The Cryosphere Discussions

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Comment on tc-2021-45

Anonymous Referee #1

Referee comment on "The distribution and evolution of supraglacial lakes on 79°□N Glacier (north-eastern Greenland) and interannual climatic controls" by Jenny V. Turton et al., The Cryosphere Discuss., https://doi.org/10.5194/tc-2021-45-RC1, 2021

Summary

Turton et al. present a new analysis of the seasonal development of supraglacial lakes at 79Ë□N Glacier between the 2016 and 2019 melt seasons. Integrating optical satellite observations, *in-situ* meteorological data, numerical modelling, and reanalysis products, they find that extensive ponding observed in 2016 and 2019 were likely related to high air temperatures, boosted by a high liquid precipitation fraction, which increased the limit of lakes to higher elevations on the ice sheet. In contrast, 2018 displayed very low lake coverage, likely related to cold temperatures restricting melt and a large, accumulated snowpack acting as a reservoir for meltwater. The factors that control lake formation in the study area appear to be correlated, at least for surface temperature, with the North Atlantic Oscillation, with high lake extents appearing in years with a strongly negative JJA NAO index.

I believe this paper is a unique contribution to the literature as it is rare to see observational studies in the northeast of the ice sheet. It is also interesting to see a more nuanced consideration of separate climatic variables and wider teleconnections, which aren't often considered in large-scale remote sensing studies of SGLs. Before publication, it would be useful to see more clarity in the communication of the climate data, in order that the reader might form a better narrative of inter-annual variability. I have also outlined further recommendations below.

My area of expertise trends towards ice sheet hydrology and remote sensing rather than climate modelling. However, this paper largely synthesises previously-peer-reviewed datasets, so I will assume that where datasets fall outside my ability to critique them, they are methodologically sound.

Specific Comments

I struggled to follow Section 3.3 - partly because it can be quite dense but mostly, I believe, because it strays from the narrative structure of the rest of the results. Sections 3.1, 3.2, and 3.4 each address individual variables (lakes, topography, and SMB respectively), describing how each of these properties vary between 2016-2019. In contrast, section 3.3.1-3.3.4 each address individual years (2016 to 2019 respectively), describing how a variety of properties (temperature, SWin, precipitation) behave in each year. This abrupt inversion to the logical structure of narrative makes it difficult to follow how the climatic variables change across years. The structure should be consistent across the results, and I believe the paper would be better served by continuing to treat variables separately, highlighting the narrative of interannual change. This would further benefit the paper by making sure each year and variable receives equal treatment: for instance, section 3.3.1 (2016) deals with observational Ta, TSK, and onset, as well as PWRF data, but section 3.3.4 (2019) discusses only observational Ta (for what it’s worth, I found section 3.3.4 more focussed and easier to follow).

As mentioned, a lot of the results are quite dense, which is understandable as a large quantity of data is being described in parallel. However, this can make it hard for a reader to follow all the moving parts, and I believe there could be some changes to the presentation of the data to aid the reader in qualitatively assessing the controls on lake development. A key point of interannual comparison is the total area of lakes, but the way this is visualised in Figure 2 is hard to interpret. It would be easier to follow a line graph, which would be simple to add as a second axis of the Figure 2 panels. Additionally, it might be useful to present lake area data alongside the later data, so that the reader does not have to continually refer back to earlier figures/text on lake development. One way (although I don’t mean to prescribe here, so certainly not the only or best way) of doing this might be to split Figures 5 and 8 into four panels - each representing individual years (mirroring Figure 2) - and including lake area as a second axis. Splitting Figure 5 into panels of individual years would also make it possible to include, perhaps as vertical lines or shaded boxes, the data presented in Table 2 (periods of Ta>0Ë□C and melt ponding). This work would allow for the easy visualisation and comparison of a lot of data that is currently only accessible via text or table, or by comparing disparate figures and tables on different pages. In turn, the authors may be able to simplify much of the denser text that is currently spent describing the temporal variations in these data.

The results tend to treat lake behaviour in bulk, rather than considering the behaviour and/or heterogeneity of individual lakes. I think this is largely fine for the purposes of the study, but it would be nice to see some consideration at specific points. First, Section 3.1 discusses late-season increase in lake area. Is this a general trend common to all lakes (due to, e.g., a melt day / rainfall event)? Or is it a result of a few individual lakes rapidly increasing in area (due to, e.g., reorganisation of the surface drainage system). If the latter, does this also occur at other points, but is masked in the bulk data? Second, it is not discussed how the lakes are draining (rapid vs slow drainage). Can the authors quantify (or at the very least, comment qualitatively on) the relative dominance of drainage modes? Recent work has begun to take an interest in how lake drainage may differ between land- and marine-terminating sectors of the Greenland Ice Sheet (e.g. Williamson et al. 2018a, Chudley et al. 2019), but this is still largely focussed in the SW/W of Greenland. Further observations from this unique sector would be of considerable interest.

On a different note, considering how much time is spent considering the influence of teleconnections in the discussion, I am surprised by their relative lack of attention in the abstract, introduction, and conclusion (and perhaps, also, their lack of inclusion graphically). On a basic level of critique, this means that their inclusion in the discussion comes a bit out of nowhere. However, more interestingly, I do not think that many (any?) observational studies of lake variation consider these modes of climate variability, so some time spent introducing them and their context may be useful for those coming from other areas of the discipline (e.g. optical remote sensing / computer vision), as well as highlighting them in the abstract/conclusion so that the interesting conclusions of this paper can reach the widest audience!

Minor Comments

Abstract

- L10: "Together with two neighbouring glaciers…". Perhaps a broad statistic for a study focussing on just 79N? Why not just say 8%, as per L25?
- L16: "2014 to 2019". The primary ablation seasons considered are 2016-2019, so this might set expectations high. Somehow make it clear that whilst you examine lakes over 2016-2019 melt seasons, you examine influences up to however many months prior?
- L18: "Over 1400 m" > "Up to [x] m"

Intro

- L34 "Low-elevation" is subjective, considering lakes can extend away from the outlet glaciers and up onto the ice sheet proper. Perhaps just 'on the ablation zone of the ice sheet'?
- L38-41 This paragraph focuses on short-term accelerations: perhaps make it clearer that meltwater has also been shown to have negative feedbacks on ice velocity in the medium-long (seasonal-decadal) timescales, at least in land-terminating sectors (e.g. Tedstone et al. 2015; Sundal et al. 2011, etc.).
- L55-56 "...likely underestimated the lake area by 12%". Was this shown in the Sundal *et al.* 2009, or did a later high-resolution study quantify this? A bit unclear as written.
- L58-59 Willamson et al. 2018b also provide a prior example of Sentinel-2 automated lake detection.

- L80 I always understood VHR to be ~1m resolution - does Sentinel-2 really make the cut?

Data and Methods

- L91-95 This introduction to the Sentinel-2 mission is generously detailed, and can probably be safely removed if the intention is to provide a brief overview (as per L91).
- L100-101 It would be nice to at least reference by name the pre-processing steps applied, so that those familiar with the techniques do not have to consult another paper. Those who are still interested in the nuts and bolts then have the option to delve further.
- Paragraph beginning L108 - From the paragraph it seems that the data was cropped to the grounded ice, but how was the spatial limit determined? A fixed outline (e.g. GIMP), user-determined annual grounding lines, etc.?

Results

- L170: These lakes are all rather small, quite close to the cutoff size of 0.015 km^2. Could the dataset be sensitive to this chosen limit?
- L174-179: It would be nice to also see absolute as well as relative changes in this text (see also my comments about Figure 2).
- L80-81: To what extent are these late-season increases spread across all lakes (e.g. due to a high melt day) or more heterogenous (due to, say, reorganisation of the surface drainage system allowing a few lakes to fill)? Is it possible to separate the data by individual lakes?
- L396 - Contextual sentence, probably better belongs in intro or discussion (alongside a citation)

Discussion

- Paragraph beginning L488: Strange absence of reference to any Greenlandic literature here. One of the unique aspects of this study, as identified in the introduction, is the lack of prior SGL studies in the NE of the ice sheet. It is a shame not to see more comparison and contrast to the established SGL literature in the SW and W of the ice sheet.

Conclusion

- Paragraph beginning L577: This paragraph probably belongs at the end of the discussion?

Figures and Tables

- Figure 1: Currently only the land extent is demarcated in Figure 1a - could the ice extent and grounding line(s) be done also?
- Figure 6/7: (i) What do the vectors represent? (ii) Could these two figures be combined into one figure of six panels, so that it is easy for the reader to compare June/July of the same years as well as individual months of different years?
- Figure 10 - Notable compression artefacts in this image - possibly just my download, but it doesn't seem to appear elsewhere so thought I'd mention in case it's common.

References not in the main text

Chudley, T. R., Christoffersen, P., Doyle, S. H., Bougamont, M., Schoonman, C. M., Hubbard, B., & James, M. R. (2019). Supraglacial lake drainage at a fast-flowing Greenlandic outlet glacier. Proceedings of the National Academy of Sciences. https://doi.org/10.1073/pnas.1913685116

Sundal, A. V., Shepherd, A., Nienow, P., Hanna, E., Palmer, S., & Huybrechts, P. (2011). Melt-induced speed-up of Greenland ice sheet offset by efficient subglacial drainage. Nature, 469(7331), 521–524.

Tedstone, A. J., Nienow, P. W., Gourmelen, N., Dehecq, A., Goldberg, D., & Hanna, E. (2015). Decadal slowdown of a land-terminating sector of the Greenland Ice Sheet despite warming. Nature, 526(7575), 692–695. https://doi.org/10.1038/nature15722

Williamson, A. G., Willis, I. C., Arnold, N. S., & Banwell, A. F. (2018a). Controls on rapid supraglacial lake drainage in West Greenland: an Exploratory Data Analysis approach. Journal of Glaciology, 1–19. https://doi.org/10.1017/jog.2018.8

Williamson, A. G., Banwell, A. F., Willis, I. C., & Arnold, N. S. (2018b). Dual-satellite (Sentinel-2 and Landsat 8) remote sensing of supraglacial lakes in Greenland. The Cryosphere, 12(9), 3045–3065. https://doi.org/10.5194/tc-12-3045-2018