

The Cryosphere Discuss., author comment AC1  
<https://doi.org/10.5194/tc-2021-116-AC1>, 2021  
© Author(s) 2021. This work is distributed under  
the Creative Commons Attribution 4.0 License.



## Reply on RC2

Julie Z. Miller et al.

---

Author comment on "An empirical algorithm to map perennial firn aquifers and ice slabs within the Greenland Ice Sheet using satellite L-band microwave radiometry" by Julie Z. Miller et al., The Cryosphere Discuss., <https://doi.org/10.5194/tc-2021-116-AC1>, 2021

---

### Author Response to Reviewer #2

*The authors present a very thorough study of mapping perennial firn aquifers and ice slabs using satellite L-band microwave radiometry. The manuscript is rather technical but extremely well thought out and provides robust results and a sophisticated new method that will be of benefit to the community in further entangling the liquid water storage on the Greenland ice sheet. The figures are clear and the placing of the sections obvious.*

*As I am not an expert on the observational techniques and algorithms used, my main comments will be on the structure of the manuscript, and I hope the other reviewers will provide more detailed comments on the methods used. My main comment is that the manuscript is too long and too technical, especially the abstract, introduction and method sections. For the manuscript to become at all readable to a neutral reader with no existing knowledge on the topic, these sections should be significantly cleaned up. For instance, the introduction (and to a smaller extent the abstract) includes lots of technical explanations of the techniques used, while it should just serve as introducing the perennial aquifers, ice slabs and perched aquifers, their importance for cryospheric studies and a brief outline of the manuscript. Several paragraphs could basically be omitted or combined and number of pages considerably cut down. If the authors are able to tighten up the manuscript I recommend publication, solely on the basis that even though my comments above are critical, the overall results and conclusions are clear and convincing.*

**Note: the editor asked the authors to respond to the reviewers' comments before revising the paper. So, the authors have described the intended revisions.**

The authors want to thank Reviewer #2 for taking the time to review a paper outside of their area of expertise. Especially, given technical nature of the paper. The authors can appreciate Reviewer #2's point of view on the technical content, but since our observational techniques are completely new, we consider the technical content to be an essential part the paper. The technical content provides details of the previously undescribed observational techniques that enable us to derive the algorithm, and support the conclusions drawn. Thus, we do not wish to reduce the critical technical detail. As we move forward with using the derived algorithm, we will focus on the science and not include this level of technical detail in future papers. As advised by Reviewer #2, we will remove repetitions to shorten the text to improve the overall readability of the paper.

*Below I note a few things in abstract, intro and summary that serve as a basis to how the manuscript could be shortened:*

*P1, 120: No note on what perennial means. One of the characteristics of the perennial firn aquifers is that they last through winter; they are perennial. I do not see this explained anywhere, while this is important for the reader to understand the importance of this phenomenon.*

Although it is true that they last throughout winter, they are also present in the spring (prior to melting), summer, and autumn (after melting), making them year-round ice sheet features or 'perennial'. The authors will add the term 'year-round' for clarity.

*P1, 140-43: Drop the technicalities. Just note: "An recalibrated empirical algorithm is used to map the extent of aquifers".*

As noted above, given this paper is specifically on the algorithm, and the authors would like to keep the technical details in the abstract. The technical description is also consistent with our previous paper on mapping perennial firn aquifers using SMAP (also in The Cryosphere, <https://tc.copernicus.org/articles/14/2809/2020/tc-14-2809-2020.pdf>.) The sigmoidal curves are widely used throughout science and engineering; however, this is the first application that I know of that applies them to microwave data over an ice sheet. This is part of the novelty of the technique.

*P1, 148-53: Manuscript has many of these extremely long sentences. Please tighten up.*

Will revise to shorten long sentences.

*P2, 168: Where is the aquifer introduced? Explain what it is first.*

There is a general description of what a firn aquifer is in both the first paragraph of the Abstract, and in the second and third paragraphs of the Introduction. Although more details are provided in the main text, firn aquifers can simply be described as 'subsurface meltwater reservoirs consisting of a meters-thick water-saturated firn layer'..., which is the first line of the abstract. For this paper, that is the key physical characteristic that we observe via SMAP. See next paragraph for further comments.

*P2-3 general comment: First explain, in less words, what a aquifer, ice slab and perched aquifers are, then come to the techniques used to measure them. Now it's back and forth between the two. The structure of the introduction is not very logical.*

The paper is focused on demonstrating the potential of L-band radiometry to map englacial hydrological features on the Greenland Ice Sheet. The introduction is specifically structured to discuss the current state of knowledge –what do we know? Not much. The very first observation that surface L-band brightness temperature is sensitive to deep subsurface meltwater (subglacial lakes) was by Jezek et al., (2015). There is one previous L-band microwave radiometry paper on shallower subsurface meltwater (firn aquifers) mapping by Miller et al. (2020). There are no previous L-band microwave radiometry papers on ice slabs. This is the first. We are not aware of any papers (or observations!) on mapping perched firn aquifers. It is hypothesized from the modeling exercise in this paper. The introduction is meant to describe known features of firn aquifers and ice slabs that are sensitive to L-band emissions, and the interactions that generate specific L-band signatures that are used to map them.

*P2, 176: "...through winter".*

See previous comments. Authors will include 'year-round' in the revisions.

*P3, 185-95: Too technical for introduction. Why is this here? Either remove or combine with paragraph p4, 1119-128.*

Will revise.

*P5, 1 152-175: This paragraph is likely better placed at the beginning of the introduction, as it is good to start by encouraging the reader by noting what is so special and important about the aquifers, instead of concluding the introduction with this.*

The authors will move this paragraph to an Implications section to shorten the introduction as advised by Reviewer #1.

*P6, 1209-214: This is exactly some thing that should be in the introduction and not in the methods sections. Many things are actually repeated through the methods section, and could be removed to clean up the manuscript.*

Although we feel that these two paragraphs are probably relevant, the authors will remove them to shorten the paper.

*P38: 1116-1150: What a big blob of text. Try to at least introduce some indentations to improve readability. To me, this paragraph is unclear. What would you want to improve exactly? Try to subdivide the respective future topics more clearly.*

The authors will put in some additional indentations, subdivisions to help improve readability. Future work (now our current work) is focused on developing better mapping algorithms based on forward and inverse geophysical-electromagnetic modeling and a potential path forward. Forward modeling provides insight into what parameters might be controlling the observed L-band signatures. Inverse modeling allows us to use these insights to more accurately map firn aquifers and ice slabs on an ice-sheet scale.

*P38: What about applications on other ice sheets?*

Thank you. This is a good suggestion. For this paper, the authors made the decision to focus exclusively on Greenland, and not to include any mention of Antarctica in this paper (the paper is too long anyway!). We a forthcoming paper that will describe an algorithm to map firn aquifers on ice shelves + a field expedition to validate the algorithm.