Mapping Greenland's perennial firn aquifers using enhanced-resolution L-band brightness temperature image time series

By J. Miller et al.

General comments

This is an exciting study, introducing a new method to map the Greenland firn aquifers from passive microwave L-band satellite observations. The study is very relevant, well-written and well-organized. I'd recommend its publication, but some important aspects first need to be addressed:

1. As also pointed out by Reviewer #1, the study lacks a clear description of the calibration strategy, and also a quantitative validation is lacking. The airborne OIB data set could for instance be split into calibration and validation subsets, in order to perform an independent performance assessment of the aquifer mapping. As it reads, it seems that the authors selected the range in ζ of [-0.04 -0.008] only based on a visual inspection of the resulting aquifer maps, in comparison with maps derived from OIB. But, the range in ζ will have a strong impact on the total aquifer extent and should thus be selected with care. In addition to a better developed calibration strategy, I'd also recommend to perform and show a sensitivity analysis of the total aquifer extent in function of the limits of ζ.
2. I miss a critical discussion by the authors of what they perceive as the strengths and weaknesses or uncertainties of their approach, and where they expect it to work well and less well. The first paragraph on page 12 (L309-L315) goes somewhat into that direction. But this discussion could be improved. For instance, are there brightness temperature signatures of non-aquifer areas that could potentially be confused with those of aquifer areas? Which areas? Or vice-versa, do some aquifer areas lack the characteristic behavior, and why? What could be the impact of seasonal meteorological conditions on the aquifer (or non-aquifer) signatures, etc.

Specific comments

1. L62: Perhaps explicitly mention that there have been flights during 2015-2019 as well? Have you considered including one or more additional years, which could be helpful for testing the robustness of the method?
2. L82-90: Would it be possible to provide an indication of the effective spatial resolution, resulting from this processing? Do you expect that the relatively coarse spatial resolution of passive L-band microwave could have a strong impact on the total aquifer extent? For instance, could the extent possibly be overestimated due to the coarse resolution, given that several pixels may only partially be covering an aquifer in reality (while I realize that also some pixels may not be classified as aquifer due to mixing signals from non-aquifer fractions)?
3. L102: I believe this is the first mentioning of OIB data being available after 2014? (see also specific comment 1).

4. L105-120: In my opinion, it would be far more interesting for this particular study to delete the entire section discussing active microwave signatures over Greenland from PALSAR (L107-118) and replace that by a section which explains more into detail the signatures in brightness temperature for different facies of the Greenland ice sheet. These passive microwave signatures could later on help supporting a discussion of strengths and uncertainties of the aquifer detection method. Active microwave signatures (the focus of this section in its present form) are nowhere used in the method, validation, or analysis; only as a background in some of the maps.
5. L162: How have IST data been projected and upscaled onto the EASE-2 grid? By linear averaging?
6. L165-168: are there any references to support these assumptions?
7. Section 2.3: The 2016 aquifer picks were based on the MCoRDS instrument. This instrument is less well suited for aquifer delineation than the OIB accumulation radar flown in several other campaign years, and may potentially lead to biases (likely under-detection)? Perhaps this is worth mentioning when comparing your classification with OIB? Also, including some of these other years may improve the robustness of the calibration of your method.
8. Section 2.4.1: This explanation is very similar to that in a recent study published by Brangers et al. (2020) in GRL, discussing signatures of active microwave (Sentinel-1) for mapping Greenland firn aquifers. Perhaps it is worth mentioning this similarity, to provide additional support for your method.
9. Section 2.4.1: I would suggest to move the section on page 13 (L338-350) to somewhere around section 2.4.1 within the methods, since this provides the theoretical support for your classification method. Moreover, it is not well placed in the summary and future work section, since it provides new theoretical information (not a summary).
10. L228-239: Which regions typically correspond to $\zeta > -0.008$ and why?
11. L244: Decreased sensitivity: do you mean relative to H-pol?
12. L289-293: Some of these aquifer locations are also revealed in the study of Brangers et al. (2020). Perhaps it'd be interesting to compare some of your results (such as total aquifer area) with that study?
13. The paper often refers to 'perennial' firn aquifers. How can you be sure that the firn aquifers in some places are not completely refrozen late in the frozen season, based on your detection method?

Technical corrections

1. Please check figure color references, subpanel references etc. throughout the manuscript.
2. L78: SMAP was launched on January 31.
3. L115: The range in wavelengths seems too wide for L-band only?
4. Figure 1c,d: A color scale is lacking. Maybe passive microwave data, or a DEM provide a more suitable background than PALSAR?
5. Figure 2a: Minus signs before the values of dzeta are missing
6. Data availability: the last link to the coastline data does not work (when I tried on my laptop).