RESPONSE TO RC2

The author used remote sensing observational data to analyze the surface water temperature changes of six lakes in West Greenland during the period from 1995 to 2022, aiming to identify the key factors influencing these changes. Overall, the author employed a wealth of remote sensing data, conducted extensive analyses, and drew some interesting conclusions, making this paper promising for publication. I have provided some major comments, and other minor suggestions will be raised during the next round of review to help further improve the paper.

RESPONSE*: Thank you to the reviewer for the constructive comments which will help improving the paper.*

Firstly, the author chose six lakes as the study objects, which represent lakes in the West Greenland region. However, why were only these six lakes selected? How representative are these six lakes? Would it be possible to consider expanding the study to include a larger number of lakes to more comprehensively reflect the trends and characteristics of lake changes in West Greenland? These questions merit further discussion.

RESPONSE*: These lakes were selected since they are large enough to be sensed by the high-quality infrared instruments used for the LSWT and LIC data. These instruments offer high temporal resolution measurements (satellite revisit depends on instrument characteristics and it can be between one and three days) and a spatial resolution of roughly 1km. We did not select more lakes since retrieving LSWT from satellite is challenging given that the size of the lakes in this region is comparable with the satellite resolution. We have selected the six lakes including lakes directly connected to the ice sheet, lakes totally disconnected in land and lakes close to the shore. We have also carried out a spatial characterisation of the lakes in the region using Landsat (a high spatial resolution instrument but with very low revisiting time) to show how representative the six lakes are of lakes in the region.*

In the introduction section, I suggest adding a detailed review of the existing research progress. This would help readers better understand the current state of research in the field and its gaps, thereby clarifying the potential contribution of the paper.

RESPONSE*: We have conducted a thorough review of the literature, and we have included all the relevant papers on this topic in the introduction.*

Furthermore, the structure of the introduction could be improved. The current logical arrangement is somewhat unclear, and I recommend reordering it around the core theme of "research significance – research progress – problems to be addressed," making the article more organized and easier to follow.

RESPONSE*: Thank you for the useful feedback. We have restructured the introduction for better readability.*

Regarding the Digital Elevation Model (DEM), the author did not use the higher resolution ArcticDEM but instead used other versions of DEM. Could the author consider using the higher resolution ArcticDEM to improve the accuracy of the study results?

***RESPONSE**: We used the ASTER DEM for the physical characterisation of the study region which we have conducted using Landsat 8 data. Landsat8 and ASTER data are at the same spatial resolution (30m). We have also found a Greenland specific DEM [Howat, I.M., A. Negrete, B.E. Smith, 2014, The Greenland Ice Mapping Project (GIMP) land classification and surface elevation datasets, The Cryosphere, 8, 1509-1518, doi:10.5194/tc-8-1509-2014] which also has the same resolution and has been derived mainly from the ASTER DEM. Moreover, since Landsat 8 data are at 30m resolution we conclude that higher resolution DEM was not necessary for this study.*

Additionally, regarding the lake bathymetry data, the author did not specify its accuracy in the study area. Given the importance of bathymetric data precision for the analysis, could the author further elaborate on the quality of this data and its potential impact on the results?

***RESPONSE**: It is very difficult to estimate an error for the bathymetry. In the paper [Khazaei, B., Read, L.K., Casali, M. et al. GLOBathy, the global lakes bathymetry dataset. Sci Data **9**, 36 (2022). https://doi.org/10.1038/s41597-022-01132-9], 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. However, currently this is the best and consistent product for global lake bathymetry.*

Optical imagery in polar regions is often affected by cloud cover and weather conditions. Has the author taken any effective measures to minimize these influences when selecting the remote sensing data? For example, did the author choose images with less cloud cover or weather disturbance?

***RESPONSE**: The LSWT and LIC values have been retrieved only where no clouds where present using algorithms to test for it. For LSWT a quality value reflecting (also) the degree of success of the water-only detection algorithm was used to select the data. The validation of the LSWT through comparison with in situ data distributed globally show a median satellite minus in situ difference of -0.15°C and robust standard deviation of ~0.5°C for the best quality data showing an excellent agreement which we showed that is also stable in time. Furthermore, the retrieval algorithm is physics based*

and therefore we expect a stable behaviour also for lakes that we cannot directly validate. (see this paper for details: Carrea, L., Crétaux, J., Liu, X., Wu, Y. et al. Satellite-derived multivariate world-wide lake physical variable timeseries for climate studies, Scientific Data, 10, https://doi.org/10.1038/s41597-022-01889-z, 2023.)

Regarding the reliability of ESA CCI's LSWT and LIC data in Greenland, is there any related validation study or literature supporting their applicability in this region? If no such validation exists, could the author explore the suitability of these data further and address potential sources of error?

***RESPONSE**: The ESA CCI LSWT dataset has been created with a physics-based algorithm, and it has been validated using in situ temperature data for lakes distributed globally some of which are at latitude above 55° in environments comparable with those in Greenland. In addition, the LSWT retrieval algorithm has been selected to be based on physics specifically because this gives good reasons to expect stable performance across domains in time and space that cannot be directly easily validated such as Greenland. See details on the ESA CCI LSWT dataset on: Carrea, L., Crétaux, J., Liu, X., Wu, Y. et al. Satellite-derived multivariate world-wide lake physical variable timeseries for climate studies, Scientific Data, 10, https://doi.org/10.1038/s41597-022-01889-z, 2023).*
We have added in the paper some information about the dataset and its validation (see also response to previous comment).

The paper utilizes various remote sensing datasets for analysis, but the spatial resolution of these datasets differs significantly. How did the author handle these resolution discrepancies? Were adjustments made to account for differences in the data sources? These aspects should be further elaborated in the paper.

***RESPONSE**: This is a very good point. We made adjustments where possible and we considered lake averages rather that considering each of each pixel on the lake in order to draw consistent conclusions. We now include these details in the paper: In section 2.9.2 we have added that we estimate the climatological curves for the lake centre and we have described how we have selected the data from the various datasets; In Section 2.9.4 we have added that we have compared trends and examined correlations on lake means and we described how we extract the data.*

Despite the extensive data analysis conducted, much of the work focuses on data processing and presentation. Could the author add more in-depth discussions to the paper? For example, what are the reasons behind the differences in surface water temperature changes across the lakes? What environmental or climatic factors might be driving these variations? A deeper discussion of these mechanisms would help uncover the underlying causes rather than just presenting the data.

***RESPONSE**:*
We appreciate the suggestion to include more in-depth discussions on the mechanisms driving the observed variations. In response, we have investigated the relationships between lake variables (LSWT and LIC) and atmospheric variables (air temperature and

solar radiation). Additionally, for lakes near the coastline, we compared LSWT with the SST of the nearest sea area. Our findings indicate that the largest differences stem from the connection with the ice sheet and the influence of ice melt on the lakes.

To address this further, we have conducted a more detailed analysis of these relationships and revised the manuscript to include new subsections in the Discussion section. These subsections focus on:

1. Seasonal trends in LIC and LSWT, providing insights into how these variables evolve throughout the year.

2. The influence of air temperature and solar radiation on LSWT and stratification, exploring the atmospheric drivers behind these changes.

3. Temporal variability of LSWT, highlighting patterns and fluctuations over time. Implications for LSWT and LIC studies in Greenland and the Arctic, offering broader context and relevance for future research.

These additions aim to uncover the underlying mechanisms driving the observed changes and enhance the interpretative depth of our findings.

Regarding the structure of the paper, there are some long paragraphs that could make reading difficult for the audience. It is recommended that the author breaks up these sections into shorter paragraphs to improve readability. Furthermore, while the author presents a large amount of data and discussion, this might dilute the focus of the paper. It is advisable that the author clearly defines the central theme of the paper and structures the analysis around it, which would help readers better understand the paper's key points.
Finally, many of the figures appear too simplistic and at times may confuse the reader. The author should consider improving the design of the figures by adding necessary details and explanations to make them more expressive and easier to interpret. For example, Figure 1 appears to be overly simplified and lacks essential geographical parameters. It would be helpful if the author could add relevant annotations or additional explanations to make the figure more informative and readable.

***RESPONSE**:*
Thank you for your constructive feedback. We appreciate your suggestions and will address each point to improve the clarity and focus of the paper.

Paragraph structure: We agree that some paragraphs may be lengthy. We have now broken them into shorter sections to enhance readability and make the text more digestible for the audience.
Central theme and focus: We understand the concern regarding the breadth of data and discussion. We have now refined the paper by clearly defining the central theme, ensuring that the analysis is more closely aligned with this theme.

Figure design: Thank you for pointing out the simplicity of the figures. We have now revised the figures to include more details and annotations, particularly for Figure 1. We also now add geographical parameters and relevant explanations to ensure the figures are informative and easy to interpret.

We appreciate your time and thoughtful suggestions, and we are confident these revisions will improve the overall quality of the paper.