Please find our responses to the reviewers below in blue text (reviewer 1: page 1, Reviewer N. Kirchner: page 2, commenter F. Paul: page 14). We thank the reviewers and commenter for their time and constructive suggestions!

Response to Reviewer 1:

This is a thorough, detailed and well written design and description of the new Austrian Glacier Inventory (AGI5).

I question the value of 10-25cm orthophotography for glacier mapping - one could not identify extent to this precision even if one was in situ, and with summer melt, it would change on a daily/weekly basis - these images were captured over two summers (2022-23). However this is the resolution of the available imagery !

The round robin experiment is curiously interesting but I note that the analyst variability far exceeds the image resolution.

We appreciate these positive comments, thank you! We understand the point about whether this level of detail is useful. It is indeed true that the 10-25cm imagery is simply what we have to work with. We believe there are some advantages when assessing very small-scale local features (which may not always be relevant for outline mapping) but agree that there is a point where increased image resolution no longer improves the accuracy of outline delineation.

I identify some very minor graphic issues in the otherwise excellent figures:

Figure 1: there is no need to add 0' in each graticule label - this is simply 'noise'

Figure 7: it seems inconsistent to shorten the labels on the Vanishing Glaciers to GI3,GI5 when even in the caption, they are written in full: AGI3, AGI5 etc..

Supplementary material: the scale bar divisions on figures should be standard/round numbers e.g. 50,100 rather than 40, 45, 0.45, 0.26, 70 etc.. (figures S1,2,4,5,9)

Thank you for pointing out these issues. We have adjusted the labels in Fig 1 and 7 and the scale bars in the supplement figures.

Response to review by N. Kirchner:

Comments on “On thin glacial ice: New Austrian Glacier Inventory shows accelerating glacier shrinkage and 31% area loss within two decades” by Hartl et al.

The manuscript describes a new Austrian Glacier Inventory 5 (AGI5), derived from mapping of glacier outlines based on high resolution imagery for 2021–2023. Austria’s glaciers cover 285 ± 12 km², with most being very small. A 31% area loss since the previous inventory highlights strongly accelerating shrinkage. The manuscript focuses on an important and relevant topic. However, it needs to be streamlined and many figures need at least some reworking. At present, it reads in parts lengthy and gives the appearance of a thesis or report rather than a scientific article. Detailed comments are listed below.

Thank you for your advice and the time spent on this review! We have gone through the manuscript to reduce redundancies, restructured some sections following your suggestions, and reworked the figures to save space. Please see below for responses (blue) to specific comments. We agree with most of your points and present our reasoning in the few cases where we would prefer a different approach.

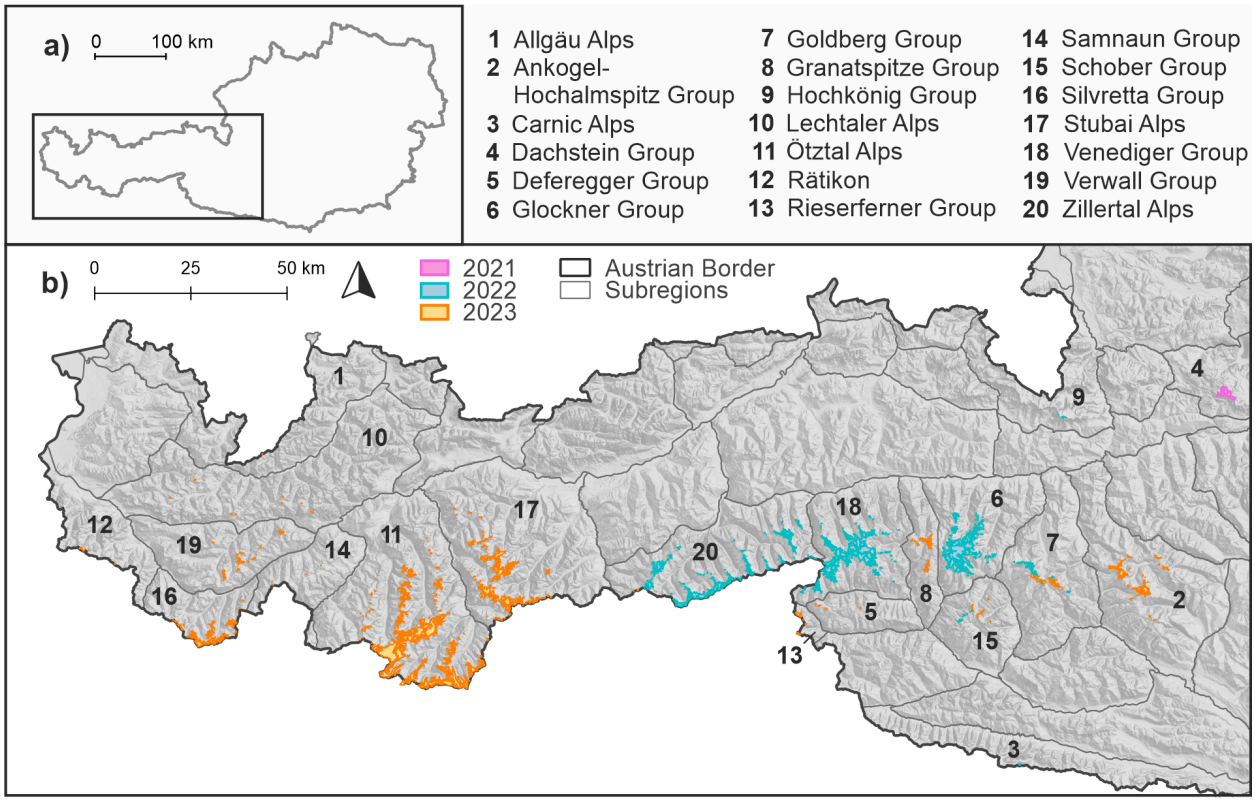
Comments

Line 56-76 (Sect. 2.1., incl Table 1) As this section contains a review of selected aspects of previous inventories and not describing methods used for AGI5, I suggest that this section is moved elsewhere – either to the Introduction (after some compaction), or to the Discussion, or to a Supplementary Information. When the current Sect. 2.1. is moved elsewhere, make sure cross-references in the text are adjusted accordingly. In lines 72 and 75, and in Table 1, specify the version(s) of RGI.

We removed the section. Some short remarks that were previously in this section were moved to the following section but we agree that most of the content was not essential. We have specified RGI 6 and 7 in Table 1.

Figure 1: As it is, Fig. 1 does not make optimal use of journal space, and the two panels (upper and lower) are lacking labels (a) and (b) or similar. The key illustration is the lower panel, which is why it should be enlarged. If context (all of Austria) is meant to be given (currently in the upper panel), I suggest that this is done by reworking what is now the upper panel into an inlet to an enlarged panel showing what is currently contained in the lower panel. The region names in the lower panel could be moved to the figure caption.

Please see the revised figure and caption below. We added panel labels and adjusted the size of both panels to focus on the main illustration. The space required is substantially reduced. We kept the region names in the figure to make it easier to identify regions at a glance without needing to refer to the caption.



[CAPTION] *a: The black box indicates the location of the 20 subregions and glacierized terrain shown in b in Austria. b: Colors indicate acquisition years of the AGI5 source data for the respective glaciers and regions. Background terrain map: Government of Austria (CC BY-SA 2.0 AU), data.bev.gv.at, region outlines: open street map data.*

Line 96/Table 2: I suggest moving Table 2 to a Supplementary Material. At its present location, it disrupts the flow and makes the manuscript unnecessarily hard to read. Also, I suggest replacing the names in the "region" column by the region numbers introduce in Fig. 1 for easier readability. In the column "Federal province", "Vorarlberg" is incorrectly splitted as "Vo-rarlberg" on three occasions, this should be corrected.
We moved T2 to the supplement, added region numbers, and checked the splitting of "Vorarlberg".

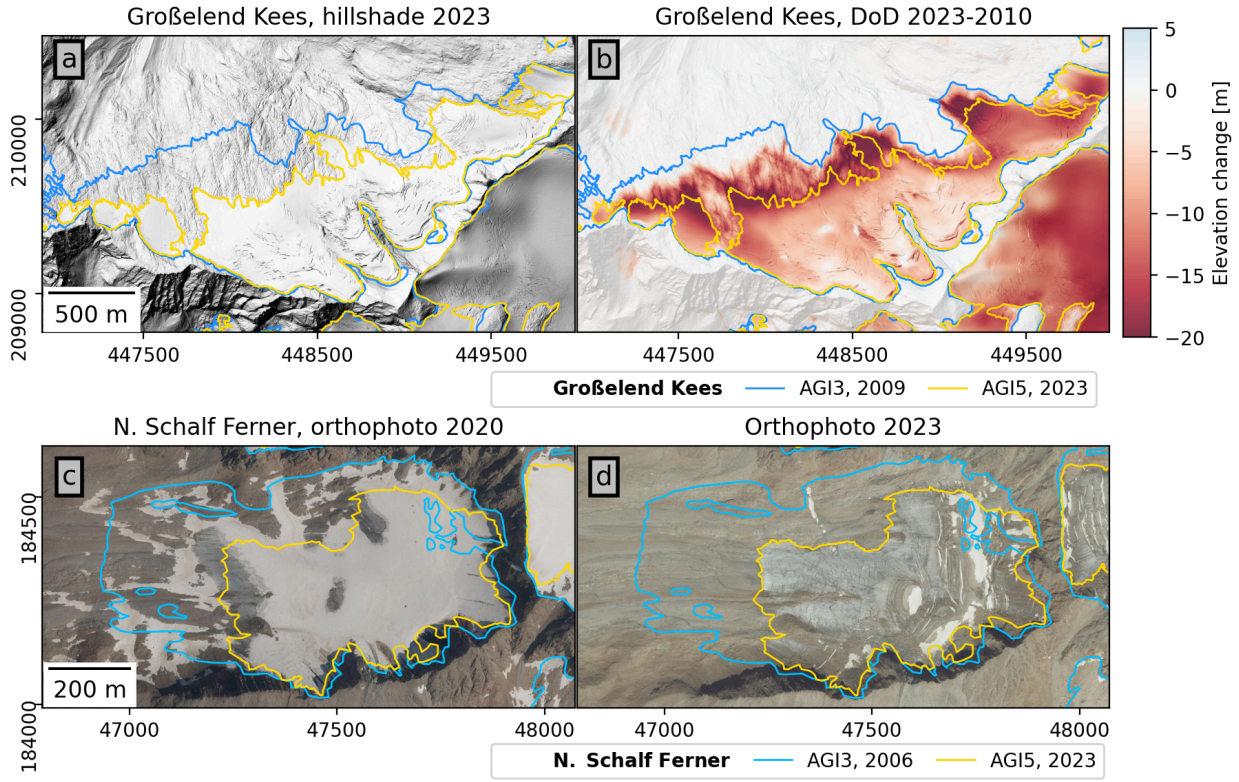
Figure 2: Fig. 2 is not publication ready. Panels b and c: add legend for outlines (as in panel a). Should the display of elevation changes in panel d be restricted to the glacier for which the AGI3 and AGGI5 outlines are presented panels a and b? The indicated large elevation changes in the lower right corner of panel d are not relevant for the figure I believe. Panels e-h: Add "Orthophoto" for consistency with panel c. Add legend explaining red stippled and purple lines to panels e-h. Add somewhere that AGI3 is for mid-2000 and add ref to what is currently Table 1 or refer to the Introduction section. This helps the reader interpret the panels more easily. Caption: Add region number (2 for Ankogel Hochalm; 11 for Ötztal). Explanations for panels g and h are missing and need to be added. Date for picture in panel e is missing (some time in 2009 based on the panel heading).

Changes applied in the revised figure:

- Reduced number of panels from 8 to 4 following the general advice to reconsider the figures and reduce the space they require. The extra panels showed additional examples of older hillshades and orthophotos, which are not really needed and can be omitted to save space.
- homogenized the line colors and legends, added outline years to legend.
- Added “orthophoto” to the panel titles for consistency
- Added reference to Table S1 in the caption (moved table to supplement)
- Added region number and fixed panel labeling and dates in caption

We would prefer to keep the elevation change visual in panel d as is. The elevation change in the lower right is simply the neighbouring glacier. The intention is to show readers an example of what the data basis used for mapping looks like and this what we were working with. We did not cut out individual glaciers and seeing elevation change of neighboring glaciers can provide helpful context while mapping.

Revised figure and caption:



[CAPTION]: a: Großelend Kees (centroid coordinates: Lon. 13.315°, Lat. 47.025°; Ankogel-Hochalmspitz Group, region 2) as seen in a hillshade generated from a 2023 DEM (September 2023; Province of Carinthia, CC BY 4.0) b) Großelend Kees elevation change 2023-2010 overlayed on the hillshade (DoD: DEM of Differences). c, d: Multitemporal orthophotos of Nördlicher Schalf Ferner (centroid coordinates: Lon. 10.956°, Lat. 46.796°; Ötztal Alps, region 11; orthophotos: 28. July 2020, 19. August 2023; Province of Tyrol; CC BY 4.0 AT).

a, b: EPSG: 31258; c, d: EPSG: 31287. Grid in meters. For additional information on data sources see Table S1 in the supplement.

Line 122: What is the reasoning behind flagging crevasses? As it is, it seems arbitrary, as one also could flag moulins for instance. Some convincing explanation is needed.
We have added the following explanation:
"In addition, the presence of visible crevasses was flagged (Tab. 2). Crevasses have been used as an indicator of past or present flow (Leigh et al., 2019) and, hence, a criterion that allows distinguishing "glaciers" from "ice bodies" as defined by Cogley (2011). AGI5 does not make such a distinction but including the crevasse flag allows users to filter the data accordingly, for example when comparing AGI5 with other datasets that do distinguish between these classes or only include glaciers that show signs of flow, such as the Swiss Glacier Inventories."

Line 123-124: Why is overlap with the Rock Glacier Inventory relevant information? This should be explained.
We have revised the sentence to include an explanation. Revised text:
"The attribute table also includes a flag indicating overlap of AGI5 with the outlines of the most recent Austrian Rock Glacier Inventory (RoGI, Wagner et al., 2020) to identify potential cases of misclassifications or ambiguous landforms."

Line 137-138: Does this mean that not only the AGI3 center-coordinate but also the AGI3 outline was kept?
We have removed the sentence. This is explained more clearly in the following list of options for treatment of vanishing features and not needed in this line.

Line 149 ff: This comment belongs to a discussion section, not the methods section. *"We acknowledge that the distinction between "vanished" and "vanishing" is not always clearcut and categorization as one or the other can depend on the data type available for mapping and the subjective interpretation of the analyst. The decision to include a "vanishing" category was based on feedback by analysts, who indicated that uncertainties in mapping the outlines of very small, debris-covered features can effectively be as large as the remaining area of said features."*
Removed here, content partially incorporated in the discussion.

Line 159-164: This comment belongs to a discussion section, not the methods section:
"In some cases, analysts found that the imagery and data used to delineate AGI5 outlines showed ice where none was mapped in prior outlines, resulting in local increases of mapped glacier area. Such increases do not represent actual glacier growth but are due to varying image quality, snow cover, and/or differences in interpretation between analysts. It is assumed that these kinds of discrepancies are inevitable given the varying quality of the source data and uncertainties inherent to the method (e.g., Kellerer-Pirklbauer et al., 2005; Fischer et al., 2014, 2021a; Strudl, 2024; Conzelmann et al., 2026). The prior outlines were not modified in these instances."

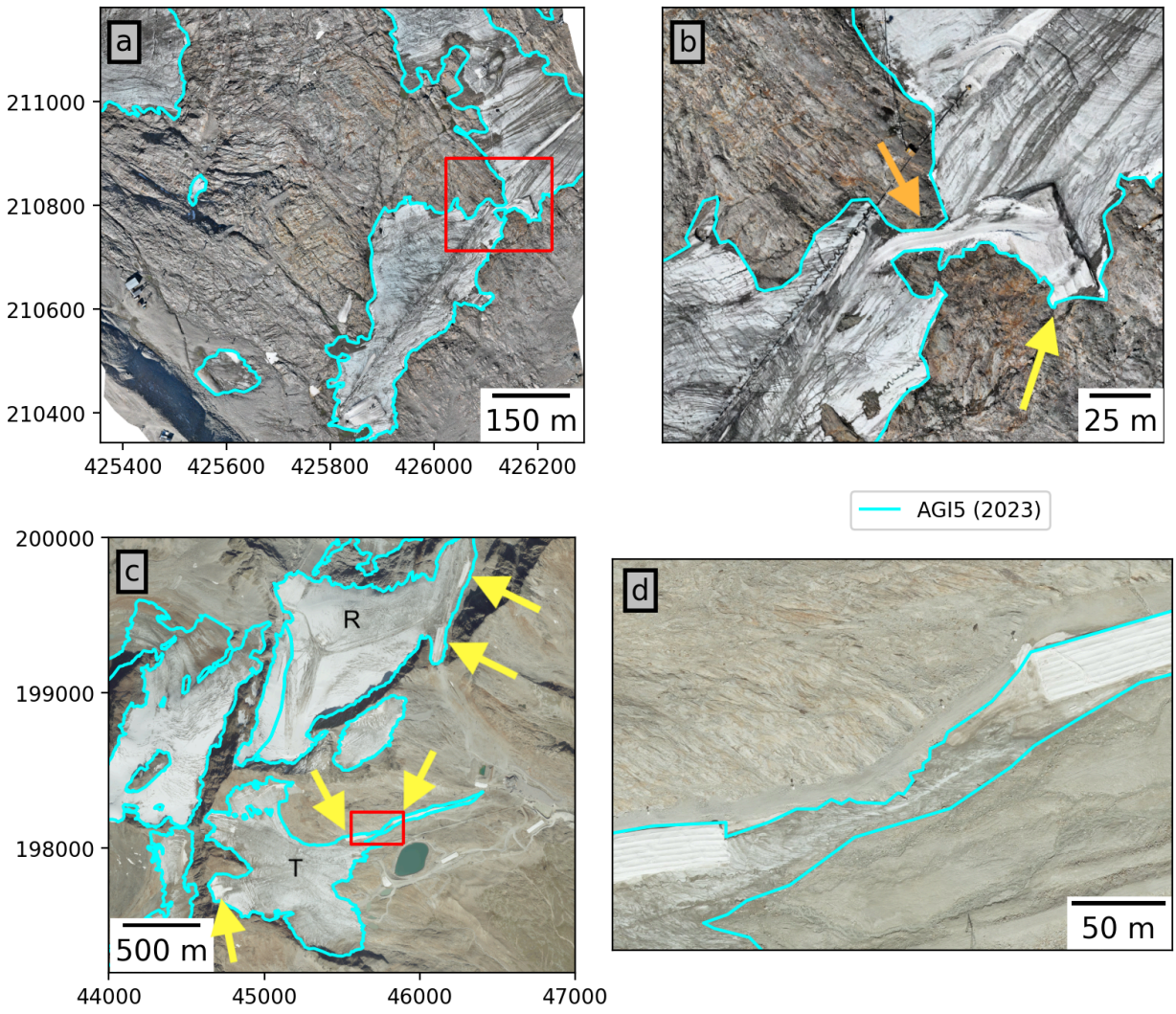
We accept that part of this is better suited for the discussion but would like to keep the information related to treatment of errors in the methods (1: errors in older outlines exist, 2: back-corrections were NOT applied). We have shortened this as follows:
"In some cases, analysts found that the imagery and data used to delineate AGI5 outlines showed ice where none was mapped in prior outlines due to varying image quality, snow cover, and/or differences in interpretation between analysts. The prior outlines were not modified in these instances."

Lines 165-168: These lines don't justify an own subsection (after the removal of lines 159-164). Find another location or consider deleting.
We removed the subsection, shortened the remaining content and incorporated it in the section "Data basis and general mapping procedure" along with the above comment on treatment of older outlines.

Figure 3: Add coordinates (as in Fig. 2 for instance) to all panels, and add which year the turquoise outlines represent (AGI5?) Remove the yellow year labels 2023 in panel c and d (multiple occasions) or explain why they are necessary. It would be helpful to indicate the reflective coverings with an arrow or similar, and distinguish between those that I believe are "counted" (I see two in panel d inside the turquoise outline) and "not counted" (I see three in panel d outside of the turquoise outline). But how can it be argued that the elongated stretches with reflective cover in panel d are connected to the glacier tongue? To me they are as disconnected as the remaining three ones outside of the outline. Also, it is hard to see the reflective covering in panel b, please provide visual aid.

- Added coordinates to panels a and c (the inset panels (b and d) seem sufficiently spatially contextualized with the red boxes, scale bars, and the coordinates in a and b and we prefer not complicating the plot with more numbers)
- added a legend for the outlines. Yes, this is AGI5.
- Removed 2023 labels
- added arrows to indicate coverings and explain arrows in the caption
- Changed the zoom level in panel d to provide a closer view of the narrow connection between the coverings. We are aware that it is debatable whether this is, or should be considered, part of the glacier. Our aim was to have a consistent approach to dealing with the coverings in the mapping process. Including all coverings still visibly connected to the rest of the glacier was the most practicable option because making decisions on a case-by-case basis or according to some criteria related to the size/volume/shape of the remaining connection seemed ultimately more subjective. Panel d is an extreme example of how this affects the shape of the outlines, which we feel is worth showing. We have expanded the explanation of this in the text, see next comment.

A zoomed in view of the connection and the revised figure are included below:



[Revised caption] a: Wurtenkees in the Goldberg Group with the Mölltaler Gletscher ski resort (Carinthia). The red box marks the subset shown in b. b: Zoomed in view of Wurtenkees; reflective coverings (yellow arrow) are applied to reduce ice melt in this sector in the vicinity of resort infrastructure. The orange arrow indicates a narrow connection between two sections of the glacier which is maintained by the resort operator through snow and ablation management measures. c: The ski resort of Sölden (Tyrol) operates infrastructure and ski runs on glacierized terrain in the central Ötztal Alps, mainly on Tiefenbach Ferner (T) and Rettenbach Ferner (R). Yellow arrows indicate coverings near the glacier margins. The red box marks the subset shown in d. d: Close-up view of reflective coverings on the terminus of Tiefenbach Ferner and a narrow band of connecting ice between the two coverings. Blue lines indicate AGI5 outlines in all panels. Background image a, b: 2023 UAV orthophoto, courtesy of Geosphere Austria. c, d: 2023 orthophoto mosaic, Province of Tyrol (CC BY 4.0 AT)

Line 174-176: This does not belong in the methods section as it gives a result and also raises a discussion item related to the mentioned “local impacts”. What are these local impacts? Is this discussed later? Elaborate or remove.

Removed phrasing about impacts and moved the area value to the results. The revised text reads:

“.... The resorts apply white reflective coverings to locally reduce melt and preserve particular patches of ice and snow relevant to resort operations (for example, to maintain lift tracks or for snow storage). Such patches of covered ice and snow were included in the outline mapping if they were connected to a remaining uncovered feature. Covered patches not connected to uncovered ice were not included. Fig. 3a and b show examples of coverings and snow management used to locally reduce ablation on Wurten Kees, Carinthia. Fig. 3c and d highlight a narrow connection between a covered remnant of the tongue of Tiefenbach Ferner, Tyrol, and the main glacier.”

In the results:

“We estimate that the area covered by visible reflective geotextiles in ski resorts amounts to <0.2% of total glacier area in Austria (that is, in the imagery used to map AGI5 outlines - the distribution of the coverings changes as they are applied and removed depending on resort operations).”

Line 178 and 186: This is confusing- the ice divides are as in AGI3 (line 178) but when they are also country borders they are as in AGI1 (line 186)? Please clarify.

Shortened and simplified this, the section now reads:

“We maintained the AGI3 ice divides in AGI5 to enable consistent area change assessments and due to the challenges associated with accurately determining the current location of the divides. The ice divides were initially defined for AGI1 and largely applied in the same way in AGI2 and AGI3. We note that the true location of the ice divides may have shifted since AGI1 due to ice losses.

Some Austrian glaciers border on neighboring glaciers in Italy. Country borders along the main chain of the Alps are generally defined based on drainage divides. That is, the country border mostly follows the ice divides in the glacierized regions of the Ötztal, Stubai, and Zillertal Alps. The main exceptions to this are Hochjoch Ferner and Niederjoch Ferner in the Ötztal Alps. Here, the country border locally deviates from the drainage divides and the glaciers extend across the border. For consistency with AGI3, we continue to include the Italian parts of the respective glaciers in AGI5.”

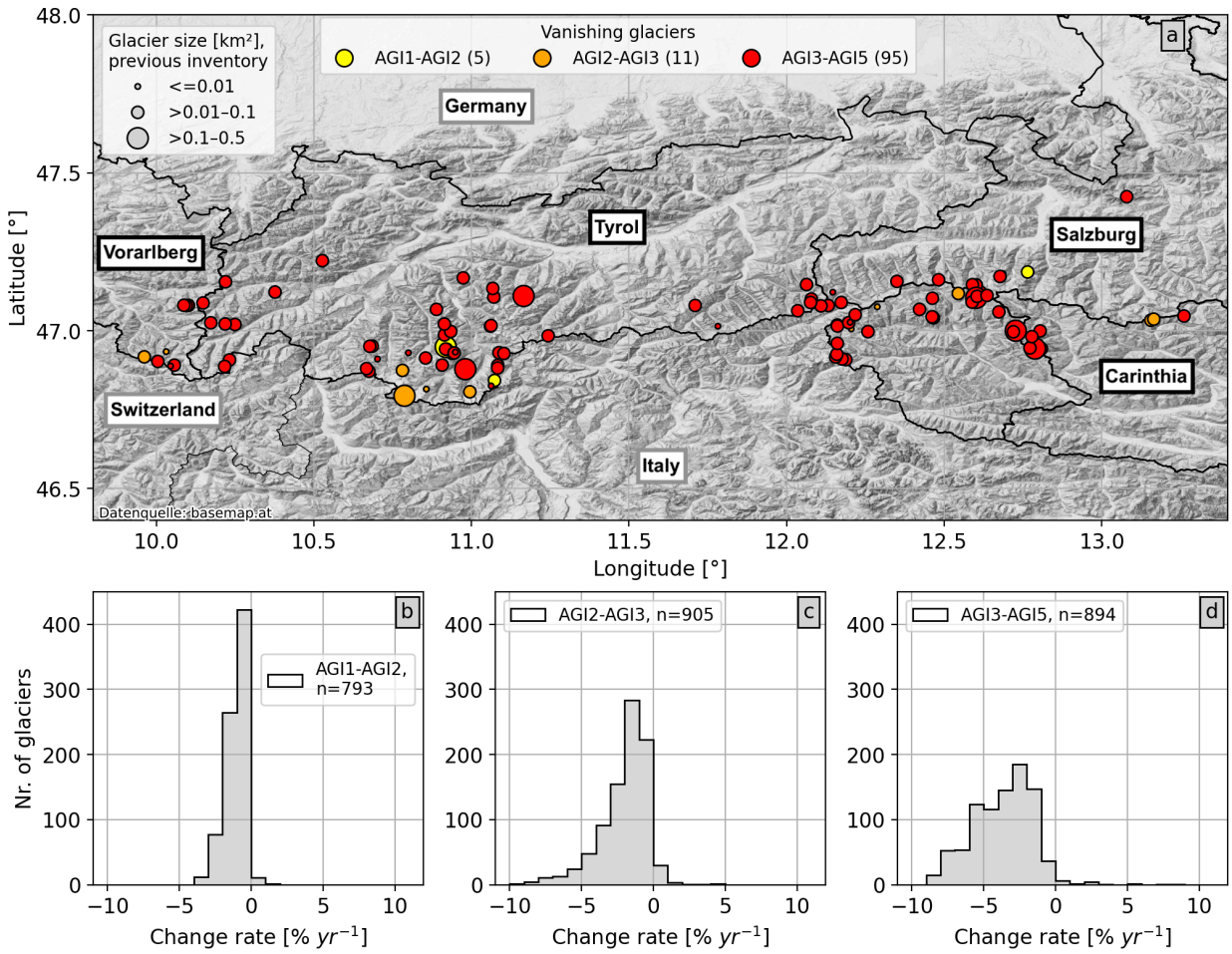
Line 253-254: “Ten glaciers are larger than 4 km2 in AGI5 and account for more than a quarter of Austria’s glacier-covered area (Fig. 4c).” This is not consistent with Fig. 4b which shows 9 glaciers in size category > 5 km2 (not 10 glaciers in a size category > 4km2). This needs to be homogenized. The ref to Fig 4c should be a ref to Fig 4b, I believe. If this is the case, then Fig 4c is not referenced in the text. Also, it appears to me that Fig 4c (glacier size) could be removed – the interesting information, glacier size change, is shown in Fig. 5a.

Fig 4c was referenced intentionally in this sentence since it shows the ten largest glaciers. Our aim is to highlight that these 10 glaciers are substantially larger than all the others and to provide an easily accessible list of names and areas for the 10 largest glaciers. We believe that

the absolute area values are of interest at least for an Austrian audience. There are ongoing discussions in Austria about which glacier is the largest one and whether this will change in the near future. We understand that international readers may not be as interested but hope this can be accepted as part of the main manuscript. If you feel strongly that it should be removed we propose adding it to the supplement.
We suggest the following revised phrasing:
"The largest size class (> 5 km2, 9 glaciers) accounts for more than a quarter of Austria's glacier covered area. Fig. 4c additionally highlights the 10 largest glaciers in Austria. The smallest glacier of this group (Schalf Ferner 4.98 km2) falls outside of the >5 km2 category by only a slight margin and is larger than all other glaciers by more than 1 km²"

Figure 4: See above. Keep panels a and b only. Add in caption that diagrams are for AGI5. Adjust caption (10 largest glaciers? 9 larges? See above). Was does the E after Taschach Ferner denote? E=East?
We would prefer to keep panel c and the 10 largest glaciers, see above. We adjusted the glacier name in the figure to spell out East.
Line 260-262: Why are crevassed glaciers considered as a specific group? See my earlier Comment.
See response to earlier comment.
Line 282-283: "the change assessment does not include the very negative melt seasons 2022 and 2023." If this sentence was kept, it needs at least to be complemented by a reference. But as it reads now the sentence implies indirectly that you suggest that area change and intense melt in 2022 and 2023 are correlated. However, such an attribution is not possible based on the data presented, and would require a more detailed analysis of climate forcing, glacier dynamics, etc. Please address.
Removed the sentence.

Figure 7: This figure is not using journal space in an optimal way (it is to a large extent the same as Fig 1). Can the vanished glaciers be incorporated in Fig 1 instead?
We propose combining Fig. 7 with elements of Fig. 8, thereby reducing the total number of figures. We would prefer not merging the vanishing glacier map with Fig 1 (overview map of study region) since 1) the former is part of the results and would be out of place in the introduction and 2) we think it would make the figure overly crowded with different types of information. Both the map of vanishing glaciers and the change rates for the three periods show that losses (of area and of entire glaciers) have accelerated over time.
Revised figure and caption:



[Caption] a: Vanishing glaciers as identified in comparisons of AGI1 and AGI2 (yellow markers), AGI2 and AGI3 (orange), and AGI3 and AGI5 (red). Marker size is scaled to glacier size categories in the respective prior inventories. Background terrain map: basemap.at. Labels indicate Austrian provinces (black border around label text) and neighbouring countries (grey border). Sources for the borders: BEV (2026), Federal Office of Topography swisstopo. b, c, d: Histograms of relative area change for AGI1-AGI2 (b), AGI2-AGI3 (c), and AGI3-AGI5 (d). The legend indicates the number (n) of glaciers assessed in each time period.

Line 305-306: The text has a ref to Fig 8b-d, but not to Fig 8a. Is that panel not needed?
We have added panel a to the supplement (with a reference in the main manuscript) and combined the other panels of Fig 8 with the previous Fig 7, see above.

Line 309-315: This is interpretation and discussion, and does not belong the results Section.
We have slightly rephrased this so it suits the results section better. We argue that the counts of positive change rates as well as the information on their cause are results since we actually checked these cases and are not speculating about this. The topic is picked up again in the discussion (section 4.1.3). Revised text:
"There are 13, 12, and 17 instances of positive change rates in the three timesteps, respectively. These are caused by differences in interpretation of outlines, imagery revealing ice that was

previously not visible, or inclusion of knowledge gained from in situ surveys (Table 4, supplementary material Section S5). For the subregions with an intermediate inventory for 2017/18, 49 of 511 glaciers show positive change rates, some of which are substantially larger than typical positive change rates associated with subjective differences in interpretation of images between analysts. These cases are primarily related to the inclusion of debris-covered areas based on local knowledge in AGI5 for glaciers in the Ötztal Alps (refer to supplementary material Section S5 for more information on this subset of glaciers).”

Figure 8: I am not sure Fig 8 is needed. Part of the info is already given in Fig 5a re the difference between AG5 and AG3. Fig 5a also has the regions (which are repeated in Fig 8), and one does not really need a time axis to understand where in time the different AGI's are placed. I suggest rethinking this figure, and perhaps combining it with Fig 5, so that figures in a final manuscript don't show redundant information. Caption: not sure about the vertical lines in panel a, seem to be missing for AG1 and AG3?
See above - we moved the previous panel a to the supplement and combined the other panels with Fig 7.

Minor comments:
Line 2: Usually, one should avoid introducing abbreviations (here: DEM) in an abstract. Check journal instructions. DEM can be introduced as an abbreviation later (eg in current line 43.
Removed “DEM” from the abstract
Line 10: “loss rate … 2-3%” This is a correct formulation which implies a change of -3%. However, after l 10 there a frequent inconsistencies, e.g. in line 280: “median area loss rates were found in the Rieserferner Group with -6.9 % yr−1”. A loss of -6.9% is a gain (because of the double minus, one inherent in “loss” and one by the use of the sign. To be consistent, you need to write “median area change rates were found in the Rieserferner Group with -6.9 % yr−1”. This applies also to formulations in Table 4 and at other occasions throughout the text (but I will not point out further occasions). On occasions, it is correct, e.g in Fig 6d where negative area change rates are plotted.
Fixed here and throughout the manuscript.
Line 58-59: Render “Refer to Table 1 for an overview of data sources and references.” a complete sentence.
We think this is a complete sentence. “Refer” is the imperative form of the verb “to refer” and we believe this to be standard usage. We are suggesting the readers should refer to the table.
Line 89: replace” GIS” by “Geographical Information System (GIS) …”
Changed.
Line 97-98: Render “Refer to Table 2 for an overview of the main data sources and acquisition years per subregion” a complete sentence.
As above, we believe this is a complete sentence. If we misunderstood what you mean, could you please clarify?
Line 102: Consider adding a ref to Fig.1 in “For the glaciers in the federal province of Vorarlberg…”
Added.

Line 104: Consider rephrasing “About 95 % of total glacier area in the study region” as “About 95 % of total Austrian glacier area” or similar. Similar in Lines 217, 236 and potentially elsewhere (I will not list further occurrences).
Changed here and throughout the manuscript.
Line 123: Replace (Tab. 3) by (Table 3)
Changed all instances of “Tab.” to “Table”
Line 145: Add “WITH” where indicated: “A glacier ID was associated with fragments that could still be mapped as well as WITH "vanishing fragments".....”..
Added as indicated.
Before line 210: Imprecise formulation, as a glacier with area 0.1 km2 can according to the text either be assigned an uncertainty of 5% or 10%. Use correct notation, eg 0.05 km2 <= glacier area < 0.1 km2: 10%, 0.1 km2 <= glacier area < 1 km2: 5%, glacier area > 1km2: 1.5%
Fixed, thanks.
Line 219-220: Render “Refer to Section 1 ...” a complete sentence, and also replace “RR glaciers” by “glaciers considered in the RR experiment” or similar.
Changed as suggested.
Line 270: Remove double %% in “...area loss rate is 3.4 % % yr−1 (Tab. 4).” Also, inconsistent use of “yr-1” (in the text) and “a-1” (eg. In Fig 6d).
Removed double %. Homogenized units to yr-1 in the Figure.
Figure 7: Legend in the panel – should it be AGI1-AGI2 instead of GI1-GI2 etc?
Yes, fixed.
Line 299: Section heading 3.4 “Area change rates over time” A rate is per definition a change over time. Rephrase, eg to Area change rates since (the LIA…..)
Changed as suggested.
Line 318: Render “Refer to…” a complete sentence (see earlier comments on the same issue)
As above.
Line 320: Table 6 is mentioned here, but appears only 3 pages later. Can some magic be done regarding the arrangement of figures and tables so that they appear closer to where they are mentioned in the text? This gets easier if (some of the) figures are re-thought regarding removal of redundant information (and therefore potentially reducing the amount of figures and/or the space they take up).
Changed the order so that the table now appears before the figures in this section. Hopefully this helps a bit.
Line 322-330: References to panels in Fig 9 are not in alphabetical order. Ref to Fig 9a should come before ref to Fig. 9b etc. Ref to Fig 9d is missing completely. Rework.
Adjusted as much as possible. Appearances are now in alphabetical order.
Figure 9: Caption: “In panel c, the AGI3 area is included for comparison...” add: and indicated by a stippled line (?)
Added line style in parentheses after “AGI3 area” in the caption.
Figure 10: Which red box is showing the zoomed in panels in b and c? Indicate in panel a. Which of b and c shows good alignment or reduced alignment? Add in caption, if both occur in both, indicate in panels.

- Added labeling for boxes to indicate the respective panels
- Added arrows to indicate good and reduced alignment

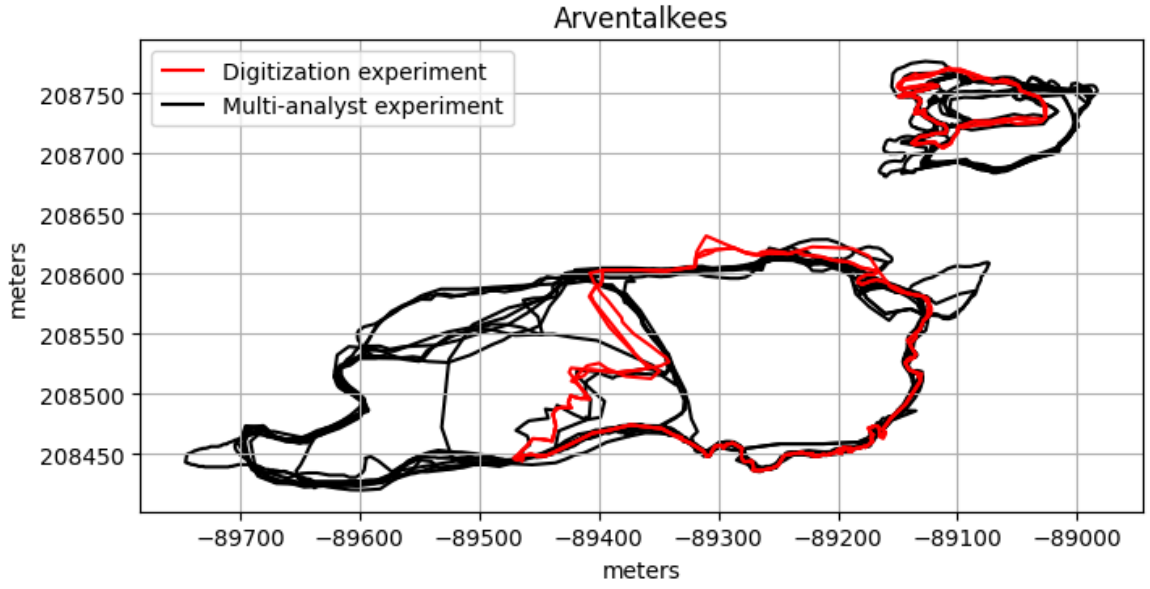
Line 338: Use “shadowed” instead of “shaded” (as eg in line 383 where, correctly, shadowed is used).
Changed as suggested.
Table 6: Use of * and ** ion column 1 confusing (for NN and Arvental) since caption only gives *.
Fixed (typo).
Line 402: Add blank between “(2026)for”
Added space.
Line 537: Correct misspelling of “recent”
Fixed.

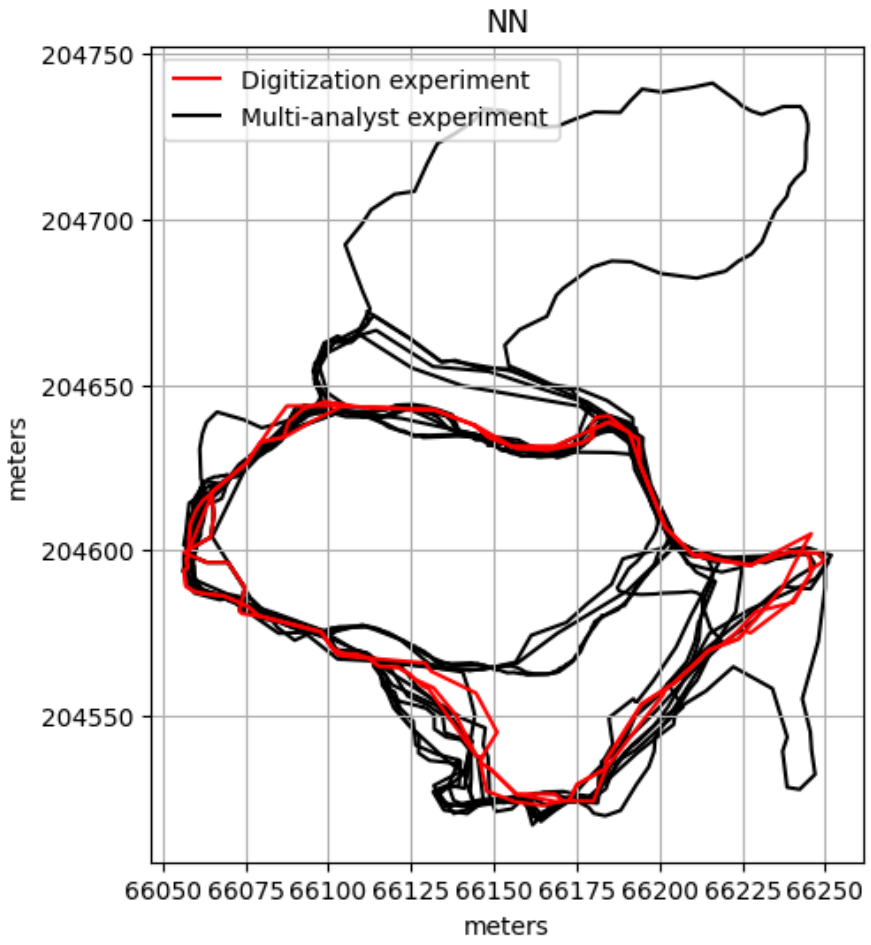
Response to comment by F. Paul:
General comments
The study by Hartl et al. is presenting the results of a new glacier inventory for Austria that has been derived by manual digitisation of orthorectified aerial photography and DEMs along with a detailed comparison to an earlier inventory for glacier-specific assessment of area changes. As the effort required to digitize glacier outlines strongly increases towards higher resolution images, the effort of the authors to create this new dataset must have been tremendous. I also acknowledge the detailed information compiled for each glacier in the attribute table. As numerous outline overlays have been provided in the paper and the suppl. Material, I do not comment on the outlines itself. I have only two larger comments related to the contents and numerous small suggestions for improving the tables and figures (see specific comments). The two larger comments are detailed below. Otherwise, great work, thank you for taking the creation of glacier inventories and the related documentation to this level!
Thank you, Frank, for your encouraging comments and taking the time to go through the manuscript!

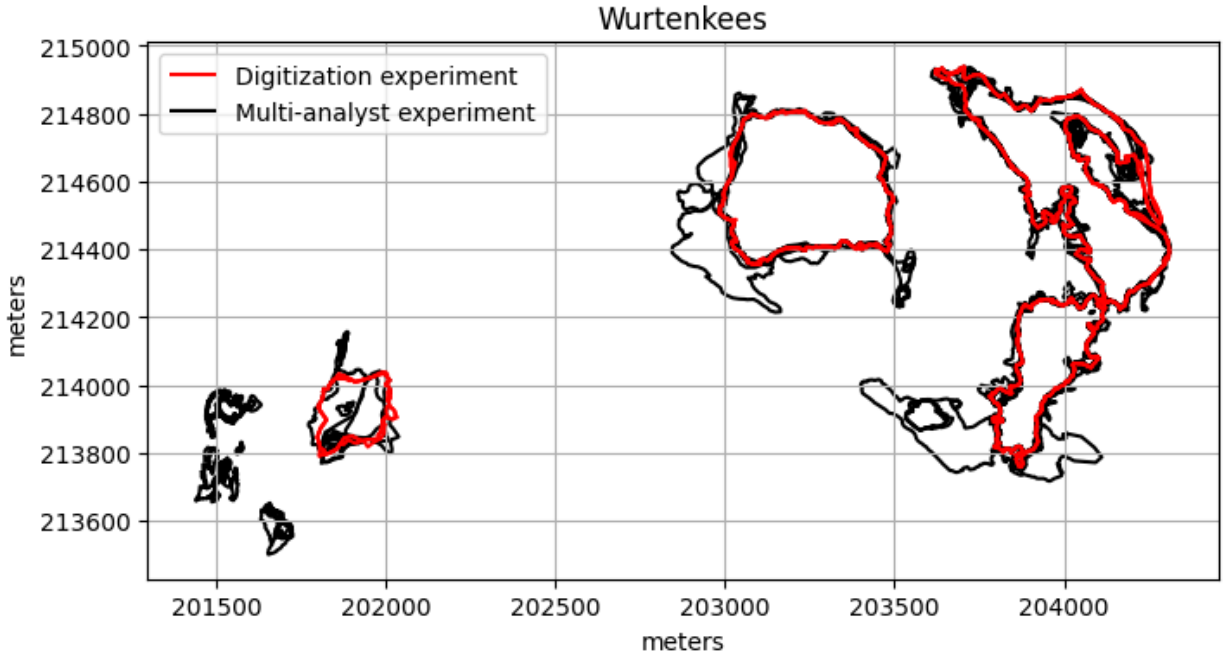
I appreciate the detailed discussion and visualization of digitizing variability by different analysts (interpretation uncertainty), yet what is missing is the digitizing uncertainty. This can be determined when the same analyst is digitizing the same glacier independently a few times. Usually this uncertainty is smaller than the interpretation uncertainty, but I think for completely manually digitized outlines it would nevertheless be insightful. I do not know if time is available, but maybe just a few of the colleagues who participated in the digitizing can do it 3 to 5 times for the six glaciers? Contrasting the resulting digitizing uncertainty (e.g. the standard deviation of the obtained areas by one analyst) with the interpretation uncertainty (from different analysts) by the values and outline overlays will likely help in interpreting the deviations across analysts.
The colleagues who participated in the digitizing were mostly volunteers who dedicated their free time to this, so we can’t ask for much more. However, following your recommendation, we carried out a smaller experiment in which one analyst mapped three of the round robin glaciers three times on different days (and with different screens). The uncertainties from this are considerably lower than the inter-analyst uncertainties, which confirms our impression from

earlier mapping and your statement above. We have added this information to the round robin section in the supplement and refer to it in the discussion section of the main manuscript:
Section 4.1.2:
"…. Aside from inter-analyst discrepancies, there is also some amount of variability in outlines mapped by the same analyst on different days (sometimes referred to as "digitization uncertainty"). In our experience, this variability is substantially lower than the inter-analyst variability and we assume it to be covered by our general uncertainty estimates (see also Section S3 in the supplement)."
Supplement:
"In addition to the inter-analyst comparison, the variability in results produced by one analyst repeatedly mapping the same glacier ("digitization uncertainty") was determined for three of the RR glaciers in a smaller experiment. One analyst mapped three glaciers (NN, Arvental Kees, Wurten Kees) three times on different days. The "digitization uncertainty" was considerably lower than the uncertainty derived from the RR-comparison for all three cases (NN: 1.9%, Arvental Kees: 0.2%, Wurten Kees: 0.3%). We therefore omit a more detailed assessment of this source of uncertainty and assume that the "digitization uncertainty" is covered by our more general uncertainty estimates."

Here are visuals for your reference, the results of the single-analyst mapping on different days are in red, the multi-analyst outlines in black:




NN
Digitization experiment
Multi-analyst experiment
204750
204700
204650
204600
204550
meters
66050 66075 66100 66125 66150 66175 66200 66225 66250
meters


Wurtenkees
Digitization experiment
Multi-analyst experiment
215000
214800
214600
214400
214200
214000
213800
213600
meters
201500 202000 202500 203000 203500 204000
meters

Whereas the issues with debris and snow cover for AGI 5 are discussed in detail, I miss a note on the impact of wrongly mapped snow in AGI 3 on area change rates. As far as I remember, the images used for it were not always optimal and due to the required consistency with previous inventories seasonal and perennial snow fields might have been included (possibly resulting in the strong area changes between 2009 and 2010 visible in Fig. 2d). As the area change rates listed in Table 4 are very high, snow fields in AGI 3 that all disappeared in 2022/23 might have an impact. As I do not know how the AGI 3 orthophotos look like, I might be wrong, but please check if this could be an explanation for the high loss rates and include a related comment in the discussion.

AGI3 was largely mapped from hillshades and other DEM derived information (DoDs). We discussed the issue you raised with colleagues who were involved in AGI3 and they are positive that both the Lidar data used to derive these DEMs and the orthoimagery used for mapping in a few regions were acquired during largely snow free, end of summer conditions (AGI3 is detailed in Fischer et al, 2015; https://doi.org/10.5194/tc-9-753-2015). We are confident that there were no widespread, systematic issues related to snow. We cannot rule out that there were some instances of snow or poor image/data quality in the AGI3 domain (AGI5 includes an image quality flag for such cases) and have added a general note in the revised discussion to highlight this.

We note that there were initial mapping limitations related to snow cover during the first data acquisitions for **AGI2**. The first AGI2 surveys had substantial cloud and snow cover in the imagery in some regions of Austria. Additional surveys were carried out at later dates for the affected regions to obtain imagery during better conditions. These later surveys formed the basis for the final AGI2 outline mapping. This is also the cause of the relatively large acquisition date range for AGI2.

New text added to revised discussion (section 4.1.4):

"The imagery and source data used for mapping of the AGI was largely acquired during favorable, mostly snow-free conditions. However, it cannot be ruled out that off-glacier seasonal snow was erroneously included in glacier outlines in some instances across the AGI time series. If these snow patches then disappear and are not included in the subsequent inventory, derived loss rates are overestimated. Due to the mostly good quality of imagery in AGI5 and based on the available information on source data of older AGI, we do not consider this to be a systematic issue in the dataset but acknowledge that the effect may be present in individual cases."

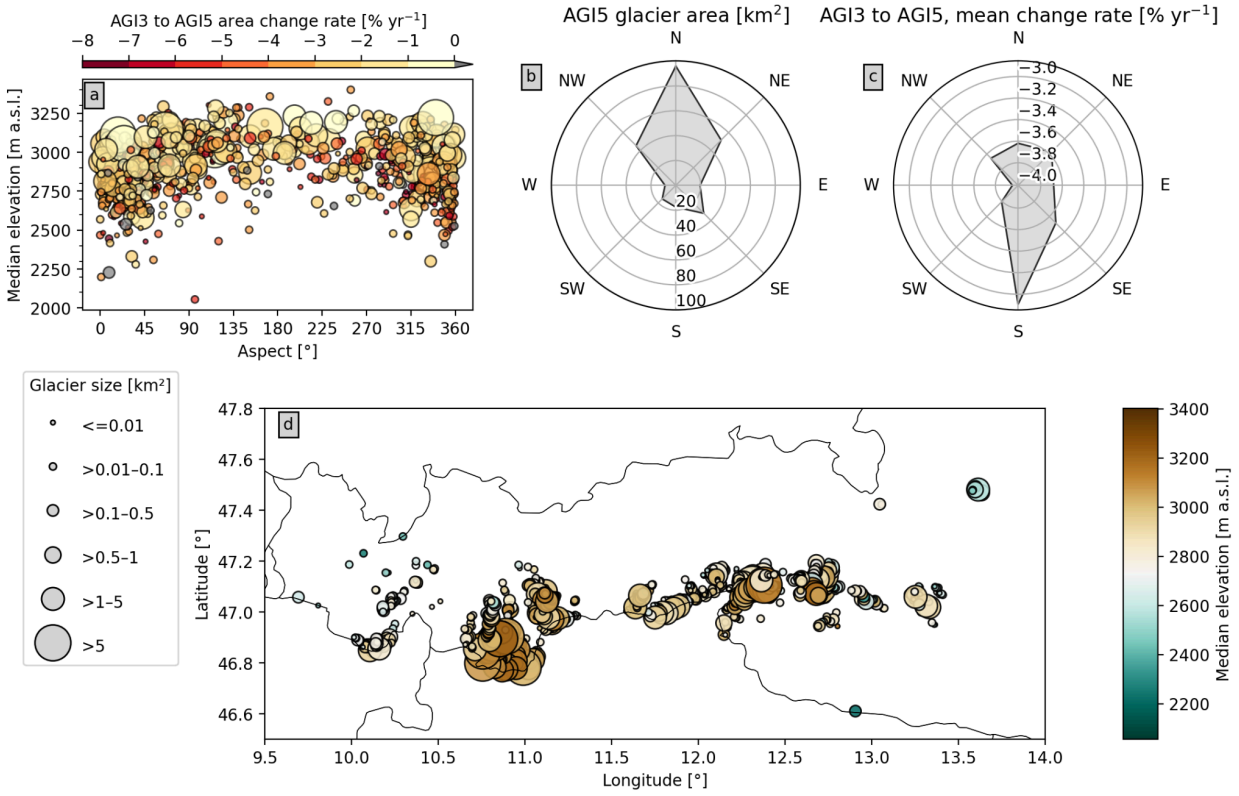
Specific comments

Comments to figures and tables

What is currently missing, but in my view also very interesting, are scatter plots showing:

- Mean aspect vs. median elevation (e.g. using differently sized and coloured circles for the size class)
- A map showing glaciers >0.1 or 0.5 km2 as filled circles that are colour-coded by median elevation (with the precipitation colour table)
- A rose diagram showing area change rates vs. aspect sector

These are all helpful suggestions, thank you. Reviewer N. Kirchner advised to reduce the number of figures in the manuscript, so we have added the multi-panel figure below to the revised supplement and reference it in the main text. (I am unsure what “precipitation colour table” means; if this is important, please clarify.)



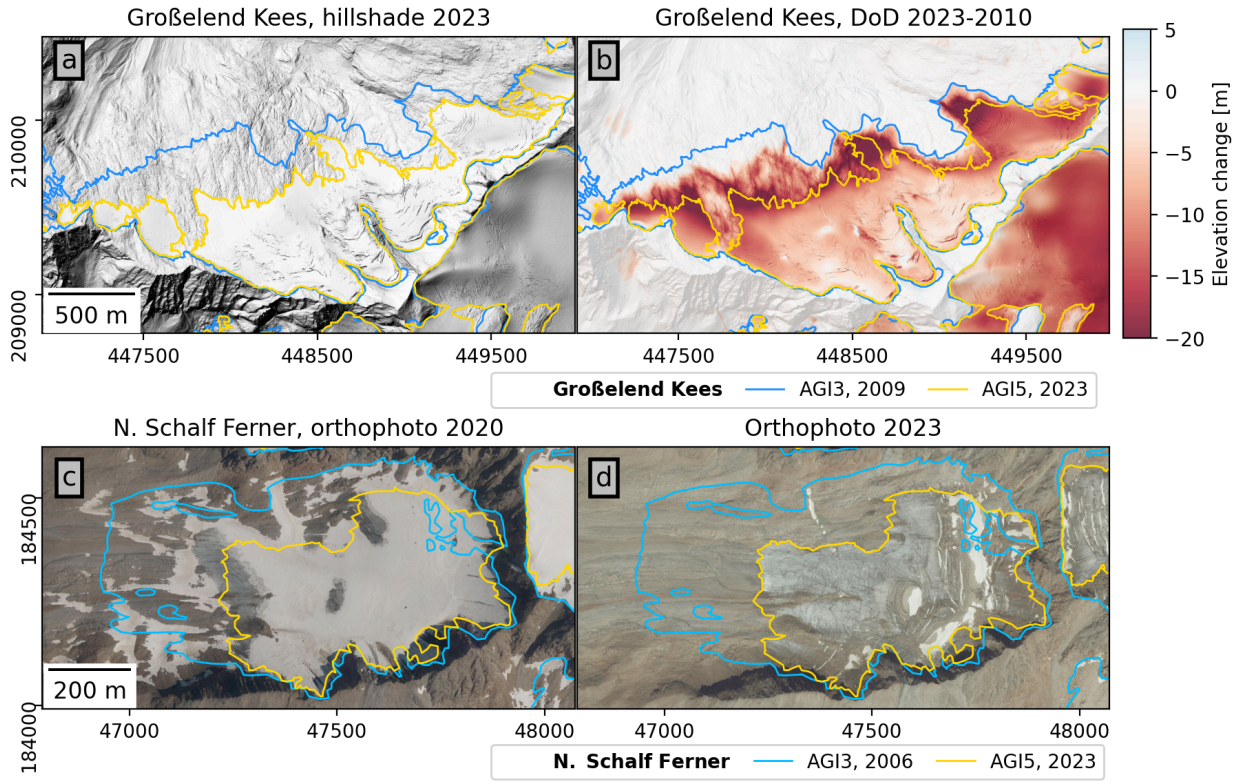
[Caption] a: AGI5 median glacier elevation against mean aspect. Marker color indicates AGI3 to AGI5 area change rates, marker size indicates AGI5 glacier size. b: Polar plot of AGI5 glacier area in 45° aspect bins. c: Polar plot of mean change rates per aspect bin. d: Markers scaled to AGI5 glacier size and centered on the glaciers' centroid coordinates. Colors indicate median glacier elevation.

Table 2:
I think this is important information, but it does not much contribute to the science. I would move the table into the supplement.
OK, moved to supplement.

Figure. 2:
All panels: Please use more different colours for the outlines of AGI 3 and 5. At this scale the dotted lines are hard to distinguish from the solid ones. For panels e) to h), please use thicker lines, they are barely visible. Panel a): Instead of using AGI 3 and AGI 5 please write to which year the outlines refer to. I assume for individual glaciers this is possible. Should the lines in the lower four panels (Schalf Ferner) have different years than the upper four, please repeat the

legend on panel e), maybe in the lower left. Legend: As the two EPSGs are difficult to translate, please add for both glaciers' approximate longitude/latitude coordinates.

- changed the colors and linewidths of the outlines to improve visibility. Note: We used this tool to check color blind suitability of the lines and they are distinguishable from the background and each other in all of the options in the simulator https://www.color-blindness.com/coblis-color-blindness-simulator/
- Added outline years to the legends
- Added centroid Lat/Lon coordinates for both example glaciers in the caption.
- We reduced the number of panels following general advice by NK to reduce the amount of space taken up by figures. The extra panels showed additional examples of older hillshades and orthophotos which are not really needed here.



[CAPTION]: a: Großelend Kees (centroid coordinates: Lon. 13.315°, Lat. 47.025°; Ankogel-Hochalmspitz Group, region 2) as seen in a hillshade generated from a 2023 DEM (September 2023; Province of Carinthia, CC BY 4.0) b) Großelend Kees elevation change 2023-2010 overlayed on the hillshade (DoD: DEM of Differences). c, d: Multitemporal orthophotos of Nördlicher Schalf Ferner (centroid coordinates: Lon. 10.956°, Lat. 46.796°; Ötztal Alps, region 11; orthophotos: 28. July 2020, 19. August 2023; Province of Tyrol; CC BY 4.0 AT). a, b: EPSG: 31258; c, d: EPSG: 31287. Grid in meters. For additional information on data sources see Table S1 in the supplement.

Table 3: Also very important, but maybe not for the science part. I suggest moving this table also to the supplemental material.

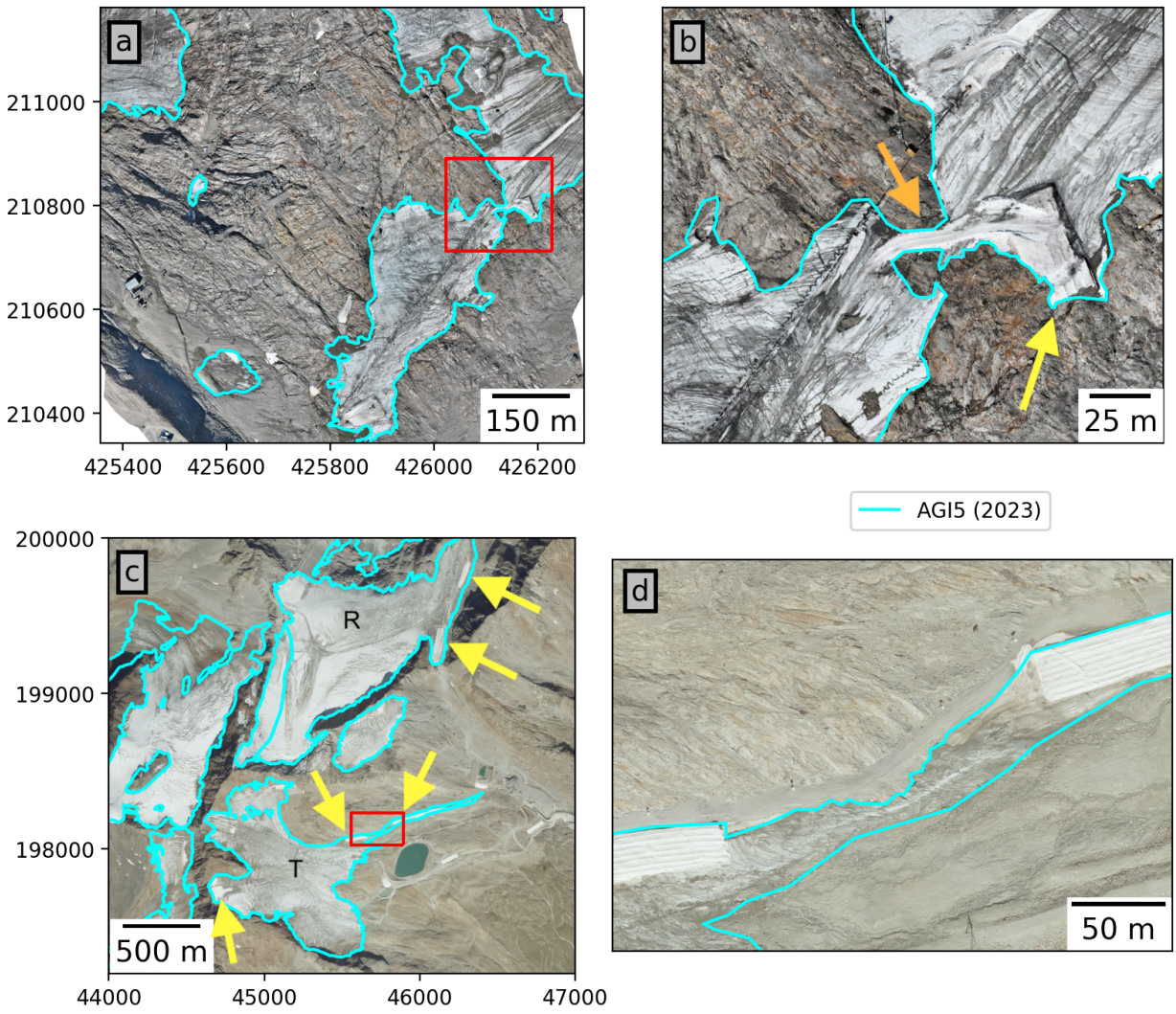
We would prefer to keep this table in the main manuscript because we frequently refer to it in the results and discussion sections where we present content related to the different categories of image quality, debris cover scores, etc, which are detailed in the table. We believe it is helpful for the readers to have the table readily accessible to understand the categories.

Figure 3: The legend for the outlines is missing. Regarding panel d, I think including the elongated ski run is a bit of a far stretch. When zooming in, it looks as if it is not connected to the glacier. But even if it is, I think it can be safely cut away as there is no active ice included here.

- Added legend.
- Added arrows to indicate coverings following comments by NK.
- Changed zoom level to show a close up of the connection between the coverings.

We are aware that it is debatable whether this "should" be considered part of the glacier. Our aim was to have a consistent approach to dealing with the coverings in the mapping process and we concluded that including all coverings still visibly connected to the rest of the glacier was the most practicable option as it avoids forcing the analysts to make case-by-case judgement calls. There are many instances of ice that is not "active" in the AGI; the covered sections are only a small fraction of this. As detailed in the manuscript, we include all ice that can be mapped and do not attempt to determine activity levels. This applies regardless of the coverings. The example of Tiefenbach Ferner is an extreme case of coverings affecting the shape of the outline, which we think is worth showing. The revised figure is below. We have also expanded the text a bit to provide further context for the figure:

".... The resorts apply white reflective coverings to locally reduce melt and preserve particular patches of ice and snow relevant to resort operations (for example, to maintain lift tracks or for snow storage). Such patches of covered ice and snow were included in the outline mapping if they were connected to a remaining uncovered feature. Covered patches not connected to uncovered ice were not included. Fig. 3a and b show examples of coverings and snow management used to locally reduce ablation on Wurten Kees, Carinthia. Fig. 3c and d highlight a narrow connection between a covered remnant of the tongue of Tiefenbach Ferner, Tyrol, and the main glacier."



[CAPTION]: a: Wurtenkees in the Goldberg Group with the Mölltaler Gletscher ski resort (Carinthia). The red box marks the subset shown in b. b: Zoomed in view of Wurtenkees; reflective coverings (yellow arrow) are applied to reduce ice melt in this sector in the vicinity of resort infrastructure. The orange arrow indicates a narrow connection between two sections of the glacier which is maintained through snow management measures. c: The ski resort of Sölden (Tyrol) operates infrastructure and ski runs on glacierized terrain in the central Ötztal Alps, mainly on Tiefenbach Ferner (T) and Rettenbach Ferner (R). Yellow arrows indicate coverings near the glacier margins. The red box marks the subset shown in d. d: Close-up view of reflective coverings on the terminus of Tiefenbach Ferner and a narrow band of connecting ice between the two coverings. Blue lines indicate AGI5 outlines in all panels. Background image a, b: 2023 UAV orthophoto, courtesy of Geosphere Austria. c, d: 2023 orthophoto mosaic, Province of Tyrol (CC BY 4.0 AT).

Figure 4: Panels a/b: Please think about the colours used for the two pie charts. They jump around but are still difficult to separate (e.g. the light blue and green). Please also consider colourblind people (no red and green in the same chart).

Panel c: Please use numbers instead of exponents for the km 2 scale (e.g. 1 instead of 100 or 10 instead of 101). I also suggest reducing the size of the filled circles a bit to better see the lines. Please also move the x-axis annotation to the bottom of the plot and show minor tick marks on both sides (please add 100 m tick marks on the y-axis). For the colours of the largest glaciers, I would use more saturated colours that change gradually rather than Random.

- Changed the colors in the pie charts.
- Reduced circle size in panel c.
- Adjusted colors of the largest glaciers to change gradually (panel c)
- Added minor tick marks at 100 m spacing (panel c)
- We would prefer to keep the legend on top of the plot to use space efficiently. We will change it if you feel strongly about this but we see no obvious benefit to moving it to the bottom of the plot.
- Similarly, we would prefer to keep the exponential notation but will change it if you feel strongly about this. Using the same tick values as on the current scale would require four decimals in “normal” notation. We assume all tick marks should have the same number of decimals, so we end up with ticks from 0.0001 to 10.0000. This seems more cumbersome than exponential notation.

Figure 5

Panels a: Please add minor tick marks to the x-axis and stretch it a bit in the x-direction. Panel b: I find it rather difficult to obtain the area change value from the colour table. I suggest using discrete values and maybe a dichromatic or spectral/rainbow colour table that is suitable for colourblind view.

- Added minor ticks to panel a
- Adjusted size of panel a to slightly stretch it in the x direction
- Changed colors in panel b to a discrete colorscale using a sequential red-orange-yellow colormap.

Figure 6

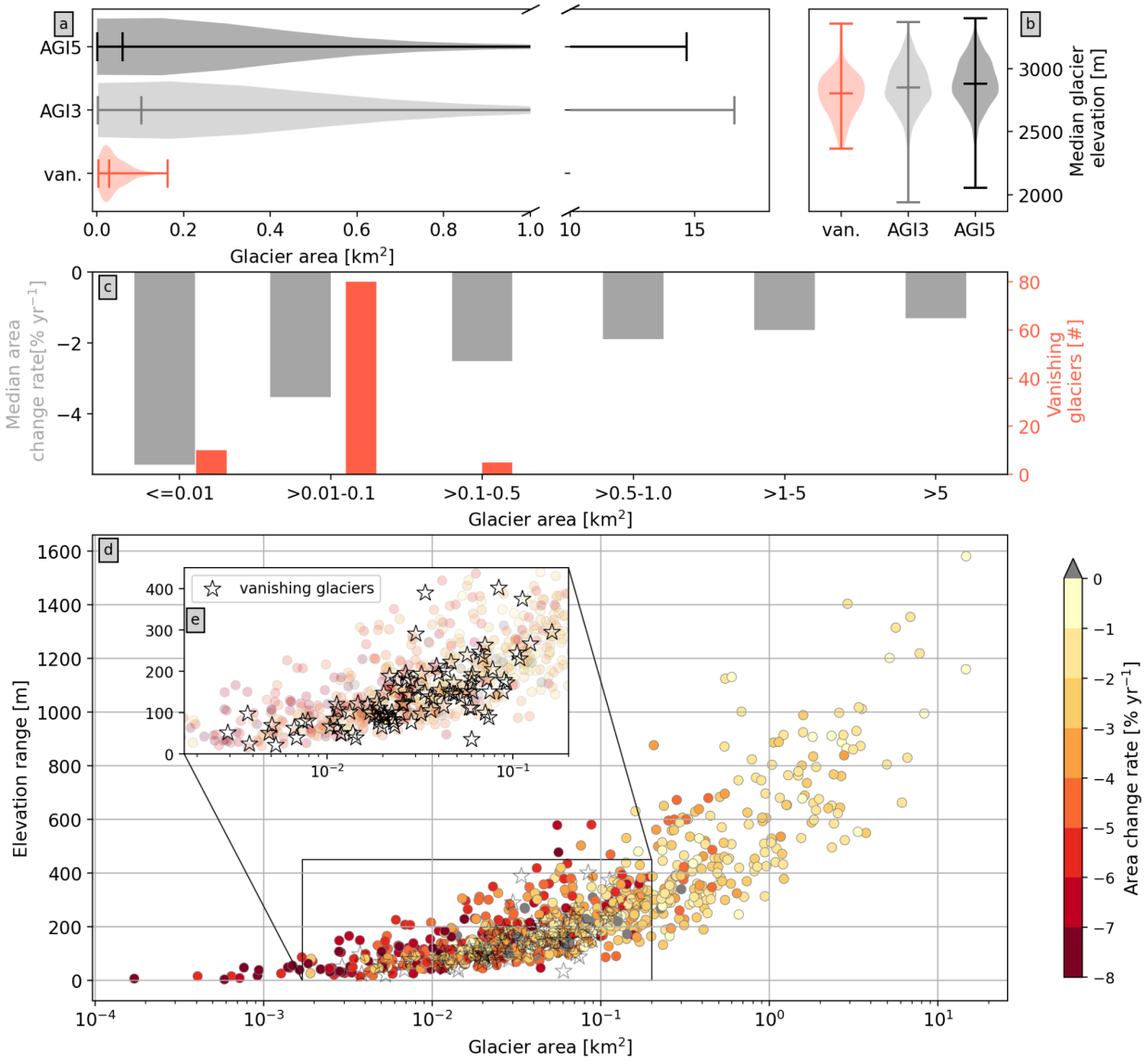
Panel c: I suggest changing the 0.01 to 0.1 size class to two size classes 0.01 to 0.05 and 0.05 to 0.1 km2. Please also provide the values (of the area change rates) in the plot or a separate table. Try to avoid on overlap with the bars for the vanished glaciers. Panel d: As for Fig. 4c, please use normal numbers instead of the exponential form for the area in km2. As the distribution against median elevation is already shown in Fig. 4c and I think there is not much to learn from it (there is no dependence with glacier size), I suggest using a more interesting parameter for the y-axis, for example elevation range. Moreover, it is quite difficult to derive area change values from the monochromatic colour table. Hence, I suggest using here relative area change for the y-axis (size for the x-axis) and elevation range for the y-axis of Fig. 4c.

The revised plot is below. Changes made:

- Moved bars in panel c to avoid overlap
- Added table of area change rates to the supplement and a reference to it in the caption of this figure. The table contains both the suggested split size class and the 0.01-0.1

value as in the figure. We would prefer to keep the size bins as they are in the figure to match the size bins we used elsewhere in the manuscript.

- For d, we changed the y axis to show elevation range and included an inset axis to highlight the vanishing glaciers and improve visibility. We adjusted the color scale for better readability (as in Fig. 5) and feel that three interesting parameters (elevation range, area, area change rate) can be included in the plot in this manner. We would prefer to keep median elevation in Fig. 4c and hope this is an acceptable compromise.
- As in Fig. 4 (see previous comment), we would prefer to keep the exponential notation on the x axis but will change it if you see a significant benefit to “normal” notation.



[CAPTION] a: Violin plots for glacier area in AGI5, AGI3, and the AGI3 area of the vanishing glaciers. b: Median glacier elevation in AGI5, AGI3, and the vanishing glaciers (AGI3 elevation). c: Median area change rates for glaciers grouped by size categories (left axis) and number of

vanishing glaciers per size category (right axis). Vanishing glaciers are grouped by size bins using their AGI3 area. These values are provided in tabular form in the supplement (Table S4.) d: Glacier elevation range (maximum - minimum elevation) plotted against glacier area (log-scale) for all AGI5 glaciers. Colors indicate area change rates. Black stars show AGI3 area and elevation of the vanishing glaciers. e: Subset of d; scale and marker transparency adjusted to highlight the vanishing glaciers.

Fig. 7: The light blue circles are hard to see against the grey background of the hillshade. You might either use a much brighter (white/yellow) or darker colour.
Changed marker colors and combined with content of previous Fig. 8 following suggestions by NK.
Fig. 8: Panel a: Please add minor tick marks on both axes.
Added minor ticks. This was moved to the supplement in response to advice by NK to reduce the number of figures.
Table 5: I suggest adding a further decimal to the area change rates in %.
Changed as suggested.
Figure 9: As we read from left to right, I would arrange 0, 1, 2, etc. in the first row and 8 to 14 in the second row. If individual analysts should be identifiable in the plot, I would not only use coloured circles but also other symbols in the plot. The x-axis legend is missing below all plots (what is shown, what is the unit)? As all glaciers have different sizes, wouldn't it be better to show relative differences?

- Removed tick marks from x-axis to avoid confusion. These are standard violin plots showing rotated kernel density functions. We have added box plots on top of the violins as additional context.
- Rearranged the legend to show the numbers row-wise.
- We would prefer to keep absolute areas in this figure to explicitly show how interpretations vary for the different selected glaciers. They vary in size and in terms of debris cover and fragmentation. Relative metrics are provided in Table 5 (note that they break down for Madlein Ferner where most analysts determined an area of zero). We believe having both absolute and relative values better contextualizes the figures in the supplement for readers interested in the details of the RR experiment.

Supplemental Material
I suggest showing Figures S1 to S7 at full page width. I suggest adding a column to Table S1 showing the size of the glacier. Please make Fig. S11 readable for (red-green) colourblind people.

- Enlarged the figures to slightly more than text width
- Added a column to the table as suggested
- Changed colors in previous Fig S11. Note that numbering has changed in the revised supplement, this is now Fig S2.