Subglacial landforms beneath the Northeast Greenland Ice Stream

Detailed bed topography from swath radar - preliminary results

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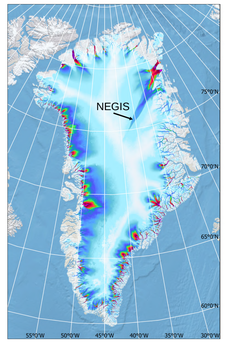
Background

A prominent feature of the Greenland Ice Sheet is the Northeast Greenland Ice Stream (NEGIS), which constitutes a 600 km long ice stream draining into three fast-flowing marine-terminating outlet glaciers. NEGIS is currently causing significant discrepancies between numerically modelled and observed ice surface velocities, so elucidating the driving factors that determine the location and characteristics of this ice stream is highly important. This survey aims to provide insight into the subglacial environment of the ice stream.

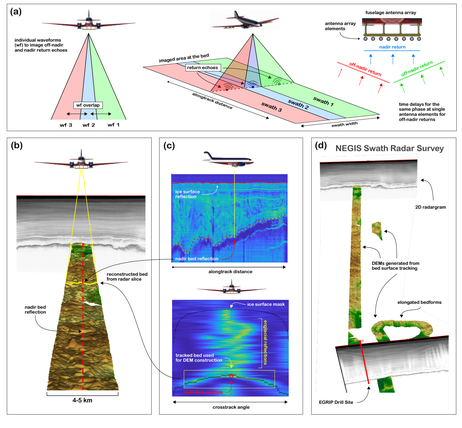
The basal conditions of NEGIS at EastGRIP have been inferred as **high-porosity, water-saturated till**[1]. Elongated subglacial bedforms at the shear margins have been identified as shear margin moraines, composed of unconsolidated deformable till[2]. Small-scale elongated subglacial landforms in the centre of the ice stream are also oriented parallel to ice flow[3]. NEGIS is **strongly interconnected to the subglacial water system** at the onset[4], and experiences episodic transport of water through the subglacial environment downstream[5].



3D swath radar

The bed topography is imaged with 3D swath radar processing, using the MUltiple SIgnal Classification (MUSIC) algorithm[6]. This uses phase differences in the arrival of backscattered energy to estimate the direction of arrival of off-nadir signals at the radar antenna array, mapping the subsurface in three dimensions[6]. The bed reflector can then be digitised in cross-track images, forming the basis for surface tracking.

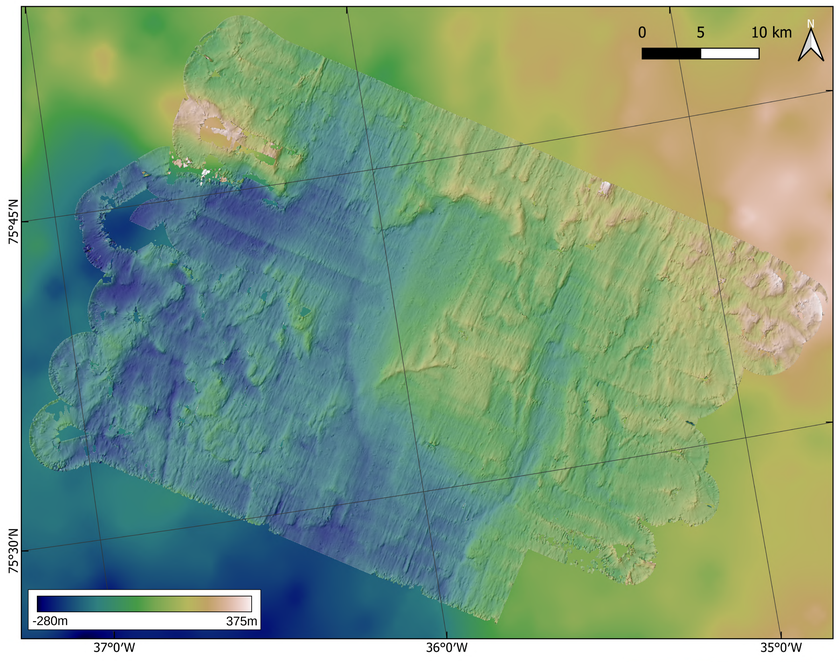
This method can produce **fine-resolution (25 m) estimates of bed topography over a 2 km swath** in this survey, comparable to DEMs used to map deglaciated landscapes. Cross-track resolution is independent of the survey design, allowing for imaging of glacier bedforms at high resolution[7].



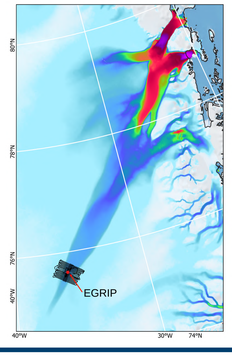
Questions to consider

1. What can the subglacial landforms tell us about the basal conditions?
2. Does subglacial water routing have an impact on bedform formation and potentially have a control on the overlying ice stream?
3. How do landforms underneath a currently actively deforming ice stream compare to those in deglaciated landscapes?
4. Could the maturity of these bedforms give an indication of the duration that NEGIS has been active?

Digital Elevation Model

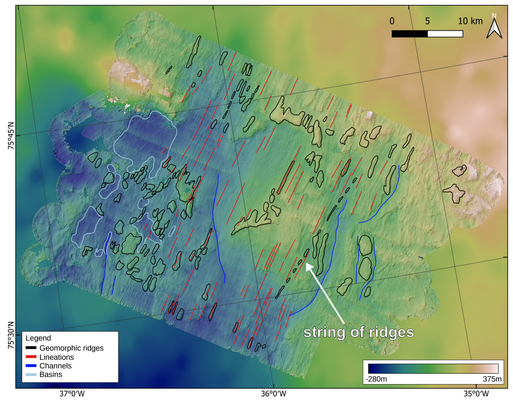


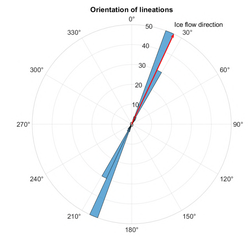
The radar data used to generate the DEM was collected in the 2018 and 2022 summer seasons, using the AWI airborne ultra-wideband radar system. The survey site was located in the upstream region of NEGIS, with the majority of flightlines oriented cross-flow. We produce a new high-resolution DEM of the subglacial topography at a resolution of 25 m. The data covers a 40 km by 60 km area, surrounding the East Greenland Ice Core Project site. At present, all indications of subglacial bedforms beneath NEGIS rely on single or a few radar or seismic lines, with their exact extent and location unknown. This dataset **therefore provides the only comprehensive overview of the subglacial environment.**

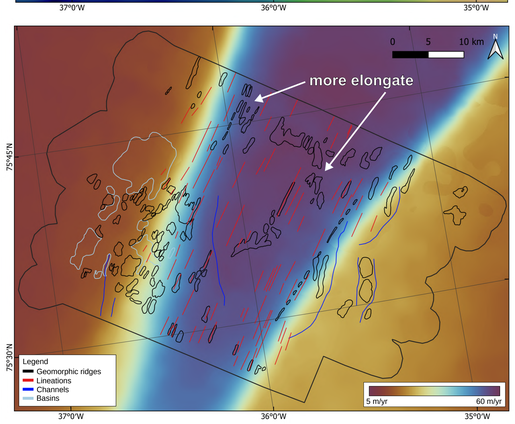


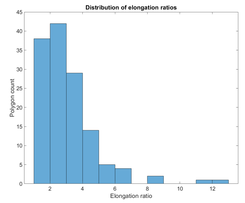
Subglacial geomorphology

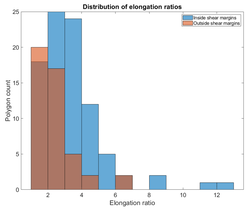
Geomorphological mapping of the subglacial landforms was carried out to determine the characteristics of the bedforms. These were categorised into **geomorphic ridges, lineations, channels and basins**.
The lineations demonstrate **alignment with the prevailing ice flow direction**, and are concentrated within the shear margins of the ice stream. Elongation ratios of the geomorphic ridges indicate drumlins, however the shape of the ridges do not always indicate this. However, within the shear margins of the ice stream, the ridges display higher values of elongation. Channels are oriented generally in the direction of ice flow, and can be found both inside and outside of the ice stream margins. Basins appear to be concentrated outside of streaming flow.
A **continuous string of ridges aligned with the shear margin** of the ice stream at first look demonstrates similarities to an esker, or R channel.











Outlook

Interpret the subglacial landforms in the context of the basal environment and subglacial hydrology of NEGIS.
Compare to the morphological continuum of deglaciated landscapes.

References
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