Response to Reviewers – second review

Reviewer 1:

The authors improved the manuscript significantly. That said, I still find it a bit odd that so much emphasis is placed on the comparison of the dSEC with the three AWS stations by figures and text. The significance of this comparison remains to be limited, as it is unclear why the author consider these three stations to be representative for the whole dSEC product. Overall, though, I very much appreciate the use of these independent observations. To further improve the manuscript, I suggest either conducting the comparison with more AWS stations. Or you could give the comparison with the three AWS less weight and move it partly to the supplement/appendix. The spatio-temporal product intercomparison could instead be expanded upon in greater detail in the main text. Table 3 is certainly helpful. However, time series plots and maps would help readers assess the differences between products much more effectively.
I suggest publication after minor revision. Line numbers refer to the document with track changes.

Minor comments
l11: Please state in the abstract that only three selected AWS are being used.
l93: Please explain how you regridded the ATL15 to the 5 km grid.
l129: Could you please explain why a location away from the edges is 'more reliable'? Do you anticipate fewer systematic errors? Could you also provide an approximate distance to the ice sheet margin?
l255: Could you please explain or provide an equation showing how you propagate the uncertainties to the regional mean? Do you neglect spatial correlations between grid cells? If so, please mention this.
4.1.2 I suggest moving this section to the data section and calling it 'Intercomparison SEC products' or something similar. Some background information about these data sets should be provided, and any similarities and differences should be highlighted. Please also explain how you brought them to a common 5 km grid.
In the Results section: Similar time series to those shown in Figures 2 and 3 should be included for the studies by Khan et al. (2025) and Zhang et al. (2022). Alternatively, these time series could be added to Figures 2 and 3, enabling direct comparison. Also, please consider including quarterly time series from ATL15. Maps showing the differences in trends between the three products and the differences between the three products and ATL15 would be helpful. You may wish to add these to the supplementary material. Maps showing differences in mean seasonal amplitudes could also be beneficial.
Discussion: Please discuss the fact that high-frequency variability is not separated by the SSM, and that post-processing is required as part of your method.

Our response to reviewer 1:
We thank the reviewer for this helpful suggestion. We agree that the comparison with three AWS stations is not intended to provide a spatially representative validation of the Greenland Ice Sheet-wide dSEC product. Rather, the AWS observations provide an independent point-scale assessment of temporal variability at selected locations with long-term in situ measurements.

To address this concern, we have reduced the emphasis on the AWS comparison in the main manuscript and expanded the product intercomparison section. Additional analyses have been added to the Supplementary Material, including (1) maps of trend differences between products, (2) maps of seasonal amplitude differences between products, and (3) representative time series comparisons between dSEC, Khan et al. (2025), and Zhang et al. (2022). Detailed AWS correlation plots have also been moved to the Supplementary Material.

We believe these additions provide a more comprehensive Greenland-wide assessment of the dSEC product and substantially reduce the reliance on the AWS-based evaluation. The new supplementary figures complement the AWS comparison by providing both spatial and temporal intercomparisons with independent SEC products across Greenland.

Minor comments:

L11: The abstract has been revised to explicitly state that the AWS evaluation is based on three selected stations and is intended as a point-scale validation rather than a Greenland-wide assessment.

L93: The manuscript has been revised to clarify that ATL15 was transformed from its native 1 km EPSG:3413 grid to the common 5 km EPSG:3413 grid used in this study. The regridding procedure is described in Section 2.2.

L129: We agree that the wording was unclear. The manuscript has been revised to clarify that locations farther from the ice-sheet margin were selected to minimise the influence of mixed land/ice pixels and edge effects associated with spatial interpolation and data coverage.

L255: We have clarified that regional means are computed as latitude-dependent area-weighted means, with weights proportional to cos(phi). The regional uncertainty is propagated from the individual grid-cell uncertainties using standard error propagation for a weighted mean. We now also state that spatial correlations between neighbouring grid cells are not explicitly included, and that the resulting regional uncertainties may therefore underestimate the true uncertainty.

Sec 4.1.2: We agree with the reviewer and have moved Section 4.1.2 to the Data section under the new heading "Intercomparison SEC Products". Additional background information describing the ATL15, Khan et al. (2025), and Zhang et al. (2022) products has been added, together with a description of the harmonisation and regridding procedures used to bring all products to a common 5 km grid.

Results: We thank the reviewer for this suggestion. To facilitate a more comprehensive comparison between products, we have added three new supplementary figures. These include (1) Greenland-wide maps of trend differences between products, (2) maps of seasonal amplitude differences derived from harmonic fits, and (3) representative time series from six locations across Greenland. These additions complement Table 3 and provide both spatial and temporal perspectives on product agreement and differences.
We considered including ATL15 time series. However, ATL15 provides biannual dh/dt estimates and does not directly resolve seasonal variability in the same manner as the monthly products considered here. We therefore focused on Greenland-wide trend and seasonal-amplitude comparisons, which we believe provide a more robust basis for intercomparison.

Discussion: We agree with the reviewer and have expanded the Discussion section accordingly. We now explicitly state that the state-space model reconstructs the dominant spatio-temporal evolution of surface elevation change but does not explicitly separate all higher-frequency variability from the underlying signal. Consequently, an additional post-processing step is required to suppress residual short-term variability and derive the final product. The implications of this limitation are now discussed in the manuscript.

Reviewer 2:

Thank you very much to the authors for addressing all comments from the first round. The manuscript has clearly improved and is clearer now. I would say it is ready for publication after addressing a few minor issues listed below.

Line numbers refer to the "tracked changes" version of the revised manuscript:

L16: SEC products from Cryosat2?

L125: Why is it the lower bound of thinning and thickening? The dynamics might cause both a thinning or thickening. So the SEC values from AWS at e.g., an ablation site, might be over- or under-estimated.

L193: How do you merge the overlapping tiles? Any averaging in the overlap regions?

L237: Do you mean 5x5 grid cells? or NN?

L255: How are the weights defined?

L259: "...is presented..."

L281: Is the interior ice sheet the same as the accumulation zone (above 1500)?

L293: "... per grid cell..."

L333ff: You should mention somewhere here that the offsets are increasing for larger elevation changes. It seems that dSEC is generally smaller than the OIB estimates. Any explanation?

L344: Both datasets should be explained quite briefly somewhere.

L348: How was the resampling done?

Our response to reviewer 2:

We thank the reviewer for the positive assessment of the revised manuscript and for the careful review of the remaining details. We appreciate the constructive comments, which have helped improve the clarity and precision of the manuscript. Detailed responses to each comment are provided below.

L16 : The text has been revised to clarify that the intercomparison includes two previously published Greenland-wide SEC products derived from satellite altimetry. One product is based on CryoSat-2 observations, while the other combines CryoSat-2 and ICESat data.

L125: We agree with the reviewer that the original wording was misleading. The statement that AWS-derived surface heights provide a lower bound on thinning and thickening has been removed. The manuscript now clarifies that AWS observations provide an independent estimate of local seasonal surface-height variability, while differences between AWS and dSEC may arise in dynamically active regions where satellite observations also capture dynamic ice-thickness changes.

L193: We agree that the original wording was unclear and may have suggested that overlapping tiles were merged through averaging. In fact, the overlap is only used as a padding region to improve estimates near tile boundaries. After processing, results within the padding zone are discarded and only the central part of each tile is retained. Each output grid cell is therefore assigned to a single tile, and no averaging or blending between overlapping tile estimates is performed. The manuscript has been revised to clarify this.

L237: We agree that the original wording was ambiguous. The manuscript has been revised to clarify that the median spatial filter is applied using a 5 × 5 grid-cell window, rather than a nearest-neighbour approach.

L255: We have revised the manuscript to clarify that regional means are computed using latitude-dependent area weighting, with weights proportional to the cosine of latitude. We also clarify how uncertainties are propagated to the regional mean and explicitly note that spatial correlations between neighbouring grid cells are not included in the uncertainty propagation.

L259: The text has been revised accordingly.

L281:. In this study, the interior region is defined as all grid cells with elevations above 1500 m, consistent with the regional classification used in Figure 3. The manuscript has been revised to explicitly state this definition and to use consistent terminology throughout the text.

L293: The text has been revised accordingly.

L333: We have expanded the discussion of the OIB comparison. The manuscript now notes that the magnitude of the differences tends to increase for larger elevation changes and that dSEC generally exhibits smaller elevation-change magnitudes than OIB. We suggest that this behaviour is primarily related to the spatial and temporal smoothing applied within the 3D-ECM framework, combined with differences in spatial sampling, whereby the gridded 5 km dSEC product represents an area-averaged estimate that may dampen highly localised elevation-change signals observed by OIB.

L344: We agree and have added a brief description of the Zhang et al. (2022) and Khan et al. (2025) SEC products in the new "Intercomparison SEC Products" subsection of the Data section, including a summary of their input datasets, methodology, spatial resolution, and temporal coverage.

L348: We have expanded the new “Intercomparison SEC Products” section in the Data section to describe the harmonisation procedure. All products were transformed to a common 5 km grid in EPSG:3413 and restricted to a common ice mask. Products available at a finer spatial resolution were resampled to the common grid using linear interpolation before temporal matching to the ATL15 reference epochs.