

Interactive comment on “Winter drainage of surface lakes on the Greenland Ice Sheet from Sentinel-1 SAR Imagery” by Corinne Benedek and Ian Willis

Anonymous Referee #2

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General comments:

This manuscript presents evidence of 6 different winter lake drainages across the Greenland Ice Sheet. The authors use a variety of methods (Sentinel-1 backscatter tracking, optical imagery analysis, photogrammetry) to provide evidence of these lake drainages and quantify drainage volumes. The findings presented in this paper are a valuable contribution to better understanding Greenland Ice Sheet hydrology. My first concern with the paper is that the writing is, at times, hard to follow. This is particularly true within the Methods section where overly wordy sentences take too long to dissect and comprehend. My second concern is that I am not convinced by the evidence for

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the ‘drainages’ of lakes 3 and 4 for reasons which I have further discussed below. Additionally, there is no elevation-change analysis from photogrammetry for these lakes. I understand that this may not be possible with the available Landsat-8 images; however, I don’t believe that the evidence presented is convincing.

Specific comments:

L7 – specify which winters

L36 – Sentence beginning with “Lake drainage events, therefore, . . .” seems out of place within the rest of this paragraph.

L37 – Where do drainage events raise levels of phosphorus, nitrogen and sulfate?

L43 – I don’t believe Koenig et al (2015) documented lake drainages, just the existence of winter-stored meltwater.

L44 – Perhaps combine these two sentences so the second one doesn’t start with “They”.

L47-49 – The sentence beginning with “conventional understanding” does not make sense

L51-53 – This sentence is somewhat unclear to me

L54 - delete “carefully” and “in” in “microwave backscatter in Sentinel-1 satellite”

L76 – what are the dates that determine a “late season” image?

L86 – Would it make more sense to use the last optical image from the summer to define the lake boundaries instead of the maximum?

L111 – What does “lakes across the scene” mean? How large of an area is this?

L112 – What does the last sentence mean?

L125-126 – Again, would it make more sense to use the last optical image from the

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summer to calculate lake volumes instead of the maximum lake area?

L175 – I imagine that partial re-freeze would greatly impact the lake volume. Some water must have frozen as these lakes are no longer on the surface but are buried beneath a layer of ice. Also, I am wondering how the lake area detected from optical imagery compares with lake area detected from S1 imagery immediately prior to collapse? I imagine that the outlines of lake 3 and 4 would look quite different between the optical and S1 imagery.

Table 1 – What are the uncertainties on lake depth and volume?

L190 – With regards to Lake 6: I looked briefly at this lake on GEE during this time period using the HH band. I noticed that surrounding lakes show an increase in backscatter similar to lake 6 with the HH band. Do you have an explanation for this?

Figure 3 – I believe it would be useful to include dates on these images. Also the last line of the caption seems misplaced. Finally, I am not convinced by the ‘drainages’ of lakes 3 and 4. Lake 3 appears more as though there was some partial freeze through of the sides of the lake. For lake 4, it is very hard to discern the lake in the Sentinel-1 image and makes me question whether there is indeed subsurface water here. What are the boundaries used for this lake?

Figure 4 – Do lakes 3 and 4 have enough backscatter data before the jump to indicate “sustained backscatter”?

Figure 5 – This analysis is extremely beneficial and I think it would be useful to show something similar for the other lakes in this study. Also, was the area used for each lake the area outlined in red in the NDWI Max Composite? This seems to miss what appears to be subsurface water for lakes C, G, and H. In fact, it seems that the subsurface part of Lake H also increases backscatter (although not as significantly as Lake 6).

L208 – “These reductions in maximum lake extent contrast with those observed for the many surrounding lakes, which fill to around the same size in adjacent summers”. A

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figure or some evidence of this would be useful.

L218 – What are the uncertainties on the elevation changes from photogrammetry? Do you have any idea why these values are so much larger than the depths from optical images?

Figure 6 – For Summer 2017 lakes 1 and 5: are these just cloudy images? If so, I would emphasize this somehow because it also looks like the lake just isn’t there. Also, a scale would be nice. Once again, I do not find this analysis very convincing for lakes 3 and 4. You mention that they “change shape” but I do not see a significant shape change for lake 4.

Figure 7 – “elevation” should be added before “difference” in the first line of the caption

L269-271 – This is already mentioned and fits better in the methods section

L290 – can Sentinel-1 be used to determine if water is present in the lake at the start of the melt season? Of course it’s harder to interpret than optical imagery but perhaps can give some idea of water presence?

L298 – Did you try DEM differencing? (<https://doi.org/10.1029/2020GL087970>)

L337 – “other hydrological phenomena” such as?

L343 – “what other types of behavior may indicate” is extremely vague

Figure B1 – Are the different colored dots significant? Also, please label the lakes in this image.

Technical corrections:

L26 – Needs a clarifier after ‘This’ to begin the sentence

L45 – “rising water levels in the lake” → “increased lake volume”

L58 – there is an extra space in “changes”

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L93 – change “files” to “images”

L263 – “cover of cloud” → “cloud cover”

L324 – Sentence that begins with “This” with no clarifier

Figure A2 – Two periods at the end of caption

Interactive comment on The Cryosphere Discuss., <https://doi.org/10.5194/tc-2020-70>, 2020.