The Cryosphere Discussions

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Comment on tc-2021-374

Anonymous Referee #2

Referee comment on "Filling and drainage of a subglacial lake beneath the Flade Isblink ice cap, northeast Greenland" by Qi Liang et al., The Cryosphere Discuss., https://doi.org/10.5194/tc-2021-374-RC2, 2022

Review of "Filling and drainage of a subglacial lake beneath the Flade Isblink ice cap, northeast Greenland" by Liang et al, 2022

The manuscript presents a time-series analysis from 2012-2021 of ice surface elevation change over a subglacial lake beneath the Flade Isblink ice cap. This analysis is a continuation of the initial study and identification of this subglacial lake by Willis et al. (2015), where the lake was identified via a collapsed ice surface indicating rapid lake drainage. Here, surface elevation data from the ArcticDEM and IceSat-2 is used to infer refilling and drainage of the subglacial lake. Ice surface elevation changes are compared to surface meltwater runoff from RACMO to infer the relative amount of surface meltwater input into the subglacial lake. Finally, a speedup of ice surface velocity downstream of the subglacial lake is linked to lake drainage in 2019.

General comments

This is well structured and generally well written manuscript that presents a new and extensive dataset revealing the filling/drainage cycle of a subglacial lake. The data is well presented and the scientific quality of the work is strong. The methods are mostly clear, however, could benefit from a few clarifications. While the manuscript does not represent novel concepts or methods itself, I believe that the observations can help address important scientific questions regarding subglacial lakes, and thus fits well within the scope of The Cryosphere. However, I find that a lot of details in the data/observations are presented, but not thoroughly discussed (for example the switch in surface meltwater drainage pattern after 2012 or the smaller lake drainage volumes in 2019 compared to 2011). This leaves me wondering about the "so what" question, and I believe that the manuscript could put a bit more emphasis on discussing the implications of the findings rather than mostly only presenting the data. Below are some specific points that I believe can be addressed with some minor revisions to improve the manuscript.

- **Ice inflow**: The concept of surface elevation change due to ice inflow and how this was calculated is not clear. I understand that this is explained in Willis et al, 2015, but I think it would help the reader understand if is briefly explained here.
- **Ice surface velocity change:** It is unclear why and how this specific small area was chosen to evaluate changes in ice surface velocity. Is this based on where subglacial water routing is expected (e.g. from water routing models)? I believe that it would be better to include a larger area in the analysis, or present velocity time series from multiple locations downstream. Another idea would be to present an additional map (rather than time series) with the velocity difference between January 2019 and July 2019 to infer the velocity changes in the wider region.
- **Figure 2:** I generally like Figure 2 as one can clearly see the surface elevation rising from 2012-2019. However, the surface lowering in 2019 and uplift afterwards is difficult to see. I suggest separating this time period (2019-2021) into a different graph, maybe in another four subplots to the right? If this way the panels become too small, I suggest putting graph a) and the legend to the bottom of the plot.
- **Discussion of surface meltwater drainage change:** It would be great to add the location of the meltwater drainage through the crevasses from 2012 to Figure 5, so that the changes can be observed more clearly. If possible, I suggest marking the location of these crevasses on one of the panels in Figure 5 or adding a separate panel from 2012. I am also curious of why there is a change in supraglacial hydrology (e.g. changes in surface slope?), and how the different drainage locations (crevasses at the edge of basin versus drainage through moulin within the basin) would affect the subglacial lake and basin volume changes. I feel that this change in meltwater routing is presented, but then not fully discussed.
- **Discussion of lake drainage 2011 vs. 2019:** The lake drainage in 2019 is briefly discussed, however, I think that there could be a bit more discussion on the difference in water release between 2011 and 2019. For example, the possibility that the lake is behind a bedrock ridge is mentioned (L238-240), but why would there be a release of all water in 2011 and not in 2019? And are there other observations of partial lake drainage elsewhere? Similarly, it would be interesting to compare the volume/time of water increase/drainage to other subglacial lakes, e.g. using the inventory by Livingstone et al, (2022). And finally, what implications could the remaining water in the subglacial lake have? E.g. would we expect another lake drainage in a few years, and would this cause a speedup or potentially a GLOF?

Livingstone, S. J., Li, Y., Rutishauser, A., Sanderson, R. J., Winter, K., Mikucki, J. A., et al. (2022). Subglacial lakes and their changing role in a warming climate. Nature Reviews Earth & Environment, 1–19. https://doi.org/10.1038/s43017-021-00246-9

- **Language/grammar**: The manuscript is mostly clear and concisely written, however, there are a few instances where the grammar/language would benefit from some minor editing. I've added a few suggestions in the specific comments, but I probably didn't catch everything.

Specific comments

L20: I suggest replacing "e.g." with "*such as*"

L24: I suggest changing to "..,*which* need to be further quantified"

L38-43, 185: I suggest adding a link to the most recent subglacial lake inventory:

Livingstone, S. J., Li, Y., Rutishauser, A., Sanderson, R. J., Winter, K., Mikucki, J. A., et al. (2022). Subglacial lakes and their changing role in a warming climate. Nature Reviews Earth & Environment, 1–19. https://doi.org/10.1038/s43017-021-00246-9

L45: Previously the abbreviation GrIS is used with "the" GrIS, I suggest making this consistent throughout the text.

L50-54: The figure caption misses a few articles, e.g. "Background und is a Landsat-8…", "The black box shows *the* location of b"

L53: I believe that "Blue lines" be replaced with "*Black* lines" in the text (Figure 2b).

L58: I suggest changing to "as supraglacial meltwater *was* transported to the ice base, *refilling* the subglacial lake."

L59: The sentence structure is a bit misleading; the similar glacial setting of the Flade Isblink ice cap subglacial lake to the GrIS is probably not the "main reason" to study this lake. But studying the Flade Isblink subglacial lake can lead to important improvements in our understanding of subglacial lakes beneath the GrIS. I suggest changing the sentence structure to be more clear.

L75: I suggest outlining the 1500 m buffer zone for the ArcticDEM co-registration to Figure 1b, so that is more clear where this zone is.

L84: I suggest deleting "accurate"

L90: add "…(4 pairs) *that* pass through…"

L91: I suggest changing "pass" to "*passing*"

L97-98: It is not clear to me what is meant by "original elevations", please specify.

L110: It is not entirely clear how the elevation change due to ice inflow is derived. I think adding a brief section to explain the concept and how this was calculated would help the reader better understand.

L120: add "… runoff within *the* catchment…"

L123: add "acquired during *the* 2014-202…"

L145: change to km^2

L156: change to …" at *a* rate of …"

L169: It is not entirely clear to me what the volume of the collapse basin contains; Is it the volume between the pre-collapse ice surface and the post-collapse (and rising) ice surface, e.g. filled with air? Or is it the combination of the subglacial lake water and the ice column above? It might be good to clarify this. From the explanation of "decreasing basin volume", I assume it is the basin volume filled with air. It might also be good to then specify on Figure 4 that the Basin volume change is a volume loss, whereas the ice flow and subglacial lake volume change is a volume gain.

L200: It would be great to show the drainage pattern in 2012 as compared to 2014-16.

L255-257: I appreciate the speculation about the "missing" surface meltwater, but is there any evidence for firn aquifers or ice slabs in this area? From a quick check, it looks like there are some ice slabs marked on the Flade Isblink ice cap by MacFerrin et al. (2019) (dataset here: https://figshare.com/articles/dataset/Greenland_Ice_Slabs_Data/8309777), but it could be worth checking with the exact subglacial lake coordinates.

MacFerrin, M., Machguth, H., As, D. van, Charalampidis, C., Stevens, C. M., Heilig, A., et al. (2019). Rapid expansion of Greenland's low-permeability ice slabs. Nature, 573(7774), 403–407. https://doi.org/10.1038/s41586-019-1550-3

Alternatively, could surface meltwater be routed to the bed through moulins/crevasses at other locations, and then flow somewhere else and not into the subglacial lake? Could other supraglacial lake drainage routes to the bed be observed on satellite imagery?

L271: This last sentence seems a bit blunt and out of context. I suggest rephrasing to emphasize that the new satellite data has *great potential* in detecting and monitoring active subglacial lakes beneath the GrIS.