

## ***Interactive comment on “Seasonal monitoring of melt and accumulation within the deep percolation zone of the Greenland Ice Sheet and comparison with simulations of regional climate modeling” by Achim Heilig et al.***

### **Anonymous Referee #2**

Received and published: 5 March 2018

#### 1 Overview/Summary:

This manuscript describes the deployment of an upward-looking ground-penetrating radar (upGPR) in the Greenland firn. Using the upGPR, the authors observe percolation of water into the snowpack, and movement of water within the firn, measuring percolation depths and deriving parameters such as bulk density and volumetric water fraction. The authors compare the measurements of these percolation parameters with the outputs of a popular regional climate model, MAR, as forced by two different reanalysis datasets. In general this is an interesting manuscript that advances knowledge in

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the field, and is worthy of publication. The science is good with no serious flaws. The presentation is a bit lacking, primarily in the use of English. I've commented extensively (though probably not exhaustively) in the 'minor comments' section below.

#### 2 Major Comments

- Page 3, Lines 16-20... Seems to me like you can either use MAR to help determine how the radar does, or use the radar to determine how MAR does, but not both. At all.
- Page 4, Lines 31-33... Not convinced that the 'compaction of the radar and the target' are actually equal; in practice the target supports may be driven down faster than the radar. Effect is likely small but will be non-zero.
- In general, much of the Results section appears to be more like Discussion; I have not attempted here to disentangle the discussion-like parts from the straight results, but this is a part of the paper that could use refinement.

#### 3 Minor Comments

- Abstract Line 2: 'act as meltwater' -> 'act as a meltwater'
- Abstract Line 9: 'capable to monitor quasi-continuously' -> 'capable of continuously monitoring' (though use quasi if you must)
- Page 2, Line 5: 'multiplied by a factor' -> 'has increased by a factor'
- Page 2, Lines 7-8: sentence needs rewording; should start '61% of the recent mass loss is ascribed to...'
- Page 2, Line 19: 'are exposed' -> 'have been exposed'
- Page 2, Line 23: Reference to Abdalati and Steffen 2001- this is a remote-sensing paper, not looking at in-situ data.
- Page 2, Line 25: unless McFerrin et al is published by the time this comes to press, remove this reference.

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- Page 2, Line 29 'inevitable'- is this the right word? Sounds like you meant to say 'imperative'.
- Page 3, Line 2: 'temporal continuous' -> 'temporally continuous'
- Page 5, Line 9: 'identification of timing' -> 'identification and timing'
- Page 5, Line 11: reference to figure 3 before I see any reference to figure 2, the first reference I see to which is on page 6.
- Page 6, Line 5: Seems  $120 \text{ kg/m}^3$  is pretty low for Greenland snow (to me) but I don't have a reference to point to.
- Page 8, Line 26: delete 'respectively' as it's not needed here.
- Page 9, Line 4: I don't understand what the first part of this sentence is referencing; I don't see the change after 19 July that I think the statement is discussing.
- Page 9, Line 21: 'equal to' -> 'are'
- Page 9, Lines 30-31: This description needs to be tightened up. The 'determined changes in snow and firn' are really 'extent of percolation'; the results you show in panel c are also 'changes in snow and firn'...
- Figure 5b: Do you really believe the high-frequency variability of the isotherms (most prominent example is between 30 May and 19 Jun going from 1 to 0 m height)? I don't. These should probably be smoother curves. Filtering these data might be what you need to do before calculating isotherms. The other really major thing here is that because you discuss the -1 C isotherm so much in the manuscript, it should be delineated clearly here- a different color, or marked in some way. This way readers can see the trends you are describing on page 12 in time and depth of the -1 C isotherm.
- Page 11, Line 2: 'outlasted' -> 'lasted'
- Page 12, Line 9: Start a new paragraph here.

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- Page 12, line 23: this assertion would be easier to verify if you plotted the 2015 summer surface on figure 5; that would show clearly the melt propagating below the summer 2015 surface (harder to verify quickly by looking at figures 6a and b as referenced).
- Page 14, Lines 5-8: Not sure why all of this is here. Why wouldn't you include the ice lenses that you observed in the pits? In that case simply report the last sentence on line 8. But it's not clear if these ice layers were measured in the pits or where they used from the radar to 'correct' the pit data? If so, not sure why it's valid to do that. Clarity of the language is required here.
- Page 15, Line 2: Rather than force the reader to look up the physical meaning of the Nash-Sutcliffe efficiency value (which one needs in order to evaluate your reported numbers), briefly define it here. Only needs a sentence.
- Page 15, Line 8: I think this kind of correction is probably fine- if you want to quote the statistics for it, you need to demonstrate how "removal of the strong increase" was done, and it would probably be good to show the resultant curve on figure 7.
- Page 17, Figure 9: I don't understand why the  $\theta_w$  NCEP is illustrated the way it is. Seems like on previous figures there was a parallel track with MAR-NCEP and MAR-ERA, and this should continue in this figure.
- Page 17, Line 18: 'entering' -> 'enters'
- Page 18, Line 9: 'plain' -> 'planar'
- Page 18, Line 16: I'm not sure that using MAR provides adequate proof of assumption iii. Isn't MAR modeling these physical processes using assumptions of its own? An observational proof would be more useful here. However, I think iii is a very reasonable assumption and don't think it really needs a rigorous proof.
- Page 19, Line 6: Strain is by definition a dimensionless quantity, if you are using a measurement of 3.7 cm, this must be deformation, or shortening, not strain.

### C4

- Page 19, Line 24: 'could not be' -> 'was not'

- Page 19, Line 30: 'could not' -> 'did not'

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Interactive comment on The Cryosphere Discuss., <https://doi.org/10.5194/tc-2017-277>, 2018.