

Interactive comment on “Near surface meltwater storage in low-density bare ice of the Greenland ice sheet ablation zone” by Matthew G. Cooper et al.

Anonymous Referee #1

Received and published: 27 July 2017

The paper presents the results of a recent field survey conducted to assess the potential for subsurface meltwater storage in porous ice in the ablation zone of the Greenland ice sheet. Focusing on a small, internally draining, hydrological catchment in the much-studied South West, the authors find that the subsurface ‘reservoir’ consists of two layers. These consist of a thin, light, unsaturated layer atop a thicker (~1 m), denser, saturated layer. Between them, these layers provide storage potential for up to 20 cm of meltwater which, integrated over the catchment, is the equivalent of one hour’s proglacial discharge from this sector.

The methods employed in the study are sensible, and their results are very interesting,

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however the manuscript is a little confused in places and I would have liked to see the field data discussed in more detail. That said, this is a good paper and I expect will make a solid contribution to the literature subject to editing as follows.

Major comments 1. The paper is lacking in analysis of spatial variability along the transect studied. For example Fig 3 reveals that ice lenses are not always common between adjacent cores. Further investigation into these features and why they arise would be both interesting and serve to strengthen the manuscript.

2. While you do not have seasonal data, you should contextualise your findings in terms of the seasonal cycle. For example what is the ablation rate in this location? Is your weathering crust likely to be the product of one, or more melt seasons? You attribute ice lenses to remnant glacier ice but to me it seems that these are evidence of meltwater refreezing at depth. Can you correlate the incidences of ice lenses to e.g. the annual cycle or specific weather events?

3. While it is good that you discuss the implications of your findings for SMB and surface hydrology studies, I would like to see a bit more qualitative information here. For example, what would the difference in ice mass be in your catchment a) at the density of ice and b) when you account for sub-surface porosity? Similarly, hydrological studies use estimates of snow permeability for water routing according to Darcy’s Law. Can you provide an updated estimate of sub-surface permeability in your study area for future use by such studies?

Minor comments: Page 1 Line 29-30: I’m not sure that meltwater throughput ‘reinforces concerns about . . . sea level rise’ Line 29: Greenland ice sheet not Greenland Ice Sheet.

Page 2: Line 3: Mention that these models assume that runoff is instantaneously lost to sea here. Line 8: Sentence structure is odd here; implies that the stored meltwater is the substrate. Is that what you mean? Line 16: Maybe mention melting due to friction from the flow of meltwater. Line 31: ‘could potentially’ rather than ‘would’

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Page 3: Line 2: logical disconnect here, add an explanatory line. Line 6: phrasing of 'near surface ablating' seems strange. Line 12: Add melt zones onto map in Fig 1 Line 16: delete 'study area' Line 27: example of logical jump; you assign and uncertainty then say where you got it. It would be better to say, 'we consider 1.3 cm (10%) accuracy to be conservative'. Line 29: just measurement uncertainty or a combination of measurement and instrument uncertainty?

Page 4 Line 12: What determined the maximum depth? Line 28: be consistent with units; you used cm³ before.

Page 5 Line 6: delete 'these' Line 7: justify this given the difference in structure between the two layers. Line 20: nearest cryoconite hole? Nearest x cryoconite holes? Line 27: another logical jump re: transition! Line 30: to what height? It would have been good to measure the water table at the drilled holes as well as at Cryoconite holes.

Page 8 Line 8: Impermeable yes, but how continuous? Are these highly localised features?

Page 9 Line 7: I think the value below snow surface would be a better one to quote. Line 10: Again, to what level? Completely full? Line 17: did you see any evidence of flow in any of the holes? Line 25: quantify 'often' Line 29: Ok so the water table is ~20 cm below the surface yes? Which is consistent with your statement that the bottom layer, from 20cm down is saturated.

Page 10: Line 29-30: This is speculative without seasonal data. If the aquifer is perennially saturated then this is not necessarily the case. Fig 3, reorient so #10 is on the left as in fig1. Fig 6 b add core depth.

Interactive comment on The Cryosphere Discuss., <https://doi.org/10.5194/tc-2017-107>, 2017.