Response of the north-western Greenland Ice Sheet to recent and future climate change (Ref IAP-16-65)

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In partnership with **Durham University, Department of Geography & British Antarctic Survey (CASE partner)**

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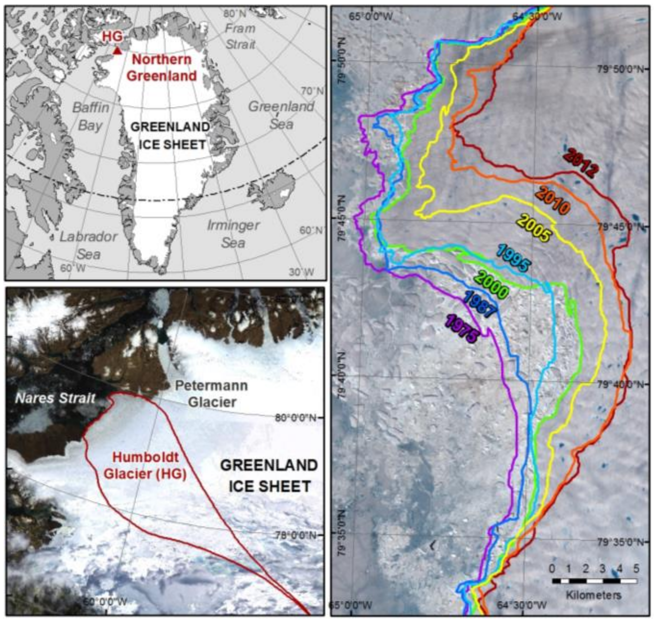
Key Words **Greenland Ice Sheet, climate change, outlet glacier, Arctic, Numerical modelling**

Overview

The Arctic is warming rapidly and temperatures are forecast to rise by up to 8 °C by 2100, which is double the global average (IPCC, 2013). Consequently, ice loss from the Greenland Ice Sheet (GrIS) has increased more than four-fold in recent decades and continues to accelerate (Shepherd et al., 2012; Helm et al., 2014). This ice loss has resulted in 0.75 mm a^{-1} of sea level rise, and the ice sheet is predicted to contribute 9 cm by 2050 (Helm et al., 2014). Mass loss has occurred via both negative surface mass balance and accelerated discharge from marine-terminating outlet glaciers. These fast-flowing conveyor belts of ice allow the GrIS to respond rapidly to climate warming and transmit changes far into the interior (van de Broeke et al., 2009). However, the factors controlling their dynamics are poorly understood and our capacity to predict their future behaviour is limited.

To date, studies of outlet glacier behaviour have primarily focused on the south-east of Greenland, where dynamic ice losses began in the early 2000s. More recently, however, north-west Greenland glaciers have begun to accelerate, retreat and rapidly lose mass (Moon et al., 2012). Although changes have occurred across the region, nine glaciers have dominated the observed retreat, many of which have accelerated substantially and are backed by major basal troughs (Carr et al., in review). It is therefore crucial to understand the present and near-future behaviour of these outlets, and their potential contribution to sea level rise.



Marked changes have also occurred in northern Greenland (Carr et al., 2015), where many glaciers have lost large sections of their floating tongues. This has had a variable impact on inland ice dynamics, potentially due to differences in the amount of buttressing provided by these floating sections. Northern Greenland drains approximately 40% of the ice sheet by area, meaning that it could contribute substantially to sea level, if climatic warming begins to affect inland ice. Despite this, northern Greenland has received comparatively little study and the relative impact of external controls (air temperatures, sea ice buttressing and ocean warming) is unclear. Sea ice appears to be an important control in certain areas of north-west Greenland (Moon et al., 2015), but its relative importance elsewhere in northern and western Greenland is unclear and has yet to be fully assessed via numerical modelling.

The key research questions that this studentship will address are:

1. How have the dynamics of north-western Greenland glaciers evolved over time and which glaciers are the primary sources of ice loss?
2. Which climatic forcing factors are north-western Greenland glaciers most sensitive to and how does this vary spatially?
3. How might these glaciers behave in the future and how is this influenced by their basal topography?

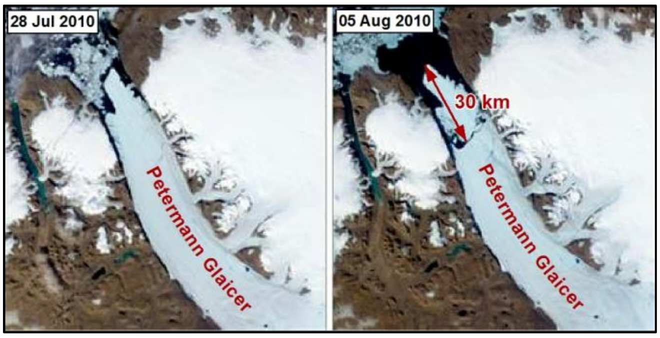
Methodology

The project will utilise new, high resolution satellite imagery, such as Sentinel 1 and Landsat 8 data, to assess changes in glacier dynamics in detail. Specifically, satellite imagery will be used to determine changes in glacier velocities and frontal position over time. This will be combined with pre-existing data on glacier surface elevation (e.g. ICESat data) to investigate the evolution of ice dynamics in northern and north-west Greenland. This will be evaluated in relation to surface meltwater inputs and formation / disintegration of the ice melange, in order to establish the influence of these forcing factors on glacier behaviour.

Numerical modelling will be used to assess glacier sensitivity to external controls and the influence of basal topography on future glacier behaviour. Specifically, the student will use a state-of-the art two horizontal dimensional numerical model, which has been developed by Dr. Gudmundsson at British Antarctic Survey (BAS). This model has been proven effective for similar applications (e.g. deRydt et al., 2015). It will applied to glaciers identified during the first phase of the project (e.g. glaciers showing the most dynamic change, those located on major basal over-deepenings) and will be set up initially using the remotely sensed data compiled during this component of the project. The numerical model will be used to further investigate the impact of surface melting and sea ice buttressing on glacier behaviour. It incorporates an ice mélange (a seasonal ice shelf, composed of sea ice and icebergs), and includes related processes that have yet to be included in most models. The numerical modelling work will involve the student working at British Antarctic Survey, With Dr Gudmundsson.

Timeline

Year 1: Remotely sensed data collection and processing.
Year 2: Data analysis and initial numerical modelling.
Year 3: Numerical modelling of key glaciers.
Year 4 (6 months): Completion of analysis and thesis write-up.



Training & Skills

Training will be provided in GIS software packages, including ArcGIS, ERDAS, ENVI and NEST Array. The student will learn to compile and analyse remotely sensed data from a variety of sources and sensors. They will be given specific, focused training on the use of the numerical model by Dr GH Gudmundsson, who has written and developed the model. The model is written in Matlab and so the student will be given training in the use of this software.

References & Further Reading

Carr, J.R. et al. 2015. Basal topographic controls on rapid retreat of Humboldt Glacier, northern Greenland. Journal of Glaciology, 61 (225)137-150.

De Rydt, J., et al. 2015. Modelling the instantaneous response of glaciers after the collapse of the Larsen B Ice Shelf. Geophysical Research Letters, 42. 5355-5363. 10.1002/2015GL064355

Moon, T., et al. 2012. 21st-century evolution of Greenland outlet glacier velocities. Science 336 (6081) 576-578.

Moon, T et al., 2015. Seasonal to multiyear variability of glacier surface velocity, terminus position, and sea ice/ice mélange in northwest Greenland. Journal of Geophysical Research: Earth Surface 120 (5) 818-833.

Shepherd, A., et al. (2012). A reconciled estimate of ice-sheet mass balance. Science 338, 1183-1189.

Further Information

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