RESPONSE TO RC1

This manuscript presents findings from six lakes in Southwest Greenland through the compilation and analysis of a plethora of remote sensing datasets. The results provide a thorough and interesting insight into the seasonal cycle of lake surface water temperature (LSWT) and ice cover (LIC), with an assessment of meltwater fed and non-meltwater fed lakes, maritime influence, and meteorological drivers. The manuscript concludes that the interannual variability in LSWT is predominantly driven by air temperature, and highlights the importance of continuing long-term remote sensing efforts and in situ monitoring to further our understanding of lake dynamics in Greenland.
In all, the manuscript effectively collates multiple datasets to investigate lakes in Greenland at an impressive level of detail. I think it also nicely demonstrates how many remote sensing datasets are readily available for constructing valuable and insightful analysis, in regions where remote sensing analysis remains in its infancy. My main feedback to the authors is on how the findings are presented through the manuscript's structure. The Results section contains interpretation of complex datasets alongside the presentation of the results, making it a very long read that I, as a reader, got lost in many times. I also think this structuring inhibits discussion of the findings, with support/comparison from the work of others from Greenland and the wider Arctic. I have made a suggestion of an alternative structure to better convey the results, interpretation, discussion and conclusions to the reader. With re-structuring, along with my other comments (detailed below), I think this manuscript would be a valuable and interesting contribution to The Cryosphere. Thank you for a very enjoyable read!

RESPONSE TO PUT ONLINE: *The authors thank the reviewer for the suggestions to improve the readability of this complex paper especially in relation to the reorganisation of the results and the discussion sections. The authors thank the reviewer for pointing to the Greenland lake databases.*

Main comments

1. The manuscript structure

In its current form, the manuscript's Results section includes interpretation alongside data presentation, which makes it quite extensive and occasionally difficult to navigate. This structure may also reduce the opportunity to provide a more in-depth discussion, as some interpretations are dispersed throughout the Results and Discussion. I recommend restructuring the manuscript to present interpretation in a dedicated section, which would allow for a clearer and more focused discussion supported by relevant evidence from other studies.
The following structure could help improve clarity, with the Results section focusing exclusively on the presented figures and findings, and the Discussion section providing interpretation, supporting references, and comparisons with other studies:
3. Results
3.1 Physical characterization of the study region
3.2 Characterization of the six studied lakes
3.3 LSWT and LIC
3.4 Lake stratification phenology

4. Discussion
4.1 Seasonal trends in LSWT and LIC
4.2 Influence of air temperature and insolation on LSWT and lake stratification
4.3 Temporal variability in LSWT
4.4 Implications for LSWT and LIC studies in Greenland and the Arctic
5. Conclusions
Most of the proposed sections already exist in the manuscript; however, additional discussion that compares findings with other studies would be helpful, particularly in Section 4.3 and 4.4. As the authors note, there are few existing studies on Greenlandic lakes, but incorporating insights from studies on lakes in the broader Arctic region would enhance this section.

RESPONSE: *Thank you for your suggestions. We agree that these changes improve the readability of the paper and have altered the text accordingly.*

2. Greenlandic names for the lakes
I noticed that the Greenlandic names for the lakes studied are not used in this manuscript, despite these names being well documented and available through the Language Secretariat of Greenland (Oqaasileriffik, https://oqaasileriffik.gl) and the QGreenland dataset (Moon et al., 2023, https://qgreenland.org/).
According to the placename database, the lakes presented here have the following names (in New Greenlandic):
Lake A – Eqalussuit Tasiat
Lake B – Nassuttuutaata Tasia
Lake C – Itinnerup Tasersua
Lake D – Tasersuaq Aallaartagaq
Lake E – Ammalortoq (please verify, based on lake extent in Figure 1)
Lake F – Tarsartuup Tasersua
I suggest revising the manuscript to incorporate these Greenlandic placenames rather than the A-F convention. Using the proper Greenlandic names would be a meaningful step toward ensuring accurate place naming and is particularly important given that Greenlandic placenames are sometimes underrepresented or misapplied in Cryosphere/Greenland-based research. Adopting these names would strengthen the manuscript's alignment with locally recognised standards and best practices in geographic terminology.

RESPONSE: *Thank you for pointing out to us the databases. This is very useful! We have updated the names.*

3. Improved figure caption descriptions
In several instances, figure captions are somewhat brief, with much of the detail given in the main text. Adding more information directly in the figure captions, such as data sources and general descriptions, would allow readers to more easily interpret each figure independently. This applies particularly to Figures 1, 2, 4, 5, and 7, and I have included specific suggestions in the minor comments below.

RESPONSE: Thank you. *We have expanded the text in the captions to make clearer the content of the figures.*

Minor comments

L19-21: I wouldn't say that this interaction is between LSWT and ice margin dynamics directly, as there are many other lake processes that influence ice margin dynamics. I would suggest changing this to encompass all lacustrine lake-ice processes, with references to work where processes have been studied in lacustrine settings; for instance calving (e.g. Mallalieu et al., 2021; Minowa et al., 2023), submarine melting (e.g. Sugiyama et al., 2021), lake temperature (e.g. Dye et al., 2021), and GLOFs (e.g. Kjeldsen et al., 2017; Grinsted et al., 2017).

RESPONSE: *We agree. We have changed the text accordingly.*

L25: How sparse are in situ LSWT measurements in Greenland? Could you provide an overview of the few in situ studies available?

RESPONSE*: We have found few studies reporting temperature measurements on lakes:*

- *[Saros et al. 2016, Thermal stratification in small arctic lakes of southwest Greenland affected by water transparency and epilimnetic temperatures, https://doi.org/10.1002/lno.10314] The paper reports temperature measurements taken in 2013 on 22 lakes and then in 2014 taken again on a subset of 8 lakes in southwest Greenland around Kangerlussuaq. All the lakes are very similar being quite small (surface area between 0.022 and 0.824 km2) and moderately deep (9–36 m). None of them are connected to the ice sheet.*
- *[Hazukova et al 2024, Earlier ice melt increases hypolimnetic oxygen despite regional warming in small Arctic lakes, https://doi.org/10.1002/lol2.10386] The paper presents temperature measurements taken between 2011 and 2022 in west Greenland on 13 lakes (mainly) between the ice sheet and Kellyville in Kangerlussuaq. All the lakes are very similar being quite small (surface area between 0.6 and 0.37 km2) and moderately deep (10.9–28.8 m). The 13 lakes are a subset of the 22 of [Saros et al 2016].*
- *[Hazukova et al 202, Under Ice and Early Summer Phytoplankton Dynamics in Two Arctic Lakes with Differing DOC, https://doi.org/10.1029/2020JG005972] Temperatures for 2 lakes (of the 22 used in [Saros, 2016]) collected in 2019 are used for the study)*
- *[https://doi.org/10.17897/BKTY-J070] In situ monitoring of two lakes in Kobbefjord in south-west Greenland (Badesø / Kangerluarsunnguup Tasia: 64,13°N, 51,36°W and Qassi Sø: 64,15°N, 51,31°W) at 2m and 10m from 2009 to 2019.*
- *[Kettle et al 2004, Empirical modelling of summer lake surface temperatures in Southwest Greenland, https://doi.org/10.4319/lo.2004.49.1.0271] For ~ 30 lakes across a E–W transect from the ice sheet near Kangerlussuaq to the outer coast south of Sisimiut, temperatures were measured in the period 1998-2000 (although part of the lakes were monitored only in 1998-1999 and the rest only in*

1999-2000). Same dataset as [Anderson et al 1999], [Brodersen et al 2000], [Brodersen et al 2002].

- *[Anderson et al 1999, Limnological and paleolimnological studies of lakes in south-western Greenland, https://doi.org/10.34194/ggub.v183.5207] Lake surface water temperature measured in 1998-2000 on >30 lakes. Same dataset as [Kettle et al 2004], [Brodersen et al 2000], [Brodersen et al 2002].*
- *[Brodersen et al 2000, Subfossil insect remains (Chironomidae) and lake-water temperature inference in the Sisimiut–Kangerlussuaq region, southern West Greenland, https://doi.org/10.34194/ggub.v186.5219] Lake surface water temperature measured in 1998 on 17 lakes, in 1999-2000 on 31 lakes. Same dataset as [Kettle et al 2004], [Anderson et al 1999], [Brodersen et al 2002].*
- *[Brodersen et al 2002, Distribution of chironomids (Diptera) in low arctic West Greenland lakes: trophic conditions, temperature and environmental reconstruction, southern West Greenland, https://doi.org/10.1046/j.1365-2427.2002.00831.x] Lake surface water temperature measured in 1999 on 29 lakes. Same dataset as [Kettle et al 2004], [Anderson et al 1999], [Brodersen et al 2000].*

We have added references to these in the article.

L26-27: I beg to differ on this point. I think yes, there are logistical costs and monitoring challenges in Greenland. However, there are research institutes and local populations that live relatively close to lakes for monitoring. I would say instead that monitoring is limited to these areas close to settlements, and access to remote regions (i.e. far from a well-connected settlement) remains challenging.

***RESPONSE**: Agreed.*

L43-44: “We have included in our study lakes that connected to…” >> “We have included in our study lakes that are connected to…”
L53: “(masl)” >> “(m a.s.l.)”
L53: “The edge of the GrIS…” >> “The margin of the GrIS…”

***RESPONSE**: Thank you for noticing it! This has now been changed.*

L64-66, 66-68: This overview of climatic conditions, next to the GrIS and towards the coast, is in reference to a relatively old study (Anderson et al., 2001). Please can this be updated reference to newer studies, or if such a reference does not exist, can you summarise the climatic conditions from data sources that are representative of the area. Data sources that I think could be useful are the DMI/Asiaq weather station networks for land observations, and the PROMICE weather stations for near-/on-ice observations (the KAN station transect in particular). Another option could be to look at updating the summary with the ECWMF ERA-5 land data that is used in this study.

***RESPONSE**: We agree. We have updated the information on climatic conditions.*

L73-74: “glacier terminal lakes” is not a common term. I think a more used and suitable term is “ice marginal lakes” or “proglacial lakes”.

***RESPONSE**: Thank you. Changed.*

L83-85: Please provide the spatial resolution of the DEM product here.

***RESPONSE**: Done.*

L89: What is "reasonable accuracy"? Can you provide an error estimate here for this dataset?

***RESPONSE**: It is very difficult to estimate an error for the bathymetry. In the paper, a validation is carried out for a small portion of the 1.5 million lakes using various metrics and the authors reports a "reasonable accuracy". The lake bathymetry is derived with a model which has been selected among few candidates. The selection is based on the comparison of the predicted maximum depth with the observed value for about 1500 lakes giving NRMSE = 0.17, and ρ = 0.94 for the selected model. Also, a cross validation has been carried out. The actual validation of the bathymetry reported on the paper consists on a visual comparison of the predicted bathymetry with the observed bathymetry for 8 lakes. Regarding the six lakes of this paper, we have found that the maximum depth of one of them is unrealistic and we have pointed it out in the paper.*

Figure 1: Where have the satellite mosaic, Greenland outline, and outlines for the lakes been sourced from? I also think panel A can be inset into panel B, rather than having panel A the same size as panel B.

***RESPONSE**: The Greenland outline has been sourced from the python basemap module, the lake outline has been created by us based on the ESA CCI Land Cover waterbody mask at 300m resolution. We have added the references. The figure has been changed according to the reviewer suggestion.*

L103: "respectevely" >> "respectively"

***RESPONSE**: Changed.*

L103-106: I understand that the relevant references explain in detail how LSWT is derived from these satellites, but for the reader here, can you provide a summary of the methodology for deriving LSWT.

***RESPONSE**: Thank you for this suggestion. We have now added some text to summarise the methodology.*

L107-108: I am not sure I fully understand this. Have LSWT and LIC been upsampled from 1 km (approx.) to a different spatial resolution? I see in Figure 5 a demonstration of the number of observations for one of the lakes, but I remain unsure. Also, for Figure 5, are these observations from the ESA CCI Lakes dataset? Clarification in figure caption is needed, along with a scalebar to demonstrate the scale of each pixel in the figure.

***RESPONSE**: The grid of the satellite measurement is not regular and therefore difficult to handle when used. The LSWTs have been retrieved in the original grid and then regridded to a regular grid of 1/120° (which is about 1km at the equator) so that the LSWT data are easier to handle. The number of observations reported in Figure 5 are the observations from the ESA CCI Lakes dataset. Each dot represents a 1/120°x1/120° resolution cell of the regular grid. We will add some clarification in the caption of the figure.*

L119: Please include a reference/DOI to the dataset in the CEDA archive here.

***RESPONSE**: OK. Done.*

L125: "detemine" >> "determine"

***RESPONSE**: Changed.*

L125: Please define the SST acronym on the previous sentence. Also, you don't need to define the CEDA acronym again here as you have previously defined it on L115

***RESPONSE**: We have now defined SST and removed the CEDA acronym.*

L181-184: How has this inference been made? From in situ observations/studies? Please can you provide clarification in the text, perhaps using the papers that you refer to.

***RESPONSE**: We have used the temperature of maximum density as a proxy for stratification onset and breakup. However, stratification depends on the lake's depth, size and shape. Some small and shallow lakes wind may not experience thermal stratification since the wind could be strong enough to contrast it and mix the entire lake. We now further clarify these limitations.*

Figure 2: The text description in L197-199 should be included in the figure caption, along with the exact Landsat 8 and ASTER products shown here.

***RESPONSE**: We have added a description of the Landsat 8 product.*

Figure 3: "…(seeData and Methods)." >> "…(see Data and Methods)."
L219: "Meltwaters" should not be plural. Please change this to "Meltwater" and modify the rest of the sentence to reflect this.

***RESPONSE**: Changed*

Figure 4: Specify where the lake area, elevation and minimum observed temperature data is sourced from in the caption.

***RESPONSE**: Done.*

Figure 4: I think the colour bar for elevation and the y axis for maximum observed temperature should be switched, as intuitively you would associate elevation with the y axis and temperature with the colour bar.

***RESPONSE**: We have exchanged the axis to make the figure clearer.*

L228-230: Please re-word this sentence as I think there are some connecting words missing.

***RESPONSE**: This sentence*
'All the six lakes have maximum distance from the closest land (Carrea et al., 2015) less than 2 km which is a useful measure for the size of the lakes in the context of LSWT remote sensing.'
has now been reworded as in the following:
'All six lakes have a maximum distance from the closest land (Carrea et al., 2015) of less than 2 km.'

L231: "However, observing these six lakes remain challenging." >> "However, observing these six lakes remains challenging."
***RESPONSE**: Changed.*

Table 1: Max. depth and Mean depth rows need a superscript "a" next to them to indicate that they are from the GLOBathy database.
***RESPONSE**: Changed.*

L255-256: I think these two sentences between Sections 3.3 and 3.3.1 can be removed as they don't describe any of the results presented in this paper.
***RESPONSE**: Done.*

Figure 6. This is a really nice plot effectively showing the seasonal LSWT and LIC results. My only comment is regarding the top panel of the LIC results - The y-axis (labelled % ice) should be a percentage (i.e. 20, 40, 60%) instead of a decimal value (i.e. 0.2, 0.4, 0.6).
***RESPONSE**: Done.*

L267: "...even at time of maximum LSWT." >> "...even at the time of maximum LSWT."
***RESPONSE**: Done.*

L283: "melt water" >> "meltwater"
***RESPONSE**: Done.*

L290: I see you refer to the 2m air temperature as "Tair" since defining this acronym in Table 2. I think you should either define this acronym when the dataset is first introduced (L131) or drop the acronym and refer to it as "2m air temperature" throughout the manuscript.
***RESPONSE**: Changed.*

Figure 7: How are the seasonal cycles for each lake location sampled from the ERA5-Land reanalysis dataset? For example, are they the data from the lake centroid position or an average based on a defined lake extent? Can this be added to the figure caption, and perhaps also L175-177.

***RESPONSE**: The data are from the centre of the lake (ERA5 Land is at about 9km resolution, regridded at 0.1°). This information has now been added to the figure caption.*

L321: Can you provide a percentage of ice-free conditions for each monthly lake mean LSWT? And will this include instances where lakes are completely ice-covered? If these are included, surely this will have a marked influence on the monthly lake mean LSWT? I would like to see this better quantified in the text.

***RESPONSE**: The number of observations used to compute the monthly lake mean is reported below the LSWT plot for each of the months. In June the number of observations used is less than in the other months shown. This is because sometimes the lake was not ice-free (completely of partially). Please not that the monthly lake mean has been computed on the anomalies and not on the LSWTs directly because anomalies have greater spatial correlation than absolute LSWTs and therefore less data points are needed for a good estimate.*

L342: "…warming of the meltwaters during their passage…" >> "warming of the meltwater during its passage…"
L329-330: Please put brackets around the values and quantified uncertainty.
L369: I am not exactly sure what "meltwater flows" refers to here. Do you mean "meltwater discharge" (i.e. Tair is expected to have a direct influence on the amount of meltwater discharge).
L411: "glacial melting dynamics" >> "glacial melt processes"
L428: "don't" >> "do not"
L435: "Furthermore, lake glacier interaction mechanisms…" >> "Furthermore, lake-glacier interactions and lacustrine processes…"
L439: "behaviors" >> "behaviours"

***RESPONSE**: Thank you for spotting these issues. We have made the necessary changes.*

L427-440: This is a powerful statement to make at the end of this manuscript, and absolutely demonstrates the need for in situ observations to ground truth remote sensing studies in Greenland. What about the wider Arctic? I would like to see Arctic studies brought in here to compare to, particularly those that estimate LSWT from remote sensing (e.g. Dye et al., 2021). I think this study is much more thorough in its analysis than most, and you can effectively demonstrate this with comparison to other studies in the Arctic.

***RESPONSE**: Thank you for the suggestion and the reference. We have now added some comments also on ASTER LSWT and reference the paper on the lakes in Sweden (Dye at al 2021).*
We have added after this sentence:
'For smaller lakes, higher spatial resolution satellites, such as Landsat 8, can offer observations at a finer spatial resolution (100m) but a much longer revisiting time is often insufficient for a good description of the temporal variations.'
the following sentence:
'An example is the use of the high spatial resolution sensor ASTER to characterise the thermal behaviour of lakes in Arctic Sweden where the measurements considered were very sparse in time (Dye et al, 2021).'

We have also modified the following sentence (modifications in bold):
*'These are **the** current limitations of the remote sensing data, **which will be partly addressed with improvements in spatial and temporal resolution such as those provided by the satellites for thermal remote sensing such as TRISHNA [**J. -P. Lagouarde et al., "The Indian-French Trishna Mission: Earth Observation in the Thermal Infrared with High Spatio-Temporal Resolution," IGARSS 2018 - 2018 IEEE International Geoscience and Remote Sensing Symposium, Valencia, Spain, 2018, pp. 4078-4081, doi: 10.1109/IGARSS.2018.8518720.**] to be launched after 2025**.'*

References

Dye, A. et al. (2021) Warm Arctic Proglacial Lakes in the ASTER Surface Temperature Product. Remote Sensing 13(15), 2987. https://doi.org/10.3390/rs13152987

Grinsted, A. et al. (2017) Periodic outburst floods from an ice-dammed lake in East Greenland. Sci Rep 7, 9966 (2017). https://doi.org/10.1038/s41598-017-07960-9

Kjeldsen, K. K. et al. (2017) Ice-dammed lake drainage in west Greenland: Drainage pattern and implications on ice flow and bedrock motion. Geophys. Res. Lett. 44(14), 7320-7327. https://doi.org/10.1002/2017GL074081

Mallalieu, J. et al. (2021) Ice-marginal lakes associated with enhanced recession of the Greenland Ice Sheet. Global and Planetary Change 202, 103503. https://doi.org/10.1016/j.gloplacha.2021.103503

Minowa M., Schaefer M. and Skvarca, P. (2023) Effects of topography on dynamics and mass loss of lake-terminating glaciers in southern Patagonia. Journal of Glaciology. Published online 2023:1-18. doi:10.1017/jog.2023.42

Moon, T. A., M. Fisher, T. Stafford, and A. Thurber (2023). QGreenland (v3.0.0) [dataset], National Snow and Ice Data Center. doi: 10.5281/zenodo.12823307

Sugiyama, S. et al. (2021) Subglacial discharge controls seasonal variations in the thermal structure of a glacial lake in Patagonia. Nat Commun 12, 6301. https://doi.org/10.1038/s41467-021-26578-0