The Cryosphere Discussions

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Review of Smith et al. (tc-2022-44)

Anonymous Referee #2

Referee comment on "Evaluating Greenland surface-mass-balance and firn-densification data using ICESat-2 altimetry" by Benjamin E. Smith et al., The Cryosphere Discuss., https://doi.org/10.5194/tc-2022-44-RC2, 2022

This study evaluates output from 3 surface mass balance (SMB) and firn density (FD) models using ICESat-2 altimetry data over the Greenland Ice Sheet. Previously, SMB and FD models had been validated using dispersed firn cores or airborne radar surveys that were widely spaced. ICESat-2 surface height measurements provide seasonal temporal resolution of net surface height changes across the entire ice sheet, and provides a useful dataset for evaluating SMB and FD model performance. Smith et al. compare ICESat-2 height changes with simulated height changes from 3 combined SMB/FD models that can account for atmospherically-derived height changes and compaction-derived surface height changes. Because ice sheet surface height changes can be caused by thinning from ice dynamics, the authors focus on regions of the ice sheet with little variation in flow velocities. This is a very thorough and detailed study that will be very valuable to the firn community. The paper is well-written and the figures are well-presented. This paper is so detailed that it would benefit readers to provide more general points at the beginning of each section for them to latch onto, particularly if they are looking for main points of the analysis/results. I have a few suggestions that I think should be incorporated before publication. These comments are listed below:

ICESat-2 began measurements in October 2018. MacFerrin et al. recently published a firn compaction dataset, and I believe 2 of the sites have compaction measurements through 2019. It may be outside the scope of this study, but it may be interesting to compare ICESat-2 surface-height changes and modeled surface height changes at these two sites to examine the influence of firn compaction/atmospheric inputs to surface height changes and see how well the models capture these.

I would have liked to see the 3 models introduced earlier. It would be nice to list them in the abstract (e.g. Line 19) and in the introduction (e.g. Line 75).

It would be nice to clarify why you evaluate MARv3.11.5, but calibrate your degree-day parameterization in the GSFC model using MARv.3.5.2 (Sections 2.2.1 and 2.2.2).

The regression analysis sections are quite detailed, and a bit difficult to understand (which may be my own problem). In Section 2.3.1, I did not quite get the point until you gave the example of scaling SMB by 0.5 (Line 254). It may be useful in this section to give a summary how the regressions are used for readers to then understand the more detailed methodology. I believe this would also be useful for Section 3.2.3

Lines 282-284: Can you make this sentence clearer? You say "we can see that melt was considerably stronger in 2019 than it was in 2020". Can you specify where in the table we look to come to that conclusion? It is difficult to find in the table by keeping track of the variables.

Lines 466 and 517: Here you say that melt for GSFCv1.1 was based on degree-day parameterization of the MARv3.11.5 melt. Earlier in the methods section you mentioned that it used MARv3.2.5. Could you clarify this?

Line 500: What about using these models to predict ice sheet mass changes in the future using these SMB/FD models? It seems important that these models overpredict FAC changes associated with high-elevation melt events, which will likely be more frequent in the future.

Figures 4, 6, 7: Could you write out what each colored histogram represents in the figure caption? That would have benefited me while reading.

MacFerrin et al. citation:

MacFerrin, M. J., Stevens, C. M., Vandecrux, B., Waddington, E. D., and Abdalati, W.: The Greenland Firn Compaction Verification and Reconnaissance (FirnCover) dataset, 2013–2019, Earth Syst. Sci. Data, 14, 955–971, https://doi.org/10.5194/essd-14-955-2022, 2022.