Ocean dynamics and the latitude of the ice edge

Lead Supervisor: David Ferreira, University of Reading, Department of Meteorology
Email:d.g.ferreira@reading.ac.uk

Co-supervisors: Daniel Feltham, University of Reading, Department of Meteorology

Because of its high reflectivity and insulating effect on oceans, the sea ice cover has a large impact on the climate state. The area occupied by sea ice, or equally the location of the ice edge, is therefore a topic of interest in a wide range of climate studies. For example, at the Last Glacial Maximum (LGM, 21,000 years ago) when the atmospheric CO_2 was only $\sim$ 180 ppm, the Antarctic sea ice is thought to have had a leading order effect on the sequestration of carbon dioxide in the deep ocean. Evaluation of the mechanisms is however hampered by the large uncertainties in estimates of the ice edge location (Fig. 1) and inconsistency between model simulations of the LGM.

This highlights the need for a theoretical framework to provide better dynamical constraints on the location of the ice edge, and on its interaction with the other climate components, notably the ocean.

Previous idealized analytical models have emphasized the sea ice and atmospheric physics and have represented the ocean as prescribed external forcings, neglecting the ocean dynamics and the coupling between ocean and sea ice.

The overall goal of the PhD is to deliver to the climate community the theoretical tools to evaluate estimates and simulated ice edge location on the scales relevant to past and future climate changes. This work will provide a pathway to identify and ultimately reduce biases in climate models.

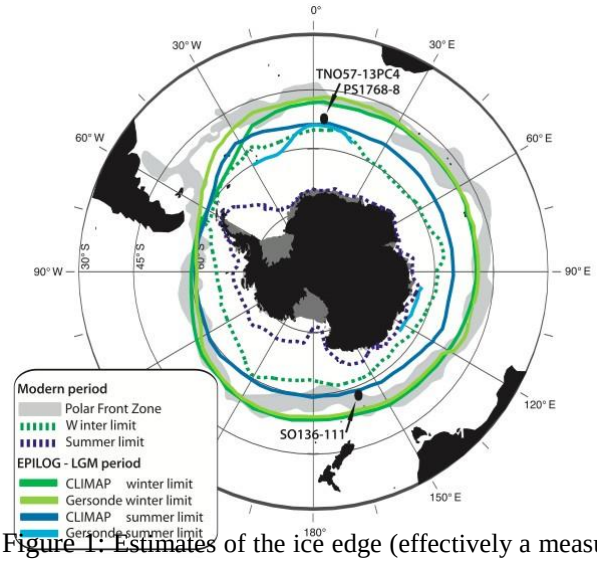

Figure 1: Estimates of the ice edge (effectively a measure of the sea ice area) for the LGM and present-day climate. Note the correspondence between the LGM extent and the Polar front in the ocean. Similar correspondence between ice edge and oceanic features are seen in today's climate. From Crosta (2009).

To this end, the student will: 1) develop an idealized system of equations describing the location of the ice edge, improving on previous work by better accounting for the interaction with the ocean (aided by the analysis of observations and idealized simulations to identify key processes) and 2) apply this mathematical framework to the analysis of simulations of future and past climates.

Training opportunities:
This project offers opportunities to attend courses on a variety of ocean and atmosphere related topics, including physical oceanography, numerical modelling, and atmospheric physics.

Student profile:
This project would be suitable for a student with a degree in physics or mathematics (or a closely related environmental or physical science) and an appetite for applying his/her knowledge to a climate science topic. The student should have a particular interest for modelling and physical oceanography.

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