Living Planet Fellowship

BI-MONTHLY REPORT

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

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1 OBJECTIVES OF WORK

This bi-monthly report represents the beginning of Phase 4, the final phase of GrIML (starting January 2024) according to the proposed project timeline (Fig. 1). By the end of Year 2, the following objectives should been 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

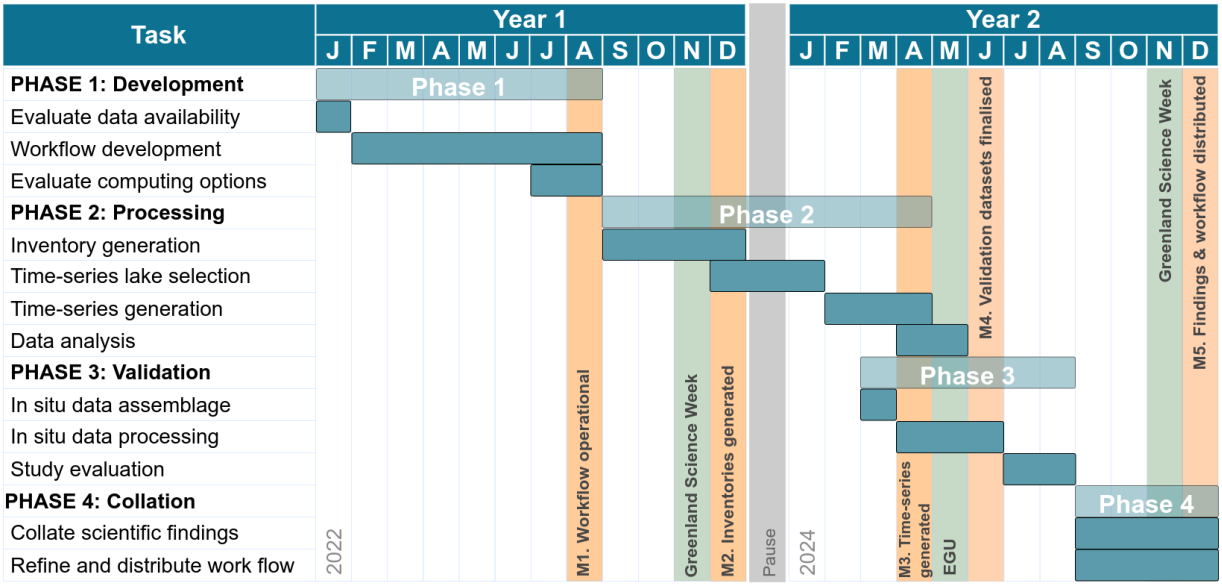

Figure 1. GrIML proposed project timeline. Note that due to parental leave, the project is offset by one year exactly as denoted by the pause between Year 1 and Year 2 (i.e. end of Year 1 is January 2024 and the end of Year 2 is January 2025).

2 WORK PERFORMED

2.1 Ice marginal lake inventory series generation, 2016-2023

Production of the ice marginal lake inventory series has been finalised, classifying lakes as a series of annual datasets between 2016 and 2023 (Fig. 2). Lakes are classified using three classification methods (SAR backscatter thresholding, multi-spectral classification, and sink detection) across three remote sensing datasets (Sentinel-1, Sentinel-2 and ArcticDEM).

The dataset consists of 8 inventories (2016-2023), containing XX lake classifications which represent the presence and areal extent of XX unique lakes across the margins

of the ice sheet and periphery glaciers (Figure 2). The identifying number of each lake is consistent across the inventory series, so time-series analysis will be possible.

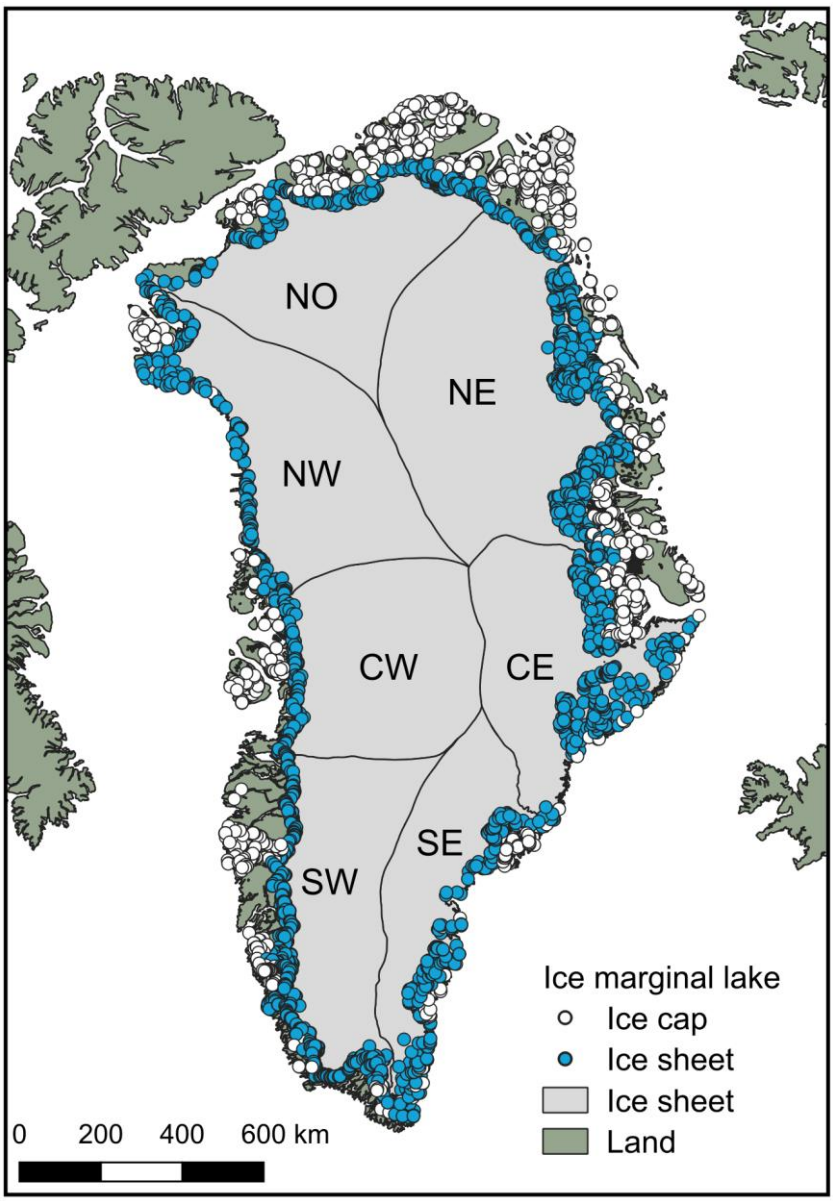

Figure 2. An overview of the ice-marginal lake inventory series, 2016-2023. Each mapped point denotes a unique lake, mapped across the Greenland Ice Sheet margin (blue) and the surrounding Greenland ice caps and glaciers (white). The catchment regions are those defined by Mouginot and Rignot (2019). Figure from How et al. (In prep).

2.2 *Inventory series analysis*

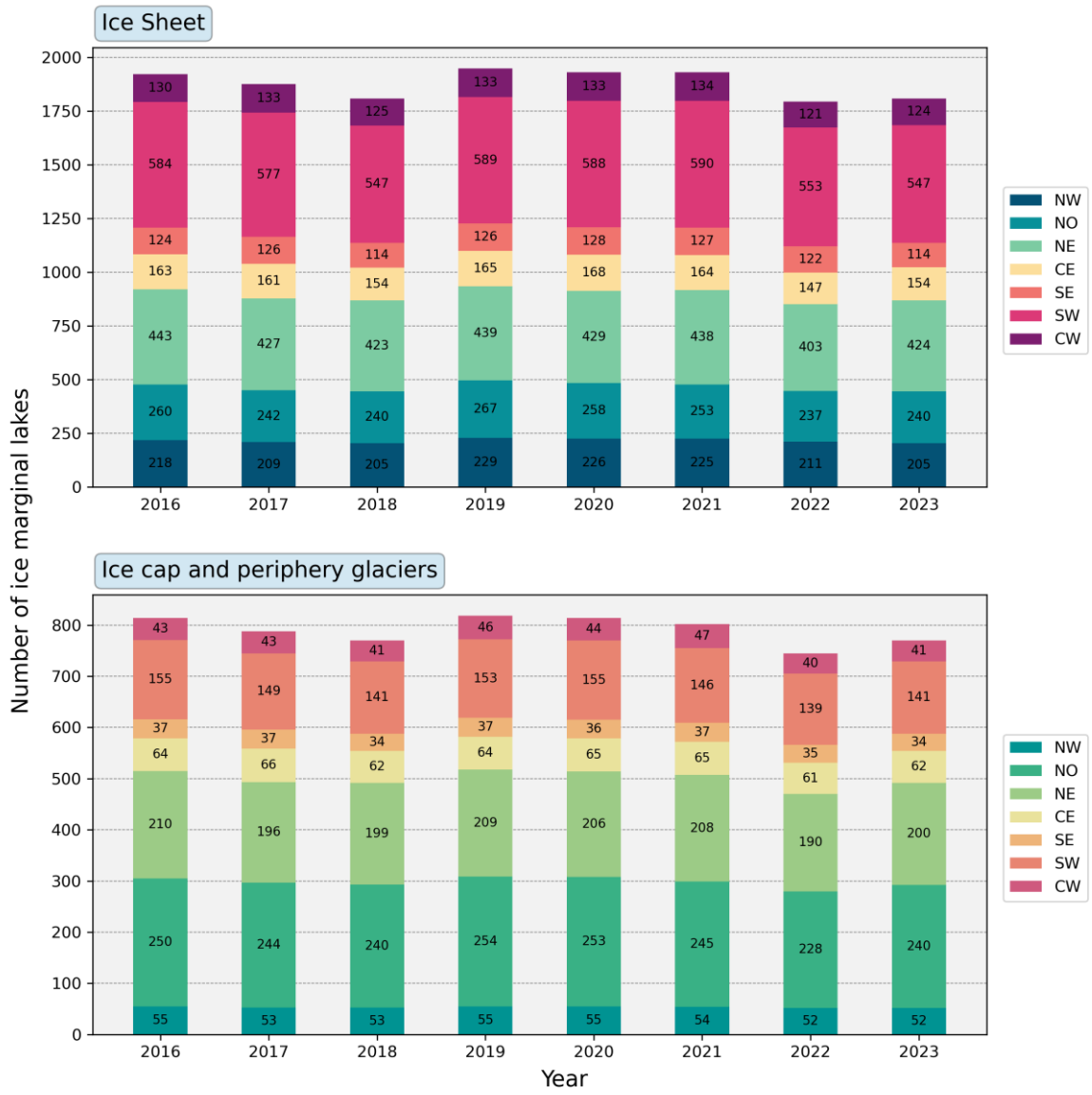

Figure 3. Change in the abundance of ice marginal lakes around the ice sheet margin (a) and the surrounding ice caps and periphery glaciers (b). Each of the coloured bars denote lake abundance per region for a given year of the inventory series (2016-2023), with annotated numbers corresponding to the number of lakes classified for each region. Figure from How et al. (In prep).

Initial analysis across the inventory series shows that lake abundance is largely unchanged between 2016-2023; with fluctuations between 1794 (2022) and 1948 (2019) at the ice sheet margin, and between 745 (2022) and 818 (2019) at the margins of periphery glaciers.

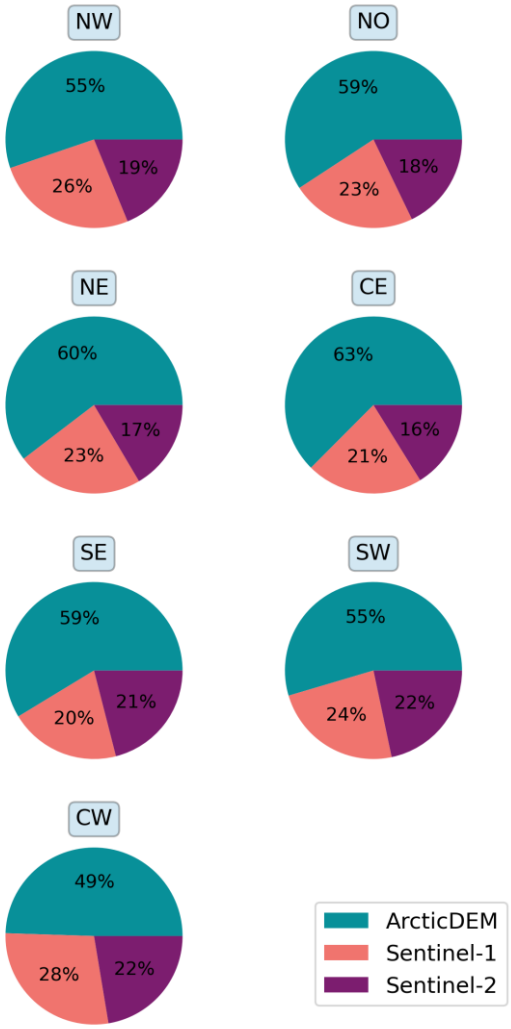

Figure 4. An overview of the performance of each classification method per region - ArcticDEM sink detection, Sentinel-1 backscatter classification and Sentinel-2 multi-spectral classification. Each pie chart denotes the percentage of lakes classified from each method for all inventory years. Figure from How et al. (In prep).

It has been previously highlighted in How et al. (2021) that the three methods of classification performed differently across Greenland due to a big span of environmental settings that reflect Greenland's large latitudinal range. This regional preference is evident across the inventory series, with a distinct change in the method performance between the east and west coast (Figure 4). Across the eastern regions (i.e. NE, CE, SE), 61% of classifications are from the indirect sink detection method (ArcticDEM), on average, whilst 39% are from the direct backscatter and multi-spectral methods (Sentinel-1 and Sentinel-2, respectively). Across the western regions (i.e. NW, CW, SW), the average is 53% of classifications from sink detection and 47% from the SAR backscatter and multi-spectral methods. This difference is likely to indicate differing conditions in the lakes (e.g. different suspended sediment loads and ice-cover conditions), which highlights the importance of adopting multi-method classification approaches in Greenland-wide remote sensing studies.

3 CONCLUSIONS

This report denotes the finalisation of the first version of the Greenland ice marginal lake inventory series. Initial analyses show that lake abundance is generally unchanged between 2016-2023. However, the performance of each classification method is inherently linked to region, highlighting the value of multi-method classification approaches when performing remote sensing work across Greenland. By the next reporting period, it is planned to conduct further analysis to examine areal extent and surface water temperature changes in lakes across the inventory time-series. In doing so, it is hoped to gain a deeper understanding of changes in ice marginal lake conditions during the Sentinel-era.

4 REFERENCES

How, P. *et al.* (2021) Greenland-wide inventory of ice marginal lakes using a multi-method approach. *Sci Rep*. **11,** 4481. https://doi.org/10.1038/s41598-021-83509-1

Mouginot, J. & Rignot, E. (2019) Glacier catchments/basins for the Greenland Ice Sheet. *UC Irvine Dataset*. https://doi.org/10.7280/D1WT11

5 PUBLICATIONS AND TALKS

5.1 Presentations

- How, P. et al. Investigating Greenland's ice-marginal lakes under a changing climate, 2016-2023. European Polar Science Week 2024, *poster presentation*

5.2 Publications

- How, P. et al. Greenland ice marginal lake inventory series from 2016 to 2023. In prep. Target journal: Earth System Science Data.
- How, P. GrIML: A Python package for investigating Greenland's ice marginal lakes under a changing climate. In prep. Target journal: Journal of Open Source Software