PROJECT TITLE: Antarctic sea ice in a changing planet – insights from palaeoclimate archives.

DTP Research Theme(s): Changing Planet
Lead Institution: British Antarctic Survey
Lead Supervisor: Claire S Allen, British Antarctic Survey
Co-Supervisor: Liz R Thomas British Antarctic Survey
Co-Supervisor: Jenny Pike, Cardiff University
Project Enquiries: csall@bas.ac.uk; lith@bas.ac.uk; pikej@cf.ac.uk
Project keywords: Sea ice, Antarctica, Ice cores, Palaeoceanography, Climate Change

Project Background:

Sea ice is currently undergoing major changes. In the Arctic, sea ice has been declining rapidly over the last few decades, with an expectation of amplified global climate change due to ice-albedo feedbacks. Conversely, the total Antarctic sea ice cover has been steadily increasing since systematic satellite observations began in the late 1970s, although a precipitous decline since 2014 has halved the increasing trend for 1979–2018 relative to 1979–2014 [1]. Observations of both Antarctic and Arctic sea ice conditions are limited to the satellite era (post 1970). Thus, it is hard to assess the significance of recent trends. Climate model simulations of future warming are heavily dependent on the historical sea ice area data [2], and thus it is of global importance that we provide reliable paleo-sea ice reconstructions to ensure that the climate models tasked with predicting future changes are fully optimised.

Prior to the satellite era (post-1970) and historical records (post-1930s), the best method for reconstructing past sea ice conditions comes from paleoclimate archives. Changes in sea ice conditions have been reconstructed from the chemical or isotopic records measured in continental ice cores and from microfossil or geochemical tracers in marine sediment cores. Marine records typically assess changes in sea ice over millennial timescales, with only a few produced at sub-decadal resolution. Conversely, ice core records are all available at annual resolution or higher but the longest ice core record extends just 300 years, which is arguably too short a time period to investigate the full range of natural variability [3]. Amalgamating these archives offers the best potential to enhance our understanding of longer term variability and place the recent changes in an extended context.

Many of the existing marine cores with sea ice records have sufficiently high sedimentation rates (≥50 cm/ka) to permit higher resolution reconstructions (Fig 1). By increasing the resolution of marine records, particularly in areas where ice cores exist, we can combine the marine and ice core records to provide a continuous record of sea ice that overlaps with satellite and historical data at the highest resolution and extends back over the last millennia to resolve natural variability.

Project Aims and Methods:

This project is aimed at enhancing Antarctic sea ice records by combining existing marine and ice core archives. In particular, the project will address some or all of the following questions:

>What were Antarctic sea ice conditions during the pre-industrial (pre-1800)?
>Are the divergent regional patterns of sea ice seen today present throughout the past 2ka?
>Are the changes observed during the satellite era unprecedented for the past 2ka?
>Is sea ice extent over the Southern Ocean the primary control on sea ice duration over the Antarctic continental shelf?

These questions will be addressed by targeting key areas where both marine and ice core archives exist. For the first time the records will be considered in parallel, adapting the sampling scheme and proxies measured to optimise the sea ice reconstruction. Including, increasing the resolution of existing marine records (Fig 1) and analysing newly discovered chemical proxies in the ice, that more closely align the changes recorded in the marine sediments [3]. This project will contribute to the PAGES 2k network, providing the student with access to a wide range of resources, access to international collaborators and newly acquired ice core databases [4].

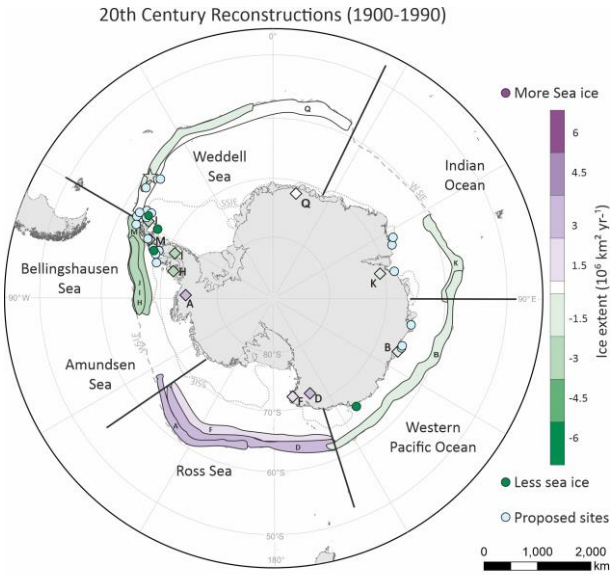

Figure 1. Reconstructed trends in sea ice extent (km2 yr−1) during the 20th century (1900–1990) [3] using ice cores (diamonds). Marine sediment records with potential for higher resolution sea ice reconstructions shown in blue circles.

The PhD student will join active research groups at BAS and the School of Earth and Environmental Sciences at Cardiff University, will have the opportunity to analyse Antarctic ice and marine cores from the UK archive and obtain a diverse skill-set that he/she can carry forward into a career in either academia or industry.

Candidate requirements: The candidate must be willing to work in cold conditions, including the -20°C cold laboratory at BAS.

Training: The supervisory team will provide all the appropriate training in: core handling, sample preparation and processing, relevant micropalaeontological, sedimentological and geochemical proxies as well as ion chromatography, working in a class 100 cleanroom and working in a -20°C cold laboratory. The student will be given opportunities to participate in formal training courses relating to professional development and life skills (writing skills, project management, communicating science etc.) and will be encouraged to promote their research by presenting results at appropriate national and international meetings.

This project can be completed using existing data and stored archives; making it secure against future lockdowns. Although not an essential part of the project every effort will be made to include the student in future polar fieldwork (terrestrial or marine), providing experience in as many analytical and field techniques as possible.

Background reading and references: **[1]** Parkinson, C.L. A 40-y record reveals gradual Antarctic sea ice increases followed by decreases at rates far exceeding the rates seen in the arctic. *Proc. Natl. Acad. Sci. USA* 2019, *116*, 14414–14423. **[2]** Bracegirdle, T.J.; Stephenson, D.B.; Turner, J.; Phillips, T. The importance of sea ice area biases in 21st century multimodel projections of antarctic temperature and precipitation. *Geophys. Res. Lett.* 2015, *42*, 10832–10839. **[3]** Thomas, E.R.; Allen, C.S.; Etourneau, J.; King, A.C.F.; Severi, M.; Winton, V.H.L.; Mueller, J.; Crosta, X.; Peck, V.L. Antarctic Sea Ice Proxies from Marine and Ice Core Archives Suitable for Reconstructing Sea Ice over the Past 2000 Years. *Geosciences* 2019, *9*, 506.

Useful links: [4] http://pastglobalchanges.org/science/wg/2k-network/projects/clivash

How to apply:

In the first instance, contact the Lead Supervisor to discuss the project.

To submit an application, please send your CV, statement of interest, degree transcripts, degree certificates and contact details of two academic referees directly to the Lead Supervisor of the project before **Friday 8th January 2021 at 2359 GMT.**

Should you have any enquiries, please contact Ali Teague at the BAS Student Office

Please visit our website to find out more about BAS and the BAS PhD Student Programme

The application deadline is Friday 8 January 2021 at 2359 GMT. Interviews will take place from 8th to 19th February 2021. For more information about the NERC GW4+ Doctoral Training Partnership please visit https://www.nercgw4plus.ac.uk.