

Interactive comment on “Water Content of Greenland Ice Estimated from Ground Radar and Borehole Measurements” by Joel Brown et al.

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Summary

This manuscript describes observations and analysis of the englacial water concentration of the western Greenland Ice Sheet from two types of ground-based radar surveys and well-established methods, with validation at boreholes whose results have been described in detail in previous studies. A key finding is that the water content they infer for the temperate layer is consistently higher than that assumed by models that account for such englacial water concentrations, such that this water may have a greater influence on the flow of the ice sheet than is commonly assumed.

Major comments

C1

This manuscript is well structured, coherently argued, well supported and well written. The data and methods are well suited to the questions posed. I find little to fault in this regard and will not belabor those points. While the observational scope of the study is fairly narrow, the broader significance of the results is reasonably established. I do not consider any of comments major.

Minor comments

15-6. While accurate, this final sentence of the abstract ought to be expanded upon in a manner consistent with both the Discussion and Conclusions sections.

2/13-14: These two sentences appear redundant in the otherwise excellent Introduction section.

3/5: Is the common-source point multi-offset survey also what's called a “walkaway” survey? If so, less of a mouthful.

4/20-29: This paragraph regarding the pros and cons of this particularly survey design seems better suited to section 2.2.

5/9-10: This sentence is surprisingly circumspect about the possibility that this reflection is due to the large englacial temperature gradient at this depth. Given the apparent coincidence between the cold–temperature transition and this reflection in Figure 3c (would be nice to also show the borehole sandwich in Figure 2), it is plausible, although the physical mechanism that generates this reflection is somewhat unclear (large increase in permittivity/conductivity/both?).

7/15-16: Not sure exactly what is meant by “grain-scale” water in cold ice. Grain-scale water bodies? Certainly liquid veins can be present even in cold ice, e.g., Dash et al. [2006, Reviews of Modern Physics, 78, doi:10.1103/RevModPhys.78.695]. This statement appears to be contradicted by later statements at the beginning of section 4.2.

8/10: Gusmeroli et al. [2010, JGR, 115, doi:10.1029/2009JF001539] is also relevant

C2

here.

8/20: Jacobel et al. [2014, *Annals of Glaciology*, 55(67), doi:10.3189/AoG67A004] used low-frequency common-offset ground-based radar to study basal crevasse morphology near the grounding zone of the Siple Coast, so this statement does not seem strictly correct to me.

8/21-22: This statement is key to the broader significance of the study and I recommend expanding on it if possible.

9/7 and 10/11-12: These statements indirectly include enhanced shearing of basal/temperate ice as part of a set of “sliding processes”, which doesn’t sound quite right (also at odds with 9/3-4). In my perhaps conventional view, it is simpler to consider sliding processes as those that cause absolute motion of ice at the bed itself, of which I would only include direct sliding over subglacial material or mechanical failure of the latter.

Section 4.3: This section would be strengthened if it considered the bulk permittivity of ice used by CReSIS for ice thickness determination (3.15). 10/12 would especially be strengthened in this regard. The sentence about velocity assumptions in 10/11-12 is practically tautological.

9/30: While the study has elucidated the englacial water concentration of the ice sheet in this region in greater detail, it’s a stretch to consider the two-layer model “complex”.

10/7-8: This statement about the possible influence of an icefall should be moved earlier and shouldn’t be first introduced in the Conclusions section.

Table 2 is somewhat confusing and ought to be reorganized so that upper/lower layers are shown as sub-columns of S3 and S4.

Figure 2: Add Figure 3c’s borehole sandwich to each panel.

Figure 4: 3-D is tough. I appreciate the effort but had of difficulty interpreting the

C3

different radargrams. Perhaps include a legend, a map and the view directions for each panel?

SI/S3: This section is worth including in the main text.

Grammar, etc.

1/23: that is tens of metres 3/3 and throughout manuscript: use “ice thickness” instead of “ice depth” when referring to the distance between the ice surface and bed 6/9: This agrees with the ~240 m... 7/30: constant: same in time; uniform: same in space 9/9: Ryser

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