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 signifies the start of GrIML Year 2 (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

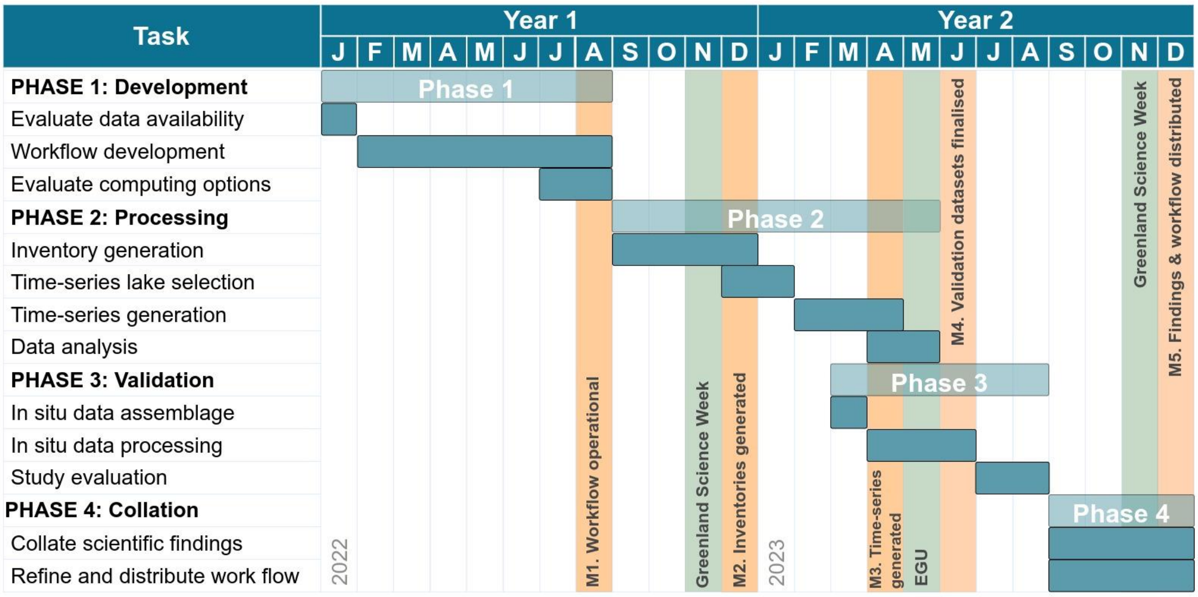

Figure 1. GrIML proposed project timeline. At the time of this bi-monthly report, we are nearing the end of Year 1 at the end of December 2023. Note that due to parental leave, the project is offset by one year exactly (i.e. end of Year 1 is January 2024, not January 2023; and the end of Year 2 is January 2025, not January 2024).

2 WORK PERFORMED

2.1 GrIML 2017 inventory lake surface temperature

Lake surface temperature estimates have been added to the GrIML 2017 ice marginal lake inventory metadata content. Surface temperature estimates are derived from the Landsat 8 Collection 2 Level 1 (L8L1) land surface temperature product. A scale factor has been applied to correct to lake surface temperatures rather than land surface temperatures (Dyba et al., 2022):

$$Water\ temperature = 2.9 \times B10 - 2.07 \times B11 + 48.48$$

where the thermal bands B10 and B11 represent the Top of Atmosphere Reflectance in Kelvins. This scale factor is based on in situ measurements from lakes in Poland to form a multiple linear regression model. A strong correlation has previously been found between the scale factored L8L1 values and in situ measurements (R=0.91) (Dyba et al., 2022).

The lake surface temperature values represent estimates from the aggregated lake profile (i.e. lakes classified with multiple classification methods are merged into one), with a mean temperature value provided that is derived from every overlapping pixel. The mean temperature value for each lake is derived from the L8L1 scenes that coincide with the inventory scene acquisition period – in the case of the 2017 inventory, scenes were collected from 01/07 - 31/08/2017. It is hoped that interesting trends and anomalies will be identified from this information over the series of inventories.

2.2 Hagen Bræ Nunatak Lake time-series, NE Greenland

Hydraulic potential analysis has been performed to determine the routing of water during GLOF events at Hagen Bræ (Fig. 2). Initial results indicate that water is routed through the southern region of the glacier tongue. A medial moraine is suspected of blocking water flowing to the main subglacial system route through a topographic overdeepening in the northern region of the glacier tongue. However, a substantial delivery of water to the bed (for example, during a GLOF event) could overcome the medial moraine, depending on the bed type.

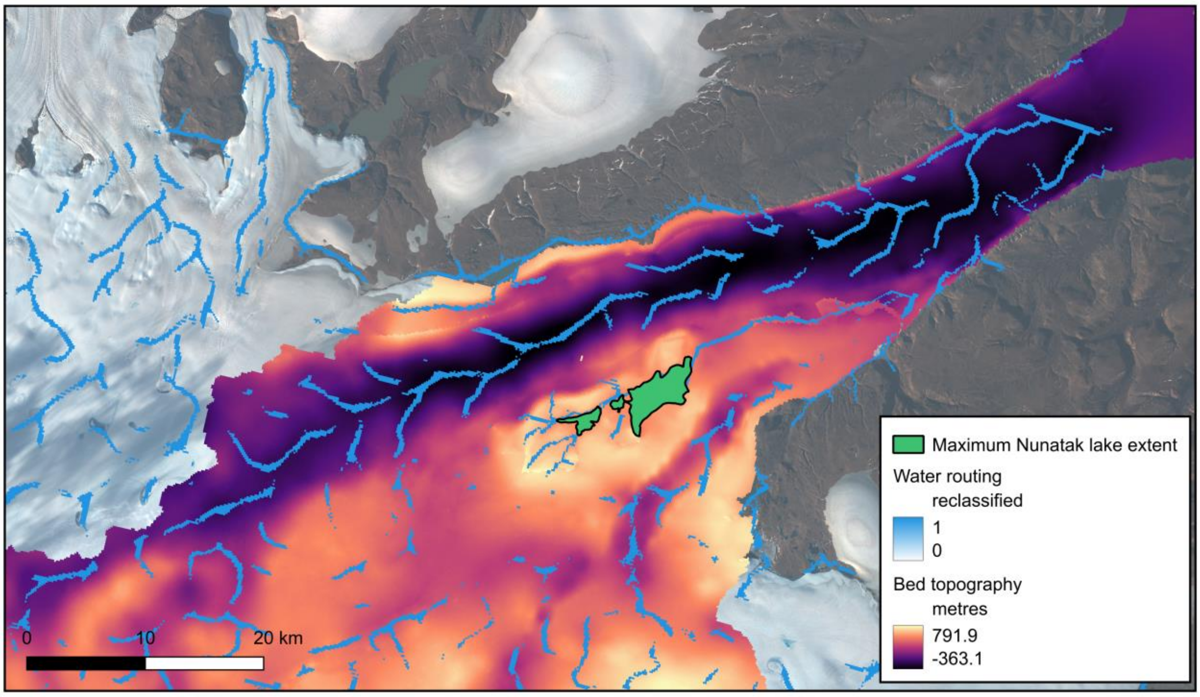

Figure 2. Hydrological potential water routing at the bed of Hagen Bræ. The surface Digital Elevation Model (DEM) is provided by the ArcticDEM mosaic (Porter et al., 2023); and the bed DEM is provided by BedMachine (Morlighem et al., 2017; 2022). Modelled flow routes were

determined using the flow accumulation algorithm in the Matlab TopoToolbox (Schwanghart and Scherler, 2014), where modelled flow routes were determined from all grid cells draining at least 200 upstream cells to identify larger flow routes. Taken from How et al. (In prep).

In addition, work has continued comparing ice velocities from the region to identified GLOF events from the Nunatak Lake. Initial results presented in Fig. 3 show that the 2021 quiescent phase ("slow-down") of Hagen Bræ coincides with the 2021 GLOF event. No other coinciding events occur in the presented time-series from 1992 to 2024. Further analysis is needed to investigate the processes behind this event.

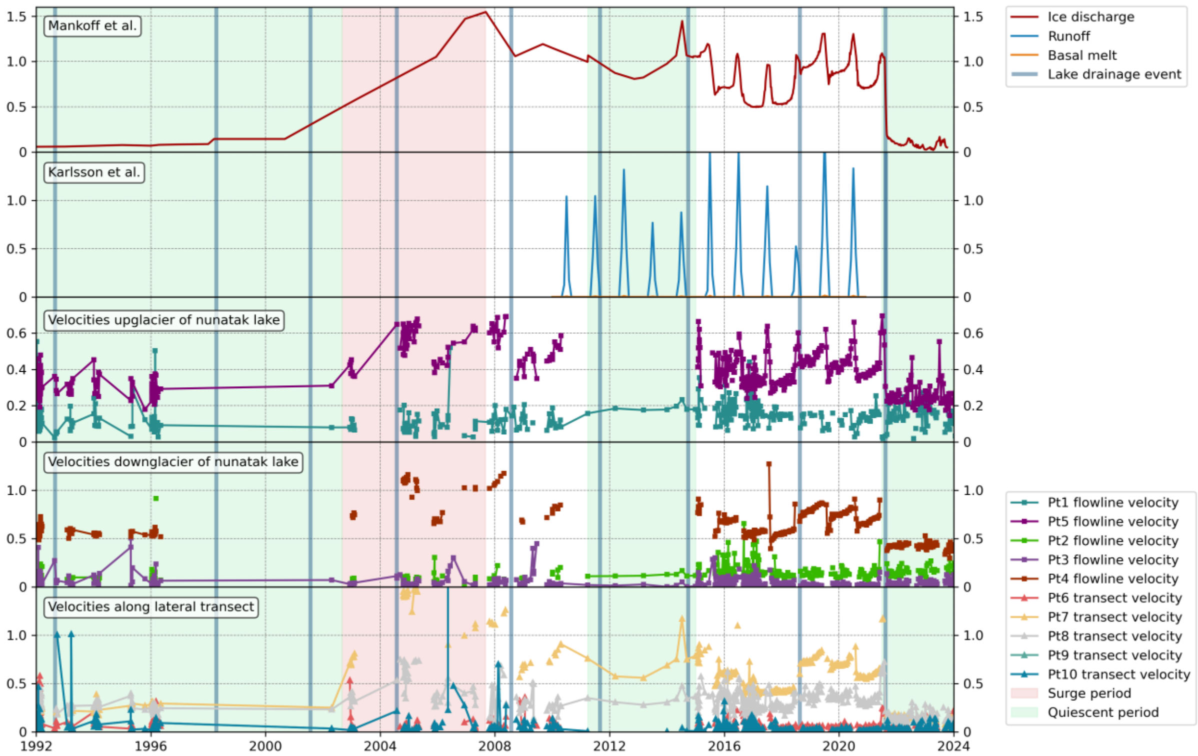

Figure 3. Time-series of dynamics at Hagen Bræ, with ice discharge (Mankoff et al., 2021), runoff and basal melt (Karlsson et al., 2023), and ice velocity (Solgaard et al., 2020; 2021) (top to bottom). Drainage events from the Nunatak Lake are superimposed on top of the time-series. Taken from How et al. (In prep).

3 CONCLUSIONS

The GrIML ice-marginal lake inventory work has progressed with the addition of lake surface temperature measurements, derived from Landsat 8 Collection 2 Level 1 (L8L1) land surface temperature product. This information will be valuable to improve understanding of ice marginal lake evolution through time and will be an insightful addition to the GrIML inventory series.

Hydraulic potential and ice dynamics analyses show greater insights into the processes at the GLOF lake on Hagen Bræ. Water is routed to the southern region of the glacier tongue, through an intermediary system. However, it is suspected that a substantial delivery of water to the bed in this area could overflow into the primary hydrological system in the northern region of the glacier tongue. Comparison of ice velocities to GLOF events demonstrate that the 2021 slowdown event on Hagen Bræ coincided with a substantial GLOF event. No other such instances are identifiable in the presented time-series from 1992-2024. Further investigation is needed to explain this phenomenon.

4 REFERENCES

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Morlighem, M. *et al.* (2022). IceBridge BedMachine Greenland, Version 5. [Indicate subset used]. Boulder, Colorado USA. NASA National Snow and Ice Data Center Distributed Active Archive Center. https://doi.org/10.5067/GMEVBWFLWA7X [2024-03-06].

5 PUBLICATIONS AND TALKS

5.1 Talks and posters

- **How, P.** (2024) Investigating Greenland's Ice Marginal Lakes in a Changing Climate. *GLIMPSE seminar, Copenhagen, Denmark*.