Reply on RC1
Lea Geibel et al.

Author comment on "Rescue and homogenization of 140 years of glacier mass balance data in Switzerland" by Lea Geibel et al., Earth Syst. Sci. Data Discuss., https://doi.org/10.5194/essd-2022-56-AC1, 2022

We would like to acknowledge the reviewer for the constructive review and the helpful comments.

All reviewer comments are pasted below (in italics) and are answered. The revised text is given in quotation marks.

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Answer:
Done.

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72: "..of an extensive glacier monitoring effort/program/network".

Answer:
Thanks, done.

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73: reword “To date mass balance measurements have been performed on more than 60 individual glaciers, most are short time series with 20 glaciers having been monitored for at least three decades.”

Answer:
Thanks, done.

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127: Is it worth explaining how potential errors can be avoided/identified? “Beginning from a point of known depth such as the snowline or from a snowpit. Measuring at a consistent interval and using the average of 2 or 3 probes within 25 m (Pelto et al, 2013).

Answer:

Yes, excellent suggestion. We fully agree with both strategies suggested which have indeed been used in the context of the described series.

Revised text:

«Information from a location with known snow depth, e.g. from measurements in a snow pit, can support identifying the last year’s late-summer horizon. Furthermore, 2-3 probings within a radius of 25 m may help detecting erroneous results, and the average of the repeated measurements better accounts for the effect of local surface roughness (see e.g. Pelto et al., 2013).»

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140: Is it worth noting here, or just near line 250, that both end of the winter snowpack and end of summer snowpack density vary from point to point but have a relatively limited mean range.

Answer:

Good suggestion, done.

Revised text:

«Snow/firn density varies from point to point but generally within a relatively limited range per glacier and a given date (e.g. Machguth et al. 2006; McGrath et al. 2015; Sold et al., 2016). »

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168: How many of these were along consistent transects where the general route is known?

Answer:

This can, unfortunately, not be generally stated. At earlier times, the location of measurement sites was maintained using the angle to terrain markers, e.g. prominent peaks. As the number of individual measurements is relatively limited, one cannot speak of “transects” as such.

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250: I agree with your approach to documenting and reporting density observations as well as examination of their variation in Figure 4. In terms of the broader import of not having a density observation, is this worth more context? You note the variation in density, does this apply to just point or the mean for a glacier? For most glaciers where detailed observations exist the variation in end of winter and end of summer snowpack density is limited. Fausto et al (2018) found that on the GIS snow density within 0.1 m of the surface had an average value of 315 kgm$^{-3}$ + 44 kg m$^{-3}$. Further they found insignificant annual air temperature dependency and suggested using a constant density was likely more appropriate for modelling than modelling surface density. On alpine
glaciers density measurements for snow during the accumulation season have limited relation to elevation or snow depth (Machguth et al. 2006; McGrath et al. 2015; Sold et al. 2016). By mid-summer on temperate glaciers the density of retained accumulation has a similar behavior approaching a consistent mean value for specific glaciers and icefields that are between 550 and 600 kgm−3 across western North America (Bidlake et al. 2010; Pelto et al. 2013; Beedle et al. 2014; Pelto, et al. 2019).

Answer:

Thanks for this detailed comment. All our assessments refer to individual points, and not to the glacier-scale for which extrapolation/modelling would need to be involved, i.e. moving away from the pure data analysis presented in this paper. We agree that the spatial variations in density (both winter and annual period) are likely to be limited for given glaciers and survey dates. This is also indicated by the minor dependence of the density on terrain elevation (see Fig. 4). However, the data set is not extensive enough to provide more detailed insights on spatial density variations at the glacier scale in a more general way.

In response to this comment, we now provide some more introduction and context into the spatio-temporal variations in density along the lines suggested by the reviewer.

Revised text:

«Previous studies in different climatic settings have indicated that, for a given date, spatial variations in snow density are relatively limited at the scale of individual glaciers (Machguth et al., 2006; Beedle et al., 2014; Sold et al., 2016; Fausto et al., 2018; Pelto et al., 2019). This is true for both the end of winter and late summer. »

326: How many measurements were complemented or corrected for missing information?

Answer:

The absolute number of such individual updates/corrections to existing data sets is very limited (in the order of a few 100) but metadata were added for all entries. The sentence was somewhat misleading and has now been reformulated.

Revised text:

«they were revisited, missing information was complemented where necessary, and metadata for each entry was added.»

330: Do you have a specific example where the intermediate measurements are valuable, such as many on a specific glacier or during a specific time interval?

Answer:

Such an example is now provided.

Revised text:

«For example, several summer seasons of continuous daily ablation data are available for Rhonegletscher providing information on short-term glacier mass changes (Landmann et
370: Figure 6 is incredibly valuable. I would encourage using a mechanism to expand the lateral and vertical extent for glaciers with more than 10 years of record. Is a landscape mode for a page allowed/usable in ESSD to accommodate a particularly wide figure?

Answer:

Indeed, we did a lot of experimenting with this figure to optimally use the available space. Landscape was also tested but is not an option as the figure would then need to stretch over several pages to actually provide an enlarged visibility. We therefore need to refer the reader to the possibility to zoom in, or to directly download our data set.

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408: Indicate the timing of this transition from accumulation to ablation at these two sites.

Answer:

Done.

Revised text:

«Some long-term measurement sites have also transited from the accumulation to the ablation area between 1980 and 2000 (e.g. Clariden Lower site, Silvretta “BU”) ... »

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410: For visualization of the trends in winter and summer I suggest adding a figure or panel with all of the summer record and winter records of the glaciers in Figure 7 on the same plot. This allows seeing how similar trends are.

Answer:

We agree that such an additional figure might be valuable. However, a direct comparison (i.e. in the same panel) of point mass balance series at different elevations is difficult both in terms of clarity/visibility, as well as conceptually. This is why we have performed a dedicated analysis to analyze differences between the sites and to compare the trends. This is visualized in Figure 8. We therefore rather would like to refer the reader to that analysis and the corresponding figure (Fig. 8) for more insights into this aspect.

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429: That summer balance changes are the key has been noted in many alpine regions around the world, is that worth noting here? WGMS GGCB #4 (2021) illustrates seasonal balance for the regions with long balance records from more than a couple glaciers 3.1 (Alaska), 3.2 (Western North America), 3.7 (Scandinavia) and 3.8 (Central Europe), all show this declining summer balance trend and limited winter balance trend.

Answer:

Good suggestion. A corresponding statement has been added.
Revised text:

«The dominant role of the recent increase in ablation rates in driving accelerated glacier mass loss has also been documented on glaciers worldwide (WGMS, 2021).»

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452: Not sure why this would be expected in a snowpack that is at 0 C. There is certainly a documented evolution of density to a through mid-summer, but after that it is more about removable of thickness than any densification/refreezing processes. No need to address unless you see value in addressing based on local observations.

Answer:

This is a very valid objection against our formulation, and we agree that such a density increase at the annual scale cannot actually be expected under climate change. The statement has been reformulated correspondingly.

Revised text:

«The absence of trends indicates that climate change has not (yet) resulted in a detectable impact on the snow density on glaciers in the Alps - neither for winter, nor the annual period - although the former might be expected from higher winter temperatures.»

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492: The lack of temporal change in density and limited EOS and EOW density all argue that applying a standard density would be appropriate to substitute for in-situ observations. Could reference Sold et al. (2016) here since they had a similar result with no trends in density spatially or with altitude.

Answer:

While our results clearly indicate that for the annual scale a standard density is appropriate (and has been used in the present study), Fig. 4A and Fig. 4C show that for end-of-winter snow density the dependency on the timing (day of year) of the measurement and snow depth is significant. As this is the Conclusion section, we would like to stay general and rather would avoid providing additional references. Nevertheless, we have added a statement to emphasize this aspect.

Revised text:

«No variables explaining variations in end-of-summer snow density were detected, while end-of-winter snow density was found to depend on the timing of the observation and snow depth.»

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References: (not pasted)

Answer:

Thanks for the extensive suggestions of appropriate reference. All of them have now been included in the revised version of the manuscript.