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Review of MacFerrin et al.

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Referee comment on "The Greenland Firn Compaction Verification and Reconnaissance (FirnCover) dataset, 2013–2019" by Michael J. MacFerrin et al., Earth Syst. Sci. Data Discuss., https://doi.org/10.5194/essd-2021-274-RC1, 2021

MacFerrin et al. describe a dataset consisting of strain rates in shallow firn, 2 m air temperature, firn temperature, and surface height from eight sites across the Greenland Ice Sheet. The dataset consists of daily strain measurements and hourly meteorological measurements spanning 2013 – 2019. Multiple boreholes have been instrumented at each site allowing for users to assess viability and repeatability of strain measurements and examine compaction rates over different depth ranges.

Given the disagreement in firn models using both steady-state and transient modes, this dataset will provide important validation data spanning climate regimes. The dataset will provide opportunity for interesting and important future work examining firn compaction on seasonal timescales and investigating the effects of meltwater on firn compaction rates.

This paper is well-written and provides a concise but helpful literature review in addition to describing the dataset. I have a few general comments and questions along with some technical corrections that are detailed below, but I recommend this paper be published in ESSD after these are addressed.

General Comments:

(1)

The authors provide a nice summary of the recent research on Greenland's firn layer. I have one suggestion that may make their discussion clearer. The authors state four main reasons for studying the firn layer: (1) to refine estimates of mass balance using altimetry

methods; (2) to estimate how much meltwater can be stored within the firn column and buffer future sea level rise; (3) to understand the development of near-surface ice slabs that block future meltwater percolation; and (4) to refine interpretations of climate records from ice cores.

In my opinion, numbers 2 and 3 essentially fall into the same category of understanding firn's capacity to buffer future sea level rise. I would recommend phrasing this section as there being 3 main reasons for studying firn: (1) to use altimetry mass balance products; (2) to understand how much water can be stored in the firn column and buffer sea level rise – can all available pore space be filled or does the expansion of near-surface ice slabs block percolation and expand runoff zones? And (3) to improve interpretations of climate records contained in ice cores. Grouping the main reasons for studying firn in this way seems to make more intuitive sense to me and better links the impacts of ice slab formation on meltwater storage. Additionally, I would consider adding an additional phrase or sentence to expand on why firn structure is important for interpreting paleoclimate records. I would recommend just explicitly stating that knowing the ice-age/gas-age discrepancy allows us to accurately date past atmospheric conditions. This last reason just seemed a bit shorter than the others listed.

(2)

I am curious about the contribution of ice flow to vertical velocities that could be captured by the installed strainmeters and misinterpreted as firn compaction. If the ice column were undergoing longitudinal extension, the borehole could be shortening even in absence of firn compaction. I imagine that at sites like Summit, there likely is not much longitudinal compression, but with EastGRIP being located on an ice stream and there being local topographic variability at sites like Crawford Point, I am wondering how much ice dynamics could affect the calculated firn compaction rates. In studies that attempt to determine vertical strain at sites using phase-sensitive radar, some have attempted to separate out an ice dynamics component from compaction (e.g. Jenkins et al., 2006).

My two main questions arising from this curiosity are: (1) Would vertical strain resulting from ice flow be recorded by your strainmeter instrumentation? and (2) If so, are there existing data that users of your dataset could find to remove an estimated vertical strain component from ice dynamics to get a purely firn compaction component?

If the answer to the first question is *no*, then perhaps adding sentence or two explaining the concern and detailing that this instrumentation would not be affected by ice dynamics processes would help readers. If the answer is *yes*, then I think it would greatly help users of your dataset to point to existing measurements or potential models that could help resolve the influence of ice flow on the compaction rates that you present.

(3)

I am interested in knowing the distance between boreholes at each site. It may be helpful to include a sentence on line 111 saying that boreholes are spaced approximately xx m apart. If available, could each borehole's coordinates be included in Table 2? It may make Figure 1 too busy, but potentially including insets for each site with the locations of each borehole may also be helpful.

This interests me because looking closely at Figure 5, it appears there are some slight differences in compaction rates between boreholes at the same site that are installed over approximately the same depth range. Specifically, I am looking at boreholes 13 and 16 at NASA – SE in the summer of 2015, boreholes 17 and 20 at Saddle, boreholes 30 and 33 at Summit (particularly in the summer of 2015), and boreholes 26 and 29 at EastGRIP. For future work, it would be interesting to examine discrepancies in compaction rates between closely-spaced boreholes instrumented over the same depth range, and knowing the length scale over which these differences occur would be useful.

(4)

Suspicious data readings that are not included in the preliminary analysis are mentioned on lines 210 – 211. Could a brief explanation as to why they are considered suspicious be provided here?

Minor Comments and Technical Corrections:

L18: Consider changing *"snow temperature"* to *"firn temperature"* or *"snow and firn temperature"*

L42: "*Adolf and Albert, 2014"* should be changed to "*Adolph and Albert, 2014"*

L82: Does there need to be a dash here in *"firn-density" ?*

Throughout the manuscript, *"SumUp"* is written when I believe the correct capitalization is *"SUMup" .*

Throughout the manuscript text and figures, EastGRIP is written both as *"EastGrip"* and

"EastGRIP". I recommend that it be written as EastGRIP throughout the manuscript.

L256: Does there need to be a dash here in *"firn-temperature"* ?

Figure 3: The caption mentions *"changes relative to installation depth plus 120 days"*, however, in line 195 you suggest removing the first month of data from analysis. In this figure, have approximately the first 4 months of data been removed? It may be helpful to state this in the text, perhaps just after mentioning that the first month of data has been removed but Figure 3 shows data with the first four months removed.

Figure 6: It appears that the firn temperatures at Summit are not captured by the scale bar on the right. I think the scale bar needs to be expanded to capture the low temperatures of firn at Summit. Additionally, the color scale used in this figure is slightly counterintuitive, as I often think of red colors as warmer temperatures. Perhaps flipping the scale may help readers interpret it better.

Table 4: I think the temperature difference column should be rounded to the same number of decimal places as the previous two columns. If there is not enough certainty to present measurements with two or more decimal places, it seems odd that the difference between the two is presented at a higher resolution than the measurements.

Reference included in review comment:

Jenkins, A., Corr, H. F., Nicholls, K. W., Stewart, C. L., & Doake, C. S. (2006). Interactions between ice and ocean observed with phase-sensitive radar near an Antarctic ice-shelf grounding line. *Journal of Glaciology, 52*(178), 325-346.