Review report

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Full Title: Smoothed monthly Greenland ice sheet elevation changes during 2003-2023

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Submitted to ***Earth System Science Data***

Recommendation: Major/Moderate revision

Overall Evaluation

This manuscript presents a comprehensive analysis of Greenland Ice Sheet elevation changes from 2003 to 2023, integrating multiple satellite and airborne altimetry datasets. The methodology demonstrates considerable rigor in data processing and uncertainty assessment, particularly in combining diverse data sources to produce a consistent long-term record. The approach to data integration and uncertainty quantification shows careful attention to detail. However, several aspects of the analysis require additional clarification and enhancement to strengthen the scientific contribution of this work. These concerns primarily relate to the physical basis of the seasonal model, methodology justification, and validation approaches.

Major Scientific Concerns and Suggested Improvements

Seasonal Signal Modeling and Physical Basis

The seasonal signal modeling presented in Section 3.2 (pages 7-8) requires substantial revision. The authors propose a new seasonal model in equation (4) that assumes 8 months of mass gain and 4 months of mass loss. While Figure 5 illustrates this seasonal pattern, the physical basis for this temporal distribution needs more rigorous justification. Specifically, the manuscript should explain how this seasonal pattern relates to known atmospheric circulation patterns and seasonal precipitation variability across Greenland. The relationship with regional climate dynamics, including the influence of the North Atlantic Oscillation on seasonal mass balance patterns, should be addressed. The authors should also demonstrate why their model performs better than the conventional cosine function described in equation (5), particularly in capturing the asymmetric nature of accumulation and ablation processes.

Methodology and Parameter Selection

The methodology section (Section 3.2-3.4) should better justify key analytical choices. The use of a 7th-order polynomial for fitting elevation changes (equation 2, page 7) lacks sufficient justification. The authors should demonstrate why this order is optimal by comparing residuals across different polynomial orders and discussing potential overfitting issues. A systematic analysis of model performance with different polynomial orders would strengthen this choice. Additionally, the kriging interpolation parameters described on page 17 (lines 334-335) need more detailed explanation, particularly regarding the choice of the 65 km range parameter. The spatial correlation structure of elevation changes and its influence on interpolation parameters should be more thoroughly discussed.

Validation and Comparison

The validation approach presented in Section 5 (pages 20-23) should be expanded. While the comparison with GRACE data and the Input-Output method provides valuable insight, the analysis should include:

- Quantitative metrics for agreement between different methods, including correlation coefficients and root-mean-square differences
- Analysis of spatial patterns in the differences between methods, particularly in regions with complex topography
- Discussion of temporal variations in the agreement between different approaches, especially during periods of rapid change
- Assessment of seasonal cycle differences between methods and their implications for mass balance estimates

Discussion and Implications

The discussion section (Section 6, pages 24-25) should be expanded to address methodological limitations more comprehensively. The authors should discuss:

- The implications of combining data from sensors with different spatial footprints, particularly for capturing small-scale elevation changes
- The challenges in detecting rapid elevation changes and their impact on mass balance estimates
- The potential impact of these limitations on ice sheet modeling applications, especially for initialization and validation
- Future improvements that could address current limitations, including upcoming satellite missions and methodological advances
- The broader implications for understanding ice sheet response to climate change

Technical Corrections and Presentation

Figures and Visualization

Several figures require improvement:

- Figure 5 (page 8): Add more detailed axis labels and improve legend readability, and if possible, include error bounds on the seasonal signals to better represent uncertainty in the temporal patterns
- Figures 13-14 (pages 20-21): Consider adding difference maps to better illustrate spatial patterns and include quantitative measures of uncertainty in the spatial comparisons

Recommendation

Major/Moderate Revision. The manuscript requires substantial revisions before it can be considered for publication. The authors should:

1. Provide a thorough physical justification for their seasonal model, including regional analysis and

comparison with known climate patterns

2. Strengthen the methodology section with quantitative justification for key parameter choices
3. Expand the validation analysis with comprehensive statistical metrics and spatial comparisons
4. Enhance the discussion of limitations and implications

These revisions are essential to ensure that this valuable dataset can be effectively utilized by the broader scientific community. Upon addressing these concerns, this work will make a significant contribution to our understanding of Greenland Ice Sheet mass changes and provide an important resource for future research in glaciology and climate science.