen et al. (2016) reported bias in conventional mass-balance records from 16 Norwegian glaciers and found bias in the range -0.58 to $+0.52$ with respect to geodetic mass-balance estimates over several-year-long periods. Bias values exceeding 0.2 m w.e.a^{-1} in magnitude are in fact quite common judging from Andreassen's analysis. Jóhannesson et al. (2013) report bias of similar magnitude for glaciological mass-balance measurements of the Hofsjökull ice cap in Iceland. The sentence on page 11 should perhaps be replaced by something like: "The magnitude of the bias is similar to bias estimates reported by Andreassen et al. (2016) for ten glaciers in Norway and therefore as such not unexpected (see also Zemp et al., 2013)."

Thank you for that comment, that puts our findings better in the context of the relevant literature: We changed that phrase according to your suggestion.

l. 175: "and ablation and accumulation was measured at several points". you must mean "summer and winter mass balance" or "seasonal mass balance" because ablation and accumulation are typically not directly measured in glaciological mass-balance measurements.

Thank you for that comment. Yes you are right, we changed the wording accordingly.

Minor and editorial comments:

The English language and the general writing could be improved in many places.

We worked on improving the language and hope, that it has improved now. We considered all the minor and editorial comments below.

Examples:

l. 22: perhaps replace "... repeated photogrammetric surveys on 11 th - 18th August 2013 and on 28th - 31st July 2021 range from ..." with "... repeated photogrammetric surveys in August 2013 and July 2021 range from ..." (too much detail for an abstract?)

l. 24: rephrase: "A main imprint ..."

l. 26: rephrase: "when in addition to above average precipitation ..."

l. 29: rephrase: "Due to a gap in valid point observations ..." (was there no gap in the invalid observations?)

l. 31: rephrase: "which demands a thorough reanalysis ..."

l. 32: rephrase: "increases the likelihood of extreme snowfall events for individual years" perhaps simply say "increases the likelihood of extreme snowfall" ("events" adds no meaning, "extreme snowfall" tends to occur in specific years so "for individual years" also adds no meaning to this sentence)

l. 83: similarly "heavier single precipitation events" could perhaps also be replaced by "heavier precipitation"

l. 112: perhaps replace "(<https://www.foto-webcam.eu/webcam/freya1/> and <https://www.foto-webcam.eu/webcam/freya2/>) (Freya Glacier Webcam 1, 2023; Freya Glacier Webcam 2, 2023)." by "Freya Glacier Webcam 1: <https://www.foto-webcam.eu/webcam/freya1/> and Freya Glacier Webcam 2: <https://www.foto-webcam.eu/webcam/freya2/>" (and eliminate the corresponding references from the reference list; these are not proper references)

l. 146-149: perhaps replace "Georeferencing of the two final DEMs is based on all respective GCPs, a co-registration of the DEMs (Nuth and Kääb, 2011) was not carried out, as the overlapping area on stable terrain outside the glacier is too small. However the small overlapping and supposed stable area was used to calculate error statistics of the two DEMs (see supplement)." by "As the georeferencing of the two DEMs is based on a large number of GCPs, co-registration of the DEMs (Nuth and Kääb, 2011) was not needed. Elevation differences in small, overlapping stable, ice-free terrain had mean bias of ? m and RMS of ? m (see supplement)."

This list is only a few examples from a much larger set of sentences that might be improved.

References:

Jóhannesson, T., Björnsson, H., Magnússon, E., Guðmundsson, S., Pálsson, F., Sigurðsson, O., Thorsteinsson, Th., Berthier, E. (2013). Ice-volume changes, bias estimation of mass-balance measurements and changes in subglacial lakes derived by lidar mapping of the surface of Icelandic glaciers. *Annals of Glaciology*, 54(63), 63-74. doi: 10.3189/2013AoG63A422

Andreassen, L. M., Elvehøy, H., Kjøllmoen, B., and Engeset, R. V. (2016). Reanalysis of long-term series of glaciological and geodetic mass balance for 10 Norwegian glaciers. *The Cryosphere*, 10, 535–552, doi: 10.5194/tc-10-535-2016

Answers to Review Comments #2 (RC... Reviewer comment, AC... Author comment)

This review considers the revised manuscript from Bernhard Hynek et al., entitled "Accumulation by avalanches as significant contributor to the mass balance of a High Arctic mountain glacier". The authors addressed the comments from my previous review in a satisfactory way, and I thank them for the time and efforts dedicated to implementing these changes. I have only one general comment that is more a thought on this topic and can easily be addressed. All the other ones are technical.

[We again want to thank the reviewer for his constructive contribution and his time put into our manuscript!](#)

General: on the orthoimage of 2021, all the patches of snow are considered as the remnants of the 2018 avalanches. Looking at figures 10 and 11, it seems that some of these areas are affected by avalanches more or less every year. Even though it is certain that these areas were affected by the 2018 avalanches, they might have also been affected afterwards, and hence the snow is not necessarily a remnant of 2018. This reasoning can also apply to the elevation change map: if these areas are regularly affected by avalanches, they act as localized accumulation areas with a positive surface mass balance (as visible on Fig. 10 and 11 with snow remaining at the end of the ablation season). We thus expect these areas to adjust in a dynamic way, with increased surface slope that leads to locally larger mass fluxes, as shown by the surface protruding at the foot of the large couloir on the right side of the glacier tongue (already visible on the 2013 hillshade, fig. 3). I just suggest to remove the references to the remnants of the 2018 avalanches, a call them as "avalanche affected areas".

[Thank you for that comment! We fully agree and changed the wording as suggested in L 224 and in the caption of Fig. 11.](#)

[We addressed all the technical corrections and suggestions below.](#)

Technical Comments:

L23: « Somewhat surprisingly » is weird -> the average elevation change is positive and hence the MB

Citations au milieu de phrases (L65, 68)

L67: typo

L75: no need of the acronym

L94: typo -> snow depth

L104: explain the origins of the different spellings

[We added the following footnote: ¹ According to the Language Secretariat of Greenland \(Oqaasileriffik.gl\) the official name is spelled as Frejagletsjer \(formerly Frejagletcher\). While \(Ahlmann, 1946\) used Frøya Glacier, in \(Higgins, 2010\) the glacier was also spelled as Fröjabreen, Frøya Glacier and Frøya Glacier. In recent scientific literature \(e.g. Schöner et al., 2009\) the spelling Freya Glacier has been used.](#)

L109: update the reference to WGMS

L144: "afterwards" typo

L159: Huss 2013 (not "et al.")

L168: rather informal "to get a good picture of"

L169: impact of the spline function?

L170: add ref to the supplement

L171: a spatial average of what?

L175: are -> were

L192 and elsewhere: "foto" -> picture, image

L197: units

L204 "snowed in" -> familiar; "buried in snow"

L242: section title is strange. Maybe change for "Winter 2018 and avalanches"

L245-246: unclear sentence with a problem of date formatting

L258: "a"->"the"

L260: are you discussing surface mass balance, as written in the text, or elevation changes, as shown on the figure 6b

[We are discussing surface mass balance at the stakes. We clarified this by the reference "\(see stake readings in Fig 6b and Table S1\)."](#)

L312: remind the contribution of avalanches to the winter mass balance in percentage

L293-295: this is a very interesting point. I was just wondering how do you estimate the surface mass balance in the accumulation area from the spring measurements only? Do you manage to observe the previous year horizon to assess how much mass was lost during summer?

[In some years, especially when winter snow depth was low, this was done by digging down to the previous years' horizon. In some years this was not feasible due to limited time on the glacier. We recognize, that this is a limitation in the glaciological mass balance observation at Freya Glacier and will focus more on that in the future.](#)

Fig. S1: consider using another colorscale because the rainbow color scale is not appropriate for colorblind people and induces misperception of the spatial patterns

