Response of the north-west Greenland Ice Sheet to recent and future climate change (Ref IAP2-18-134)

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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 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 (e.g. Moon et al., 2012; Carr et al., 2013). This retreat has persisted for the past decade (2005-2015), albeit with substantial temporal and spatial variability (Bunce et al., 2018). Although changes in glacier dynamics have occurred across north-west Greenland, nine glaciers have dominated the observed retreat, many of which have accelerated substantially and are backed by major basal troughs (Carr et al., in press; Fig. 1). It is therefore crucial to understand the present and near-future behaviour of these outlets, and their potential contribution to sea level rise.

![Figure 1: North-west Greenland retreat rates 2000-2010 (circle size and colour), and basal topography: white = low elevation; brown = high elevation.](image)

A number of external factors are believed to influence marine-terminating outlet glacier behaviour in north-west Greenland, including air and ocean temperatures, and sea ice concentrations. Based on remotely sensed data, sea ice has been identified as an important control on a subset of 16 north-west Greenland glaciers (Moon et al., 2015). However, it is unclear how its influence varies along the coast, with different fjord geometries, and how ‘strong’ the sea ice needs to be, in order to
impact glacier behaviour. Furthermore, it is uncertain how much of the current pattern of glacier retreat and acceleration is determined by ongoing external forcing, versus the topography of the glacier fjord and bed.

The key research questions that this studentship will address are:
1. How have the dynamics of north-western Greenland glaciers evolved since 2010?
2. To what extent does sea ice control glacier dynamics, and how does this vary with the different fjord configurations and sea ice properties observed in north-west Greenland?
3. How might north-west Greenland glaciers behave in the future, and to what extent is this influenced by their basal topography?

Methodology

The project will utilise new, high resolution satellite imagery to assess detailed changes in glacier dynamics. Specifically, the project will combine pre-existing ice velocity datasets (provided by the MEASURES programme) with velocity data derived from Sentinel 1 and 2 imagery, to compile a comprehensive, high resolution dataset of recent dynamic change in north-west Greenland. Pleiades imagery will be used to generate high-resolution DEMs, and analysed with pre-existing datasets (e.g. ICESat data) to assess surface elevation change in north-west Greenland. This will be evaluated in relation to surface meltwater inputs and the formation / disintegration of seasonal sea ice, in order to establish the relative influence of these forcing factors on glacier behaviour.

Numerical modelling will be used to assess glacier sensitivity to external controls, particularly sea ice, 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. G. H. Gudmundsson. This model has been proven effective for similar applications (e.g. deRydt et al., 2015). It will be applied to the 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. A particular focus of the numerical modelling component will be to investigate the impact of sea ice buttressing on glacier behaviour in north-west Greenland. The model 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. There may be the possibility of fieldwork in south-east Greenland, but this cannot currently be confirmed.

This project is a collaboration with Prof. G. Hilmar Gudmundsson, Northumbria University.

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 only): Completion of analysis and thesis write-up.

Training & Skills

Training will be provided in GIS software packages, including ArcGIS, ERDAS, and ENVI. 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. G. H. 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


Further Information

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