Review of “Sentinel-1 Detection of Ice Slabs on the Greenland Ice Sheet”
Culberg et al.

This manuscript describes a new algorithm which uses Sentinel-1 backscatter observations to detect ice slabs across the Greenland Ice Sheet. The work is new and interesting and will help fill important scientific gaps by providing a method to detect ice slabs at higher spatial and temporal resolution. Overall the paper is clear and well written and has high-quality figures. Once my concerns are addressed, I believe this paper will be an excellent contribution.

Major comments

1) I understand that the authors take into account different incidence angles for the Sentinel-1 data by applying a linear fit to incidence angle and backscatter; however, I feel like the impact of incidence angle on this work needs to be more fully understood before this algorithm can be applied. How many different incidence angles are available for each pixel? If one pixel has substantially more incidence angles available, how does this impact the cross-pol ratio and therefore the delineation of ice slabs? It would be interesting to investigate how the defined ice slab boundaries change if only some of the available incidence angles in a given region were used. This would shed some insight into how sensitive this algorithm is to various incidence angles.
2) I am also a bit concerned (or maybe just confused) about the testing of the algorithm. In the abstract, the authors state “The S-1 inferred ice slab extent is in excellent agreement with ice penetrating radar ice slab detections from spring 2017”. However, I find this to be misleading since the training dataset was from spring 2017. Of course the S1 ice slab extent is in good agreement since the algorithm seems to be empirically derived from this data. Was there a completely independent dataset used to test the algorithm? Can it be tested with OIB data from a different year? It seems that the F1 scores given in lines 205-208 and Figure 7 were from the training dataset.
3) I am also a bit confused with how the folds were created. Were these folds selected completely randomly or separated by specific regions of the ice sheet. If the latter, this could provide insight into the spatial robustness of this algorithm. For example, in Figure 4, which region corresponds with fold 2 and why is the F1 score for the lower elevation limit so much worse in this region? The authors state in the caption of Figure 4 that “we discard the iteration marked with the red bar due to anomalously poor F1 score…” but it seems like this anomalously low F1 score should be important as it says something about the robustness of the algorithm? This should be further explored and discussed.

Minor comments

1) In paragraph 1 of the introduction please also mention that mass is also lost due to dynamical processes and it would be helpful to briefly compare this mass loss to that from surface processes.
2) L28: “preferences the formation of perennial firn aquifers” is a bit awkward wording.
3) L42: “… including the first high elevation rain event, such as 2019, 2021, and 2023.” This wording makes it sound like the rain event occurred in 2019, 2021, and 2023.

4) L111: From Fig. 1, it looks like the HV backscatter is closer to -4 dB in the percolation zone.
5) L112: "…eventually reaching a plateau around -11 dB". This is a bit misleading I think. There is still substantial variation around this new plateau as the HV backscatter changes from -8 dB in the upper part of the ablation zone to -13 dB in the wet snow zone.
6) L191: "… we optimize independent backscatter thresholds…" What are the thresholds independent from?
7) L196: What is meant by "high-end estimate"?
8) L202: what step size did you use to test α and β within these ranges?
9) After the 10-fold validation, how were the optimal empirical parameters chosen?
10) L243: Please add Dunmire et al 2021 with Koenig et al 2015 citation.
11) Lines 285-290: I find this section confusing. Isn't "ice formed be refreezing" (L286) the same as an "ice slab"? The distinction between ice slabs and other refrozen ice is unclear throughout this section. Also, it seems that "ice formed by refreezing induces significant volume scattering due to trapped air bubbles…" (L286) contradicts the introduction "with relatively little volume scattering since heterogeneities such as air bubbles are significantly smaller than the C-band wavelength" (L95).

Technical corrections

1) L22: Please add "meltwater" before "retention and runoff"
2) L32: Please add "elevation" in "upper *elevation* limit" (also for L194).
3) L150: Delete "to" before "correction" at the start of this line.