Reconstructing the Past Topography of Greenland (Ref IAP2-18-20)

Durham University, Dept. of Geography
In partnership with British Antarctic Survey and Newcastle University

Supervisory Team
- Dr. Stewart Jamieson, Durham University
- Dr. Fausto Ferraccioli, British Antarctic Survey
- Dr. Dave Roberts, Durham University
- Dr. Neil Ross, Newcastle University

Key Words
- Greenland, ice-sheet, topography, tectonics, geophysical modelling

Overview

The bed of the Greenland ice sheet controls ice growth and discharge in a region where ice sheet collapse could contribute over 7 m to global sea levels. Short-term satellite observations have illustrated the sensitivity of the ice sheet to rapidly changing climatic and oceanic conditions. However, over millennial to million year time-periods, the ice sheet is also known to have changed dynamically\(^1,2\) during periods of warming potentially analogous to the future. It is therefore important to consider whether long-term processes like glacial erosion (Fig. 1) and tectonics may influence ice sheet response to warming.

![Figure 1: A glacial trough in SE Greenland, near Sermilik Fjord. Has trough incision altered the stability of the Greenland Ice Sheet through successive glacial cycles?](image1)

The aim of this project is to reconstruct the past topography of Greenland. This is important because past analogues of ice sheet sensitivity in warm climates occur during the Pliocene or during the last Interglacial when Greenlands topography may have been significantly different. Models cannot agree on ice extents in this region during key warm periods (Fig. 2) and we hypothesise that this is partly because past topography is poorly known. Throughout the glacial history of Greenland, topography beneath the ice has evolved via glacial erosion and sedimentation, tectonics and volcanic activity. As the topography has changed, it is likely that there was an impact upon the behaviour of ice flow during successive glacial periods.

![Figure 2: Disagreement in ice sheet extent during the Last Interglacial from all available ice-climate models. If palaeotopography is reconstructed will models reach better agreement?](image2)
The project will use landscape metrics to characterise the morphology and geology of the present-day topographic troughs through which the ice streams flow. In addition, it would use geophysical techniques to investigate the geology and earth structure in Greenland. We would link our understanding of form to the processes of landscape evolution that have occurred in order to investigate how Greenland has evolved topographically over the last 5 Million Years or longer. We would then seek to reconstruct past landscapes using geophysical modelling techniques to reconstruct landscape changes in response to erosion and tectonic processes.

Methodology

The project will use GIS to analyse available subglacial topographic and ice flow datasets. In particular, the student will morphometrically analyse the depth and width of ice-stream beds using 2-D bed topography data and will quantify the extent to which these characteristics change along the length of an ice stream. Interpretation of existing airborne geophysical datasets will enable the structure and geology of the Greenland bed to be interpreted and, in conjunction with the ice topographic and ice flow analysis will enable processes controlling the topography to be quantified. We will use any available information on denudation, for example thermochronometric data, to constrain our understanding of erosion patterns and rates.

GIS will also be used to analyse available offshore seismic datasets for key areas of Western Greenland (data available via Prof. Colm O Cofaigh in Durham). This will enable approximate sediment volumes to be calculated offshore under the assumption that they were eroded from specific ice stream catchments. Following a process developed in Antarctica, these sediments will be ‘backstacked’ onto the topographic data based on assumptions about rates of past erosion. A similar process has been applied by this research team for Antarctica using simple numerical models of earth structure response to loading and unloading. The result will be a digital elevation model which reconstructs the past topography of Greenland and which will be a key dataset for ice sheet and climate models seeking to understand ice sheet growth and behaviour, especially during warm periods of the past.

Develop an understanding of Greenland Ice Sheet behaviour and controls; develop and apply a GIS methodology for subglacial mapping. Run a workshop on Greenland topography and ice sheet interactions.

Year 2:

Analyse offshore seismic data to calculate eroded sediment volumes; identify key catchments for topographic reconstruction; Identify key processes of topographic evolution and their timing and rates; conduct geophysical modelling experiments.

Year 3:

Carry out palaeo-topographic reconstruction of Greenland; conduct further modelling experiments; develop writing skills; draft publications; present outcomes to IAPETUS2 and at international conference; draft thesis.

Final 6 months:

Submit thesis; finalise remaining publication manuscripts.

Training & Skills

Techniques of geomorphic mapping, GIS analysis, geophysical data interpretation and earth modelling will form the core of this project. Applicants must be numerate with some previous experience of geophysics being particularly beneficial. Specific training in all aspects of work will be delivered in Durham and at British Antarctic Survey, and via internationally recognised ‘summer schools’. The student will be supported in broader skills training via the award-winning Career and Research Development (CAROD) group at Durham (thesis writing, writing for publication, presentation skills, enterprise skills etc.) and will benefit from cross-enterprise training provided as part of IAPETUS2. The training is designed to ensure that the student becomes a well-rounded scientist who is comfortable working independently and in teams.

References & Further Reading


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Further Information

Please contact Dr. Stewart Jamieson:
Email: Stewart.Jamieson@durham.ac.uk
Tel: +44 (0) 191 33 41990
Website: Durham University