Review of ‘**A basin-scale mapping method for crevasse depth using ICESat-2: a case study on Greenland’s Sermeq Kujalleq (Jakobshavn Isbræ)**’ by Chang et al.

<u>Summary</u>

This study develops and applies an automated workflow to the ICESat-2 ATL03 (along-track geolocated-photon) data product to extract 2019-era crevasse locations and depths across the highly dynamic Sermeq Kujalleq drainage basin in western Greenland. The authors implement a sensible roughness-index pre-filter to isolate crevassed regions and reduce data volumes before further processing. The glacier surface is then reconstructed using an adapted, simplified form of a methodology previously developed by the authors to make glacier surface-height estimation more feasible over larger study areas. Surface-depression features are extracted and crevasses detected (as opposed to other features such as topographic undulations and supraglacial streams) using width and depth threshold criteria. Finally, crevasse extraction and depth estimates are evaluated using metrics that reflect the proportion of true positives, false positives, and false negatives, where truth is determined from manual inspection of the photon profiles. ICESat-2 ATL03-derived crevasse depths are also compared against depths measured from IceBridge ATM data acquired on a shared date (15 May 2019). Measured depths across the comparison sample ranged from ~2.5m-17.5m, with an RMSE of just under 1 m. I found the results describing comparisons to crevasse depths detected from ArcticDEM especially compelling (and perhaps worth highlighting more as a major finding in the text), as these results seem to suggest a consistent underestimation of crevasse depths in ArcticDEM (and that this bias is not dependent on elevation). The study reports 18,775 crevasse locations with a mean depth of 7.20 ± 0.03 m at Sermeq Kujalleq (SKJI) in 2019, and found distinct elevation distribution differences between crevasses detected in the north and south branches of the glacier.

The study is well written and generally clear, with helpful and detailed figures to supplement the text. The developed workflow shows promise and is likely to be a valuable contribution to the community by enabling future crevasse work at larger spatial scales. However, there are some missed opportunities for comparison to prior work, and important context surrounding temporal biases and relative errors is currently missing; discussion of biases and uncertainty attribution is also very light. Their inclusion would improve the quality and scientific rigor of the manuscript. I therefore suggest several revisions prior to publication, presented below first as major comments under ‘Main’, followed by line-by-line minor comments.

<u>Main</u>

Comparison and benchmarking against prior methods: The manuscript would benefit from more direct comparison against previously published crevasse-detection and depth-retrieval approaches. The density-dimension algorithm for ice surfaces (DDA-ice by Herzfeld et al.) would be the most directly comparable prior method, as this approach retrieves surface heights and crevasse morphology from the same ATL03 photon data and has been applied over the same Sermeq Kujalleq study region. A comparison against DDA-ice, even over a limited shared segment, would more convincingly demonstrate the added value of the proposed workflow and clarify where it improves upon existing ATL03-based methods.

Continuity of detected crevassed regions: It is unclear how non-contiguous detections are handled when defining a crevassed region. For example, if the roughness index remains near the threshold value along-track but dips below t_a for short distances (e.g., 150–300 m), are these short segments still merged into a single overall crevassed region, or are they treated as separate regions? I generally had trouble understanding how the authors envision the crevassed region detection step, which I agree is a beneficial step for reducing processed data volumes, should be implemented across wider spatiotemporal scopes. For example, should crevasse-laden tracks be converted into a spatial mask with simplified geometric boundaries, and used to clip ATL03 along-track data? Or, would this step likely vary between years and varying degrees of temporal biases that it would need to be repeated for different study periods?

Temporal coverage and representativeness: More language is needed on the temporal distribution of the ATL03 acquisitions beyond simply restricting to the year 2019. The subplot in Figure 1b is helpful, but this likely reflects the temporal distribution of the full SKJI basin and not the smaller near-terminus areas later determined to be the crevassed region (less than 10% of the total basin area). Do the authors have a sense of the impact on temporal biases on results, and/or can justify why including all months is a more robust approach over, for example, targeting data in the summer months when the greatest area of bare ice is exposed? Relatedly, the crevassed-region detection evaluation was performed on a subset of 2019 data (January–March); it would help to explain why this window was chosen and whether it is representative of comparisons to the full-year product. I would suggest, at the least, also conduct a similar comparison for a subset of data during summer months when surface conditions are distinctly different.

Uncertainty, bias, and descriptive statistics: The manuscript would benefit from further quantification of bias and uncertainty in some areas. For example, what is the sensitivity of the estimated crevasse depths to the outlier filter (i.e., how important is using a well-suited, region-specific and empirically derived threshold to algorithm performance)? In addition, I would suggest reporting sample/population descriptive statistics alongside the statistics describing the ATM–ICESat-2 crevasse-depth differences — for instance, the median crevasse depth derived from ICESat-2. It would also be helpful to express the reported depth differences as a fraction of the depth magnitude (e.g., is a 0.06 m difference ∼1% of a ∼20 m crevasse, or a considerably larger fraction of a shallower one?). This information is somewhat shown in Figure 8c, but would be helpful if the text provided these figures directly as well.

<u>Minor (line-by-line)</u>

Updated data citation: Please verify/update the in-text citations and bibliography with the version of the ATL03 product used in the study. For example, the current Version 7 user guide (found here: https://nsidc.org/sites/default/files/documents/user-guide/atl03-v007-userguide.pdf) provides the following data citation: which differs and

Neumann, T. A., Hancock III, D. W., Robbins, J., Gibbons, A., Lee, J., Brenner, A., Felikson, D., Harbeck, K., Saba, J., Luthcke, S., Rebold, T., Reese, A., & Sutterley, T. (2025). ATLAS/ICESat-2 L2A Global Geolocated Photon Data (ATL03, Version 7). [Data set]. Boulder, Colorado USA. NASA National Snow and Ice Data Center Distributed Active Archive Center. https://doi.org/10.5067/ATLAS/ATL03.007 [Date Accessed].

The above reference is more recent than the citation provided in the bibliography (which lists a 2019 Neuman et al product). The bibliography's 2019 reference is also different than the one listed in the Data Availability section (which indicates a 2023 entry for the version 6 product).

Line 205 – Is there a citation that can be used for this 150 m threshold, or was this value determined empirically?

Line 280 – Consider adding a brief explanation of how the depth and width thresholds for crevasse detection were derived. Is this based on literature?

Figure 2 – Rotate the titles/text along the left side of the flow chart by 180 degrees for readability (consistent with the orientation used in other figures, e.g., Figure 3).

Figure 4 – Consider making the underlying markers for the glacier-surface signal photons larger or more distinct so that they are more easily visible.

Figure 5 – Consider including the equilibrium line, or the approximate snowline for January–March, in subplots 5a and 5b. Alternatively, overlaying the 600m or 900m elevation boundaries could also be useful to orient readers, as these elevation bands are discussed in results later in the manuscript.

Line 434–435 – Is there a typo here? Should 'estimate' instead read 'underestimate'?