**Review of "A high-resolution pan-Arctic meltwater discharge dataset from 1950 to 2021"**

by Adam Igneczi et al.

This is my second review of the manuscript by Igneczi et al. Overall, the authors well addressed my previous concerns, but some clarifications are still required. The authors can find my comments below.

Reply
Thank you for the constructive review. Please find our responses below.

**Response letter**

**Reviewer #1 L124:** I understand that the authors prefer using a binary mask retrieved from a nearest neighbor interpolation over creating a fractional mask. However, at high-resolution, binary masks may lead to large area discrepancies, notably for small glaciers and ice caps. Table 1 suggests relatively small area differences between original and downscaled MAR, but this does not imply that these areas compare well with GIMP/RGI reference masks. To address this, the authors could report in Table 1 the difference in integrated ice mask area between GIMP/RGI, and the original (5 km) and downscaled (250 m) MAR grids for each investigated region. See also my comment on Table 1 below.

Reply
Thank you for this suggestion. We agree that including the reference masks (shapefiles and 90 m resolution rasters) in the comparisons will improve confidence. We have now carried out area comparisons between the original reference masks (RGI, GIMP, Copernicus) and the converted versions (i.e. resampled to 250 m) that were used for downscaling. Overall, we find that area discrepancies remain within the ±1% range.

These discrepancies are small and would be hard to spot in Table 1. Also, they do not directly influence the downscaling procedure (i.e. as only the 250 m masks are used there, which we already compare with the MAR fractional masks).
Thus, we discuss these comparisons in Section 3.1.2, together with the data processing steps, to avoid overcomplicating Section 5.2. We have added a new table (Table 1) with all the results and discuss it in a few new sentences.

**Point comments**

My comments are based on the line numbering of the tracked-change document.

**L20-21:** As mentioned in my previous review, and to avoid being misleading, I strongly recommend clarifying that daily runoff data are spatially integrated over relevant catchments/basins, i.e., not gridded at 250 m.

Reply
Thank you for the suggestion. We agree that it is important to communicate this clearly. We have added the following clarification to the abstract: "..Coastal meltwater discharge data – i.e. spatially integrated runoff that is assigned to the outflow points of drainage basins…"

**L71-77:** Same comment here, it would be beneficial to clarify that the final data set is spatially integrated over catchments/basins.

Reply
We agree with this suggestion; we added the following amendments to the relevant section:
"…algorithms to estimate coastal surface runoff fluxes by reporting spatially integrated runoff at coastal outflow points. Bamber…"
"…available, efficiently stored – i.e. by reporting runoff that is spatially integrated over drainage basins – and covers …"

**L260-262:** From Fig. 3, it looks like large areas are locally discarded from the study based on your 90% threshold. At least, it would be interesting to give (1) insight on the discarded area fraction compared to the total area, i.e., discarded area / total area (%); (2) briefly elaborate on why spatial extrapolation is not suitable over these discarded areas, e.g., are the neighboring estimated gradients not representative/suitable enough?

Reply
The footprint of Figure 3 was chosen specifically to illustrate the effect of this step (i.e. it is one of the most strongly affected area in the Arctic).
Although spatial extrapolation is permitted (and we think it is appropriate over small distances), we wanted to strongly curtail extrapolation beyond MAR domains to provide a more robust dataset (hence the 90% threshold) and err on the side of caution. Though we concede that a lower threshold would also be appropriate.

We added the following section to the text to aid the readers in assessing the scale of this step.
"...Thus, altogether, 1.01%, 2.68%, and 3.85% of the MAR domain was discarded in Arctic Canada North, Russian Arctic, Arctic Canada South, respectively. Other regions were unaffected by this step, and the discarded area had negligible ice coverage."

**L307:** "Ice and land runoff were handled separately." Please, briefly elaborate on why doing so is important as you did in your response letter, e.g., large runoff contrast at the ice/land interface. Same comment in L351-352.

Reply
We amended the sentence to indicate the importance of considering the large runoff contract at the ice-tundra interface: " Ice and land runoff were handled separately to prevent "leakage" due to large runoff contrast at the ice-tundra interface."
". …Similar to the calculation of the vertical gradients, ice and tundra runoff were handled separately to prevent biases caused by the high runoff contrast at the ice-tundra interface. Henceforth…"

**L312-314:** Please give an example of what you mean by "elevation independent variance" as in the response letter, e.g., firn retention processes nearby the equilibrium line.

Reply
We have included a few examples at the relevant section.

**L366-367:** Are annual data gridded at 250 m? Are they part of the published data set? Please clarify.

Reply
Yes, but due to their large size (~60 GB altogether) they are not part of the published data set that we've uploaded to Pangea. We added the following clarification: "…Due to their large size, these files are not published, but they are available on request…"

**L449:** Could you explicitly write down your R2 values in the text (Fig. 8) to facilitate interpretation/comparison. It would be good to list mean bias and RMSE (model vs. measurements) in Figs. 8a-b, and report the values in the main text.

Reply
We now include RMSE and MBE on the figure. Also, we quote our own $R^2$ in the text to facilitate comparisons.

**L468-513:** I do not think that using "over or underestimate" is correct when comparing downscaled and original MAR data, as this comparison does not involve observations. Please replace "overestimate" by "is larger than" and underestimate by "is smaller than" (or equivalent) where appropriate, e.g., L468, 471, 477, 492,499, and 510.

Reply
We agree that over- and underestimation are not the precise terms to use here. We have revised this section to use more appropriate terminology.

**L479-482:** "However, this is … also need to be considered." These sentences are unclear, please reformulate. Do you mean that ice area between downscaled and original MAR does not change much except for the Russian Arctic? This is surprising, especially when comparing the ice/tundra area difference at 5 km and 250 m in, e.g., Figs. 5a-c and 6a-c in Canada and Fig. S1a-c in Greenland.

Reply
Thank you pointing out these confusing sentences.
Ice area does in fact change elsewhere, even more so than in the Russian Arctic (see Table 1). What we were trying to point out is that the change in tundra area is not reciprocal to the change in land area (x % decrease in ice area will not lead to x % increase in tundra area), and in some regions (e.g. in the Russin Arctic) tundra area decreases (slightly) while tundra runoff increases. Thus, topography needs to be considered.

Please note that ice and land runoff is shown on Fig 5a and Fig 6a where the fractional MAR mask indicates some ice/land coverage (which could be just a few % of the pixel), thus these figures should not be used to compare ice/tundra area differences. We have amended the caption to warn readers about this.

**Table 1:** This is an interesting comparison; however, I miss the difference in ice mask area between reference GIMP/RGI ice masks, and those from downscaled and original MAR for all regions. I recommend adding this information as additional columns in Table 1, and briefly report the outcome in the main text, e.g., near L479-481.

Reply
We agree that further comparisons are useful (please see our previous reply).
Overall, we find that area discrepancies between the original masks (shapefiles and 90 m rasters) and their 250 m versions are small, remaining within the ±1% range.

As these discrepancies are small, they would be hard to spot in Table 1. Thus, we discuss them explicitly in Section 3.1.2.

**L582:** What do you mean by "static", a fixed topography and ice mask in MAR? Please, clarify.

Reply
Yes, we mean time-independent forcing (e.g. a fixed ice mask). We have added examples to clarify.

**Style**

**L14-15:** I suggest "To date, meltwater discharge data at Arctic coastlines are only available from two datasets that are limited by their spatial resolution and/or coverage."

Reply
Corrected.

**L71-77:** You could split this long sentence at L75 after "1950-2021" as "… for the period 1950-2021. Our database is publicly available, efficiently stored, and covers the most important …". Do you mean "publicly available" by "easily accessible"? Please clarify.

Reply
We have split the sentence. Yes, we mean publicly available.

**L286:** "MAR variables within an 8-neighbourhood (8-N) moving window." And then in L304: "…, first, an 8-N moving window was applied …"

Reply
Thank you for noticing this. We have corrected it.

**L418 and 420:** I would recommend "5.1 Evaluation against …" and "To evaluate our product …".

Reply
Corrected.

**L464:** "specific" instead of "characteristic"?

Reply
Yes, specific is a better choice. We have switched the word.

**L 477:** "Lower ice runoff in downscaled MAR mostly stems from reduction in ice area …"

Reply
We agree that this read better. We have edited the relevant section.

**L597-598:** "… is difficult to estimate as localized in-situ runoff measurements are extremely sparse."

Reply
Thank you for the suggestion. We have edited the relevant sentence.

**L604:** "… against in-situ measurements collected in the field, and found that …"

Reply
Corrected.

**L615:** "… but not in terms of predictive performance …"

Reply
Corrected.

**L641:** "For instance, the duration of buffered …"

Reply
Corrected.

**Figures**

**Fig. 9** caption in L476 "… for (a) ice and (b) land areas …"

Reply
Thank you for spotting this. Corrected.

**Supplement**

**Fig. S2** caption: "However, it is important to note that the edges of the integrated basins were …", and "one third of the aggregated …"

Reply
We revised this section.

**Fig. S4** supplement text: What do you mean by "We propose that this is due to the topographical configuration of the ice coverage"? This is vague, please clarify.

Reply
We added a short explanation to briefly outline the idea before discussing the details "..i.e. the predominant type and geometry of ice bodies (e.g. valley glaciers versus ice caps)…"

**Fig. S5:** "COP-250 DEM is lower than MAR DEM towards lower elevations and vice versa." From the graphs, it looks like the opposite, i.e., positive values in lower areas (COP-250 >

MAR) and negative values higher up (COP-250 < MAR). Please verify this carefully here, in Fig. S4 and in the main text when referring to these Figures.

Reply
We revised the section to better reflect the figure. Previously we were referring to Svalbard and the Russian Arctic (where COP-250 DEM is lower than MAR at low elevations).
Now we include a more comprehensive discussion to cover regions where the situation mentioned in the comment is more typical (e.g. Canada North, Canada South).

**Fig. S6** supplement text: In the last line of the paragraph, do you mean "more intensive runoff per unit area"?

Reply
Yes, we corrected this.