Responses to Reviewers' Comments for Manuscript
EGUSPHERE-2025-2516

Greenland Monthly Accumulation Maps (1960-2022): A Statistical Semi-Empirical Bias-Adjustment Model

Addressed Comments for Publication to

The Cryosphere

by

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The study presents a statistical model reconstruction for bias-corrected gridded regional model (e.g., HIRHAM and RACMO) and reanalysis model (CARRA) accumulation fields for the Greenland Ice Sheet (GrIS). The authors use an empirical orthogonal function (EOF) approach to reduce the model accumulation fields into primary spatial modes. Thereafter, the means, climatologies, EOFs and corresponding principal components (PCs) are adjusted through a set of coefficients that attempt to minimize the differences between modeled accumulation and SUMup in situ observations across the GrIS. Prior to adjustment, RACMO is shown to have the smallest absolute monthly mean accumulation biases, followed by HIRHAM and CARRA, but all accumulation zone and ice sheet-wide maps' biases are reduced, especially in RACMO, after the adjustment takes place. It is interesting to note that post-adjustment, the biases of the highest resolution product, CARRA at 2.5 km, are not reduced further. The authors' posit this may be due to such limited observations within these small gridbox areas.

The paper mainly showcases the statistical techniques and insights the render more accurate annual and seasonal accumulation maps and trends versus those produced with the native, unadjusted regional model/reanalysis outputs. This work may represent a significant advance toward understanding and developing Arctic/Antarctic accumulation maps going forward.

The paper is nicely written, and results are by and large clearly presented. Several of my comments, however, are along the lines of structural changes where disentangling the tandem pairing of methods with or immediately followed by results is warranted. **A more clear outline of the paper's sections toward the end of the Introduction, followed by distinct separation of methods from results would improve the flow and readability of the manuscript.** Further comments are noted by line (L) number below. In summary, these collectively constitute at least minor revision.

AC: Thank you for your helpful comments and interest in our paper.

We agree the manuscript would benefit from a clearer outline of the paper's structure and a better separation of methods from results.

We will revise the end of the introduction to provide a clearer outline of the paper's structure, and address the distinction of methods and results as suggested in your specific comments.

Major (Technical suggestions)

General comment: While each regional model is shown for their respective dataset start years to 2022, what about also showing maps for consistent periods (i.e., the CARRA record), 1991-2022 for more direct comparison of seasonal patterns and trends? This could complement Table 3.

AC: To reduce the number of figures in the main text, the maps for 1991-2022 were provided in the appendix – '*Spatial patterns are shown here for HIRHAM (1960-2022), RACMO (1980-2022) and CARRA (1991-2022), and periods of overlap are provided in the appendix, Fig. A1'*. However, we agree the overlap period should be highlighted more clearly.

In the revised manuscript we will carefully consider whether to show the 1991-2022 overlap in the main text and provide the full model periods in the appendix instead.

Minor (Typographical/Structural suggestions)

L83: leavingàleave
AC: corrected

L95-104: This content seems like more methods and initial results than introductory material, particularly in the description of the number of principal components retained and their explained variance.

AC: We agree this interrupts the flow of the introduction and such details should be reserved for the methods section.

In the revised manuscript we will condense this and relocate more detailed information about the number of PCs and their explained variance to the methods section.

L138: What is meant by "is merged with" – please clarify.

AC: Thank you for the suggestion, we agree this is ambiguous.

We will clarify the wording to make the relationship between the variables more explicit in the revised manuscript.

L156-166: This comparison of RACMO P-E and SMB against SUMup precedes introduction of the SUMup data. These results should be given after SUMup is described in detail in 2.3 or as initial results within the Results section.

AC: Thank you for your comment. In response to Reviewer 2's feedback regarding snow erosion being substantial in parts of the ice-sheet, we will use SMB minus runoff rather than P-E, and so this discussion will be removed.

In the revised manuscript this discussion will be removed.

L189: some time à sometimes
AC: Corrected

L193: subject-verb agreement here needs corrected to the "pre-summer/post-summer end dates are"
AC: Corrected

L328: Why use HadCRUT5 versus another global temperature dataset such as Berkeley Earth or GISTEMP? A brief note justifying use and acknowledging shortcomings of this product is warranted here.

AC: Thank you for this comment. The three NH temperature reconstructions are very similar in the period considered in this study (post-1960), and we do not believe this choice has any impact on our conclusions.

We will perform a test to verify that our conclusions are robust to this choice. We will also include a brief justification for our choice of HadCRUT5 in the revised manuscript.

L523: overestimatesàoverestimate
AC: Corrected

L623-630: Seems like these large-scale climatic dataset descriptions should go in the data section, then a results subsection could be framed around climate relationships to the PCs.

AC: We agree that the descriptions of the large-scale climate datasets are more appropriately placed in the data section. However, to reduce the length of the manuscript, we will consider cutting or moving the discussion of the PC correlations to supplementary material in the revised version.

We will consider whether to remove or relocate the analysis of the PC correlations to supplementary material. If retained in the main text, we will introduce the large-scale climatic datasets in the data section and move the PC correlation table (Figure 8) to the results section after Figure 3 (bias-adjustment coefficients), with corresponding revisions to the text.

L649-650: "This is particularly relevant near the coast, where sea ice variability is known to strongly affect snowfall." A citation to previous work is needed here at the conclusion of the sentence.

AC: Thank you for the suggestion. We agree that adding relevant citations will strengthen this statement. These could include Shahi et al. (2023), who highlight how changes in sea ice impact local climate and SMB through temperature and snowfall effects in Northeast Greenland, and Kopec et al. (2016) who present observational evidence for the response of precipitation to sea ice reduction in the Arctic. However, to reduce the length of the manuscript, we will consider cutting or moving the discussion of the PC correlations to supplementary material in the revised version.

We will consider whether to remove or relocate the analysis of the PC correlations to supplementary material. If retained in the main text, we will add relevant citations to support this statement regarding the influence of sea-ice variability on coastal snowfall.