Living Planet Fellowship

BI-MONTHLY REPORT

Investigating Greenland's ice marginal lakes under a changing climate (GrIML)

Penelope How

Geological Survey of Denmark and Greenland (GEUS)

Prepared by	**Penelope How**
Approved by	**Signe Bech Andersen & Andreas P. Ahlstrøm**
Reference	**BR_GrIML**
Date of Issue	**2024-11-06**

1 OBJECTIVES OF WORK

This bi-monthly report represents the mid-stage of Phase 4, the final phase of GrIML (starting January 2022) according to the proposed project timeline (Fig. 1). By the end of Year 2, the following objectives should be completed:

a. A series of ice marginal lake inventories should have been generated, which cover the Sentinel-era between 2017 and 2023
b. Ice marginal lake inventories should have been validated, using the pre-existing ESA CCI ice marginal lake inventory and other complementary datasets such as in situ observations and oblique terrestrial time-lapse observations
c. Time-series analyses for individual lake studies should have been generated, where lakes are selected based on scientific or societal relevancy

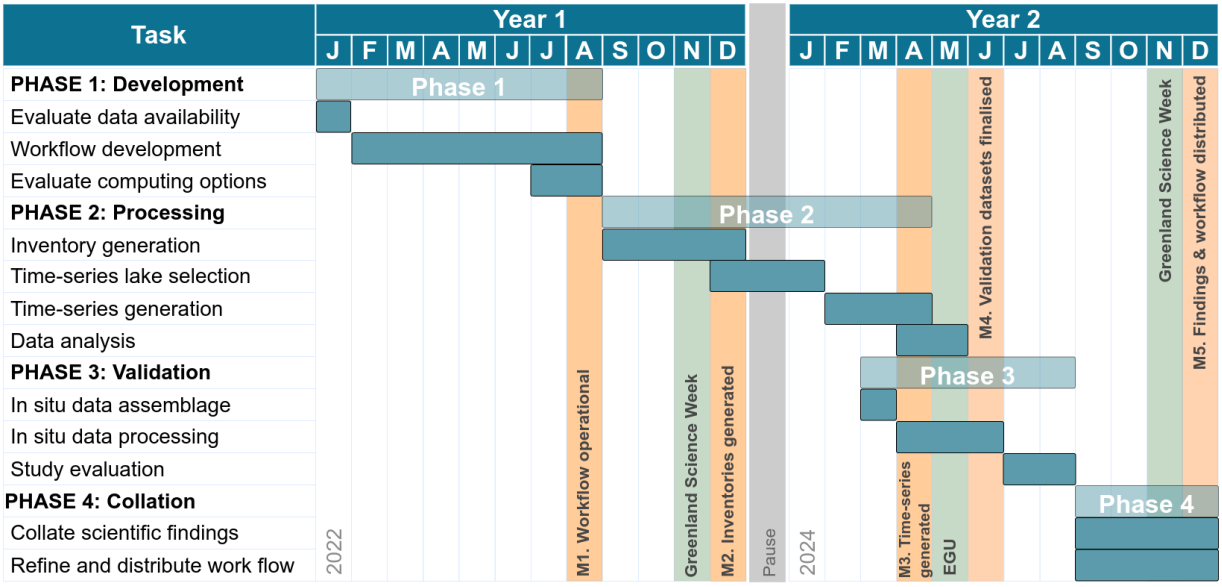

Figure 1. GrIML proposed project timeline. Note that due to parental leave, the project is offset by one year exactly as denoted by the pause between Year 1 and Year 2 (i.e. end of Year 1 is January 2024 and the end of Year 2 is January 2025).

2 WORK PERFORMED

2.1 Ice marginal lake inventory series dataset release

The ice marginal lake inventory series is drafted as a dataset release on the GEUS Dataverse (https://dataverse.geus.dk). When released, it will have the following DOI: https://doi.org/10.22008/FK2/MBKW9N. In addition, a tutorial is included with the GrIML processing pipeline with guidelines for how to retrieve the dataset and handle the dataset in Python, with examples of plotting, statistical analysis and time-series analysis through cross-inventory comparison (https://griml.readthedocs.io/en/latest/tutorials-data.html) (How et al., In prep, a).

2.2 Ice marginal lake inventory series surface temperature record, 2016-2023

Since the last reporting period, the surface temperature record has been derived and added to the ice marginal lake inventory series; calculating the average surface temperature estimate for each lake over each inventory year. Surface temperature estimates are derived from Landsat 8/9 scenes acquired in the month of August for each inventory year, in order to limit the risk of ice-cover conditions. Comparison to in situ surface (2 metres) temperature records from two lakes in southwest Greenland indicate a strong correlation (>0.9) to the Landsat-derived estimates. An error estimation of ±0.88°C can be determined by the average difference from all data points across the two lake sites.

A slight increase in surface lake temperature is evident, with the average lake surface temperature increasing from 5.78±0.88°C in 2016 to 6.16±0.88°C in 2023 (Figure 2). Fluctuations year on year vary, with instances of lake temperature falling between annul time steps (e.g. falling from 5.17±0.88°C to 4.44±0.88°C from 2017 to 208), rising (e.g. from 5.59±0.88°C to 6.16±0.88°C from 2022 to 2023), and remaining consistent (e.g. from 5.56±0.88°C to 5.59±0.88°C from 2021 to 2022) (How et al., In prep, b).

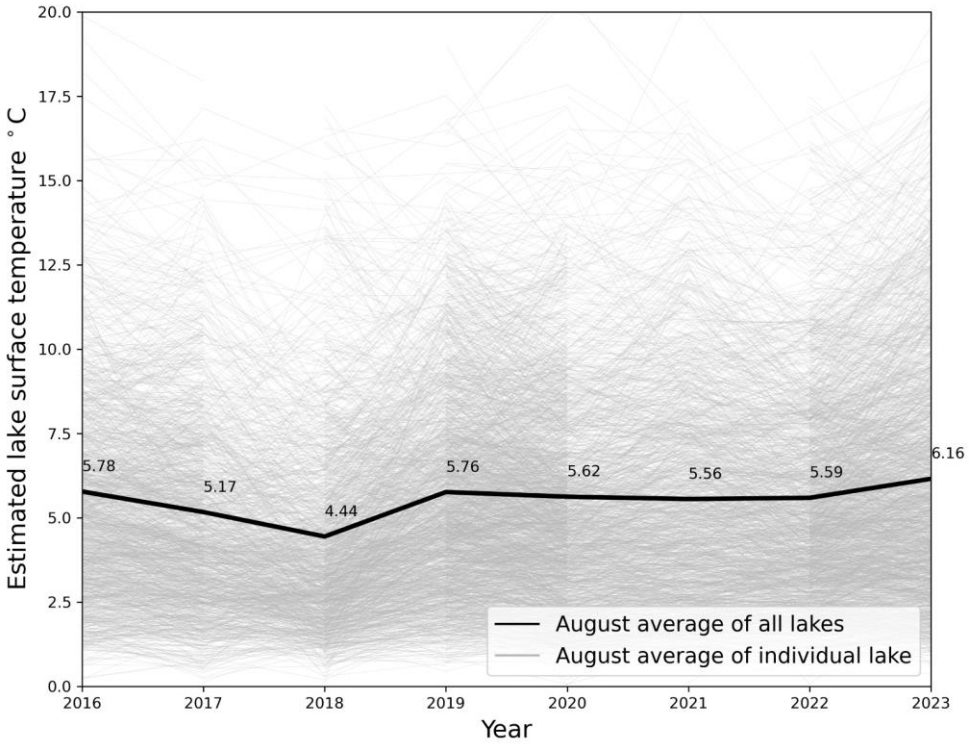

Figure 2. Average surface lake temperature estimates from the month of August at each inventory lake for each inventory year (2016-2023) (grey), with the average of all lakes overlaid (black). Surface lake temperature is derived from Landsat 8 and Landsat 9 OLI/TIRS Collection 2 Level 2 surface temperature data product. Averages are calculated from all available scenes acquired from the month of August to limit the risk of mis-estimates due to ice-covered conditions. Taken from How et al. (In prep, b).

Surface lake temperature estimates vary by region, with ice marginal lakes over the SE, SW and CE regions displaying warming trends of 0.87°C, 0.36°C and 0.62°C between 2016-2023, respectively (Figure 3). Lakes over the two most northerly regions, NW and NO, demonstrate cooling trends of –0.05 and –0.18°C between 2016-2023. Little difference is discerned when comparing lakes adjacent to the Ice Sheet margin versus lakes with an Ice Cap/periphery glacier margin; in particular at the NE, NO, NW, CW and SW margins. The largest differences are evident in the SE region, with Ice Cap lakes being markedly cooler than Ice Sheet lakes; for example, the average surface temperature in 2023 is 2.52°C warmer at the Ice Sheet lakes than the Ice Cap lakes (Figure 3, top panel; How et al., In prep, c).

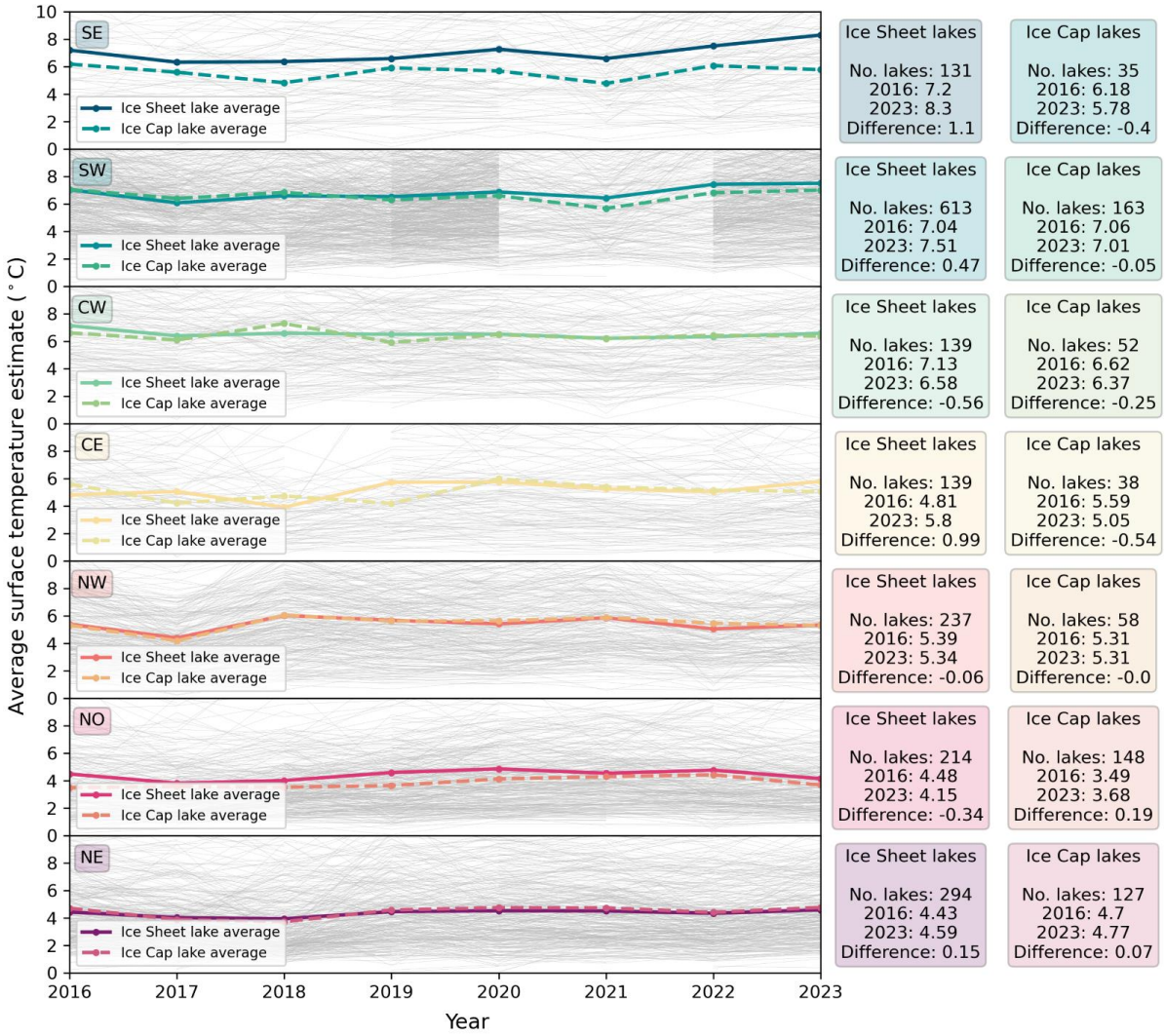

Figure 3. Average surface lake temperature estimates (from the month of August) grouped by margin type (Ice Sheet, solid lines; and Ice Cap, dotted lines) and region (SE, SW, CW, CE, NW, NO, NE) for each inventory year (2016-2023). Taken from How et al. (In prep, c)

3 CONCLUSIONS

The ice marginal lake inventory series dataset has been finalised and ready for release under a cite-able DOI (https://doi.org/10.22008/FK2/MBKW9N). Included with the dataset is easy-to-access guidelines for retrieving and handling the dataset in Python (https://griml.readthedocs.io/en/latest/tutorials-data.html). Lake surface temperature estimates have been updated and added to the ice marginal lake inventory series, revealing interesting trends in warming/cooling, with a high level of certainty based on comparison to in situ lake temperature measurements. The dataset, processing pipeline and findings from the dataset culminate as three separate publications (details provided subsequently), which are currently in preparation.

4 REFERENCES

How, P. *et al.* (In prep, a) GrIML: A Python package for investigating Greenland's ice marginal lakes under a changing climate. Target journal: Journal of Open Source Software.
How, P. *et al.* (In prep, b) The Greenland ice marginal lake inventory series from 2016 to 2023. Target journal: Earth System Science Data.
How, P. *et al.* (In prep, c) An 8-year record of Greenland-wide ice marginal lake change. Target journal: Scientific Reports.