Title: **Observing glacier elevation changes from spaceborne optical and radar sensors – an inter-comparison experiment using ASTER and TanDEM-X data**

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We thank the two reviewers and the editor for their feedback on our manuscript. We revised our manuscript under consideration of their comments and suggestions, which helped to improve the clarity of our paper.

The main changes we made to the manuscript are as follows:

- We improved the method and discussion sections by clarifying the challenges for optical and radar data and the solutions implemented by the participants within their processing chain.
- Throughout the manuscript, we improved the description and clarity of the challenges of radar data, especially in mountainous areas, and the impact of radar penetration on the assessment of elevation changes.
- We adjusted Figure 4 by adding a list of all participants for each group.

We are convinced that these revisions - as detailed in the point-by-point reply below - addressed all the comments raised by reviewer 1 and the editor (based on the feedback from reviewer 2) and made our manuscript more understandable.

Point-by-point reply to reviewer comments: editor and reviewer comments are in black, and the authors' response in blue, with citations from the revised manuscript in green.

……………………………

RC2: Editor, 21 Feb 2024

We note that the anonymous reviewer 2 provided an extensive report, which lists more than 90 generically formulated points, each with a list of sub-points. Unfortunately, these points are too generic to be addressed effectively, and many of these points have already been implemented in the manuscript or are clearly beyond the scope of the study. In fact, this report reads to us as if it was produced using Artificial Intelligence assistance, which would be against EGU recommendations: https://www.egu.eu/news/1031/statement-on-the-use-of-ai-based-tools-for-the-presentation-and-publication-of-research-results-in-earth-planetary-and-space-science/

Consequently, in agreement with the Editor, we have limited the response to the points below, which are selected and further clarified by the Editor, based on the original comments from reviewer 2.

Specific comments:

Line No. 318: While the authors have indicated that details of corrections applied by each group are provided in tables S4 to S15, it would be beneficial to include a note on the lack of incorporation of seasonality corrections by many groups. Additionally, specify the buffer area chosen by each group to consider the stable area?

Response: We agree that most participants did not apply seasonal correction except for two groups (ETH and LMI). However, this depends also on the type of approaches used (e.g., pair or time series) and the selected DEMs. For example, in the case of a pair approach, where the two DEMs are very close in date to the target period but with different years, an annual correction was required rather than a seasonal correction. This was the case for the ASTER pair approach in the Hintereisferner case study. In the discussion section (lines 714-734), we explained the type and impact of the temporal correction according to the survey date.
However, in subsection 3.3.6 about temporal correction, we added a sentence summarising the main corrections used by the participants.
Line 452**:** "It is important to note that most groups did not apply seasonal corrections. However, the type of corrections applied depended on the approach used to estimate the elevation change (i.e., single pair or time series and related regression approaches) as well as the closeness of the selected DEMs to the target period when using the pair approach."

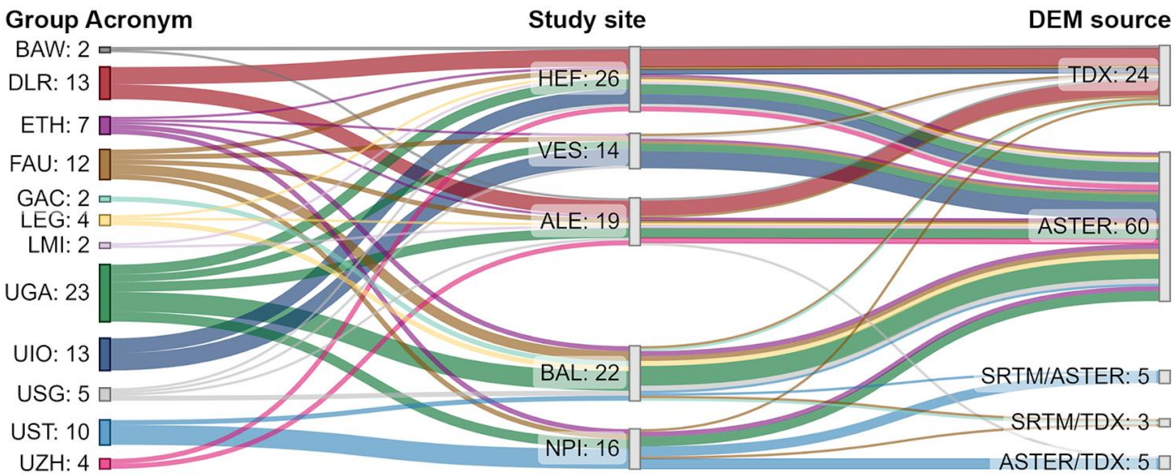
Thank you for asking about the buffer. Indeed, we mistakenly reported a buffer of the glacier outline in the DEM co-registration section, while participants only applied the buffer for the area uncertainty calculation in section 3.4. We removed the sentence about the RGI buffer (line 374).

Line no 399-401, 403, 409-410: Indicate theoretical penetration depths that has been observed from these studies, with respect to C- and X-band wavelengths. The authors do provide a good literature reference but could be improved if you could provide a quantified threshold to the depths observed on both cold and warm glacier ice and through 'snow' (tricky right?).

Response: As mentioned in the discussion section (Line 754), radar penetration is challenging and requires further research to determine its impact in different areas of interest and for different wavelengths. Setting a threshold for cold and temperate ice is difficult, as this will strongly depend on snow depth and underlying firn density/structure - and, therefore, on the climate and the relative elevation of the glacier.
According to our experiment, we observed a maximum penetration of up to 8 meters on the accumulation area of Aletsch glacier, a finding confirmed by other studies such as Leinss and Bernhard (2021) and Bannwart et al. (2023) over the same glacier. As written below, we reported the penetration depth estimates of C- and L-band from the studies by Dall et al. (2001) and Rignot et al. (2001).
Line 423: "... For TanDEM-X, the penetration depth is within a few metres, but average penetration depths of up to several metres (> 5 m) have been reported previously on Aletsch Glacier (Leinss et al., 2021; Bannwart et al., 2023) and other mountain glaciers in the Alps and High mountain Asia (Dehecq et al., 2016; Li et al., 2021) as well as the ice sheets (Abdullahi et al., 2018; Rott et al., 2021), while for the longer wavelength C-band of SRTM, even higher penetration depths can occur (Dall et al., 2001; Rignot et al., 2001). Dall et al. (2001) show that the height difference between lasers and InSAR in East Greenland changes from 0 m to a maximum of 13 m in the soaked and percolation zones, respectively. Similarly, Rignot et al. (2001) discovered that the radar penetration depth of C- and L-bands varies in different zones of Greenland (e.g., cold polar firn, exposed ice surface and marginal ice) and ranges from 1 to 15 m. For temperate glaciers in Alaska, the penetrations are between 4 and 12 m in C- and L-bands, respectively, with little dependence on snow/ice conditions. These studies highlight the challenge of establishing a radar penetration threshold for cold and temperate ice, as it depends on snow depth, underlying firn density/structure, climate, and the relative elevation of the glacier."

Figure 4 and section 3.x.x.x. – I wonder if there is a better way to show all 12 groups in the figure and in text. Readers have to refer to Supplement to know more about the groups and the members, which sometimes can be annoying. Can you provide a table in the manuscript referring to these members and groups. I know it will be cluttered but atleast useful not to check multiple documents at the same time. Think about it!

Response: We think that the Sankey diagram clearly shows how the study sites and DEM sources are connected to different groups. However, we agree that making the group members more visible is important. To address this, we included a table in Figure 4 that lists the names of the participants in each group with their main institution. Thank you for this suggestion.



Group Acronym – Main Institute	Participants	Group Acronym – Main Institute	Participants	Group Acronym – Main Institute	Participants
BAW – Bavarian Academy of Sciences and Humanities (GERMANY)	Anja Wendt	**GAC** – Gustavus Adolphus College (USA)	Laura Boehm Vock, Jeff D La Frenierre	**UIO** – University of Oslo (NORWAY)	Livia Piermattei, Désirée Treichler, Ruitang Yang, Luc Girod, Robert McNabb, Andreas Kääb
DLR – German Aerospace Center (GERMANY)	Lukas Krieger, Dana Floricioiu	**LEG** – LEGOS, Laboratoire d'Etudes en Géophysique et Océanographie Spatiales (FRANCE)	Etienne Berthier	**USG** – United States Geological Survey (USA)	Christopher McNeil, Caitlyn Florentine, Louis Sass
ETH – Eidgenössische Technische Hochschule Zürich (SWITZERLAND)	Romain Hugonnet	**LMI** – National Land Survey of Iceland (ICELAND)	Joaquín M.C. Belart	**UST** – University of St. Andrews (UK)	Tobias Bolch, Gregoire Guillet, Atanu Bhattacharya, Daniel Falaschi, Owen King, Sajid Ghuffar
FAU – Friedrich-Alexander-Universität Erlangen-Nürnberg (GERMANY)	Christian Sommer, Thorsten Seehaus, Philipp Malz, Matthias Braun	**UGA** – Université Grenoble Alpes (FRANCE)	Amaury Dehecq, Friedrich Knuth, Shashank Bhushan, David Shean, Erik Mannerfelt, Romain Hugonnet	**UZH** – University of Zurich (SWITZERLAND)	Inés Dussaillant, Michael Zemp

"Figure 4: … Sankey produced with Sankeymatic (SankeyMatic, 2023). At the bottom is the list of the participants in each group with their main institution."

The explanation for UIO-4 and UIO-5 not showing stable terrain due to their use of a time series approach based on elevation bins (Table S12) is somewhat vague. Please provide a more detailed explanation of why the time series approach they used could provide stable area changes?

Response: Thank you. We provided more details in the figure caption about the lack of stable area in the dh/dt map.
Line 531: “Note that UIO-3 and UIO-4 do not show stable terrain as they used a time series approach based on elevation bins within the glacier area (cf. Table S12).”

Line No. 684-685: The authors mentioned, "Different tools, in combination with a priori or posteriori bias corrections, were used to correct shifts, rotations, and scale effects between DEMs." To enhance clarity, elaborate on the specific bias correction methods used instead of referring to them as a priori or posteriori? Additionally, instead of writing "a few meters," specify the value of the correction factor applied for the study?

Response: Thank you for the suggestion. We agree that the sentence regarding bias correction was unclear. We have now clarified it and explained what "corresponding corrections" means. Instead of repeating the methods used by the participants, we prefer to refer to the method section regarding the co-registration and bias approaches. Additionally, we replaced the generic phrase "few metres" with a specific value, as reported below.
Line 713: “... Different co-registration tools (Sect. 3.3.3) were used to correct shifts, rotations, and scale effects between DEMs in combination with bias corrections applied before or after the co-registration to correct spatial trends and vertical deformation (Sect. 3.3.2). Figure 10 illustrates that co-registration corrections can be up to 2 metres per year and, hence, ….”

Line 704: The authors stated, "Participants have applied various void-filling techniques to calculate glacier-wide elevation changes." To improve understanding, provide examples of the techniques applied for void filling?

Response: Thank you. We prefer not to report additional details in the discussion section. Our aim here is to summarise the main factors that impact elevation change estimates and highlight which factor has the most impact according to different approaches and data. However, we added the reference to the method section where we described the solutions implemented by the participants for the void filling (line 392). In the method section, we rephrased the sentence and provided more details about the used approaches.
Line 408: “Voids in the DEM difference maps were filled by almost all groups using spatial methods such as the local or global hypsometric approach (McNabb et al., 2019). This method divides the glacier into elevation bins ranging from 20 m to 100 m intervals and assigns the average elevation change of the corresponding elevation bin to the data voids. Additional solutions included the weighted version of the local hypsometric method (ETH, Hugonnet et al., 2021), and the UIO group also applied a simple Inverse Distance Weighting interpolation.”

Line No. 765-774: Regarding glacier area, did the authors compare RGI 7 glacier data with other globally available glacier boundaries for Baltoro Glacier (Karakoram, Pakistan) and other data for High Mountain Asia, such as GAMDAM? Clarify

Response: For the inter-comparison experiment, participants were provided with the RGI6 outline of each study site and requested to provide elevation change estimates within that area. Therefore, we did not compare the results with other glacier inventories like GAMDAM Glacier Inventory as it was beyond the scope of the experiment, as reported in line 762: “In addition, there are some issues that were not covered in the present inter-comparison experiment, but that can have an important impact on geodetic glacier mass change assessments.”

We used RGI6, as stated in line 148 because at the time of the experiment, RGI7 had not yet been released. We also received estimates from the Hugonnet et al. (2021) study that relied on RGI6 within the experiment.

Line No. 775: Density conversions: It was unclear what value of density was considered for the study 900-850? Clarify.

Response: As for the glacier area changes, the issue of density conversion is not part of this experiment. However, in the discussion section 5.2, we listed and described all the factors that can affect the elevation change estimates, including the problem associated with the density conversion (line 775). So, here, we do not refer to any specific values as this section is a broad description of the issue; instead, we reported the two most commonly used values in the community for the density conversion.
To clarify, the density conversion factor of 850 kg m−3 following Huss (2013) was used in this experiment for the temporal correction of the estimates provided by the participants, using the methods developed by Zemp and Welty (2023) as reported in section 2.6 and the discussion (line 728).