IAPETUS

NERC DOCTORAL TRAINING

Constraining post-LGM accumulation rates from the interior of West Antarctica with radar data: implications for ice sheet dynamics and evolution

Project reference IAP/13/68. Please quote this reference when applying.

Newcastle University, (School of Geography, Politics and Sociology)
In partnership with: Durham University (Department of Geography)

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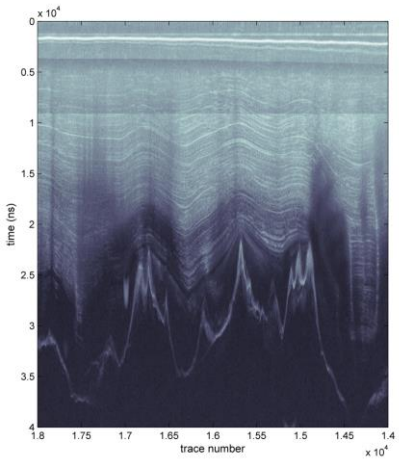
Key Words	**Antarctica, ice-sheet mass balance, englacial layering, radio-echo sounding, numerical modelling**

Overview

The West Antarctic Ice Sheet (WAIS) is currently losing mass at an accelerating rate. Processes controlling loss are uncertain, however, and it is unclear whether the current changes are anomalous over centennial to multi-millennial time spans. Long-term, i.e. post-Last Glacial Maximum (LGM), reconstructions of ice sheet surface accumulation and ice thickness based on spatially extensive and temporally-detailed observations are therefore required to provide long-term context for recent change.

Radio-echo sounding (RES) (see figure) is uniquely positioned to provide information on the spatial pattern and temporal variability of past ice-sheet surface accumulation. Although ice cores are more precise in quantifying rates of past ice-sheet accumulation, as point measurements they cannot achieve the extensive spatial information that RES techniques allow. Despite the significant potential offered by RES for assessing long-term (e.g. post-LGM) ice-sheet mass balance, this project will be the first to apply it across large swathes of West Antarctica. The project will develop, and extend, a methodology of Siegert and Payne [2004], who utilised data from a single RES flight line over central WAIS to quantify the rate and variability of surface accumulation during the last 16,000 years. Few studies have undertaken this task at an ice-sheet scale, and none have used RES to assess the impact of past surface accumulation on glacio-isostatic adjustment (GIA) models.

The project will utilise airborne RES survey data acquired over the main WAIS ice divides [e.g. Ross et al., 2012] to quantify post-LGM rate(s) and spatial pattern(s) of surface accumulation across central West Antarctica, using these findings as input data to assess the sensitivity of GIA models to past accumulation variability.



Methodology

The project will use geographical information systems (GIS), geophysical visualisation software and numerical ice sheet models to: **[1]** Identify, trace and map internal layers in RES data across central West Antarctica; **[2]** Date mapped internal layers by correlation with known, dated stratigraphic units in ice cores; **[3]** Use the stratigraphic relationships between dated layers to determine the post-LGM rate and spatial pattern of surface accumulation over West Antarctica; **[4]** Use numerical models of post-LGM ice-sheet behaviour and evolution to test the sensitivity of WAIS thickness, extent and loading history to the temporal and spatial accumulation patterns identified above, and to evaluate the impact of uncertainty in the accumulation reconstructions.

The student will constrain the reconstructed palaeo-mass balance with post-LGM and present-day rates of accumulation based on data from shallow ice cores, snow pits, satellite observations, and estimates provided by numerical models. The consistency of the reconstruction will be assessed against ice-sheet reconstructions constrained by glacial geological evidence from exposed regions at the margins of the WAIS (e.g. cosmogenic isotope dating of terrestrial surfaces, sediment cores and marine geophysical surveys) [e.g. Hillenbrand, Bentley et al., in press].

The outcomes and impacts of this project will be: (i) the first reconstruction of long-term rates of surface accumulation across the central WAIS; (ii) improved reconstructions of post-LGM WAIS ice surface evolution; (iii) an assessment of the impact that variability in rates of ice-sheet surface accumulation may have had on the extent and thickness of WAIS and the post-LGM glacio-isostatic signal in West Antarctica; and (iv) an assessment of whether present-day rates of mass loss occurred in the pre-instrumental period, and the timescales over which they were sustained.

Timeline

Year 1: develop an understanding of surface mass balance processes and GIA; familiarisation and training of radio-echo sounding datasets and software; commence radar layer picking.

Year 2: Generate 3D dataset of dated internal layers over WAIS; identify regional patterns of post-LGM accumulation across WAIS; receive training in ice-sheet modelling; develop presentation skills by attending UK-based glaciological conference.

Year 3: interpret temporal and spatial patterns of accumulation across WAIS; conduct sensitivity modelling experiments; draft manuscripts for publication; present outcomes at international conference; draft thesis.

Year 4: Complete and submit thesis; finalise manuscripts for publication; attend international conferences.

Training & Skills

This project will develop cross-disciplinary scientific training in problem solving, data analysis and report writing. It will provide the student with high-level skills in: (a) glaciology; (b) processing and interpretation of geophysical and geographical information systems (GIS) data; and (c) numerical modelling.

The student will also benefit from broad skills training provided in-house at Newcastle (e.g. thesis and paper writing, presentation skills etc.) and from a broad range of environmental science training provided within the IAPETUS Doctoral Training Partnership framework.

References & Further Reading

Hillenbrand, C-D., **Bentley, M.J.**, and 13 others, Reconstruction of changes in the Weddell Sea sector of the Antarctic Ice Sheet since the Last Glacial Maximum. Quaternary Science Reviews, in press

Karlsson, N and 3 others, (2013), Tracing the depth of the Holocene ice in North Greenland from radio-echo sounding data. Annals of Glaciology, 54, 44-50.

Ross, N., and 8 others including **Siegert, M.J.**, and **Bentley, M.J.**, (2011), Holocene stability of the Amundsen-Weddell ice divide, West Antarctica, Geology, 39, 935-938. doi:10.1130/G31920.1

Siegert, M.J., and Payne, A.J., (2004), Past rates of accumulation in central West Antarctica, Geophysical Research Letters. 31, L12403, doi:10.1029/2004GL020290

Further Information

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