Project EARTH-16-HLJ2: Is water mass transformation in the Barents Sea important for the Atlantic meridional overturning circulation?

Supervisor: Helen Johnson

Warm water from the Atlantic penetrates all the way up into the Barents Sea, where it is strongly cooled by the very cold overlying atmosphere, resulting in large buoyancy loss and dense water formation. The resulting dense water is exported to the Arctic Ocean and, eventually, through Fram Strait to the Nordic Seas, where it contributes to the dense overflow over the Greenland-Scotland ridge and the southward flowing limb of the Atlantic meridional overturning circulation (AMOC).
Recent work in a low resolution model suggests that the volume and properties of dense water exported through Fram Strait may be inferred from the atmospheric flux over the Barents Sea (Moat et al. 2014). However, dense water formation processes, and the interplay between the atmosphere, ice and ocean in this region are poorly understood.

This project will explore the role of atmospheric forcing over the Barents Sea in determining the intensity of the AMOC. The student will begin by investigating the link between atmospheric forcing/surface inflow properties in the Barents Sea, dense water export through Fram Strait, and the AMOC in the long control run of a coupled climate model. Hypotheses to be explored include that (a) sea-ice extent plays a key role, since air-sea exchange in the region is modulated by the position of the sea-ice edge, and (b) the impact on the AMOC will involve the integrated effect of surface buoyancy forcing, due to the capacity of the Nordic Seas to act as a reservoir for the dense water. The student will use data from a high-resolution ($1/12^{o}$) ocean model to investigate the deep water formation processes in detail. We will assess whether there is a feedback between the northward transport of heat associated with the AMOC (and North Atlantic Current) and the formation of dense water, which may have implications for variability on palaeo timescales (e.g. Dokken et al. 2013).

The student will also use an ensemble of climate simulations recently performed with an earth system model to explore future changes in the timing and location of dense water formation (in the Barents Sea and elsewhere), how much of this is due to natural internal atmospheric variability (c.f anthropogenically-forced change), and the impacts of each on the AMOC downstream.

This project will involve the statistical analysis and interpretation of large geophysical datasets including coupled atmosphere-ocean-sea-ice general circulation models. Key processes and feedbacks will be explored through the development of simpler 1D and 2D numerical models, and the application of fluid dynamics theory. The project would best suit a strongly motivated student with a solid background in maths and physics and a desire to learn about high latitude ocean dynamics. The student will interact regularly with collaborators at the UK Met Office, the National Oceanography Centre in Southampton and Ifremer in Brest, France. The student will be part of the Oxford Physical Oceanography group, which straddles the gap between the Earth Sciences and Physics Departments. They will work closely with other members of the group who are also involved in investigations of high-latitude ocean dynamics and climate. There may also be an opportunity to participate in a research cruise should the student wish.

Selected relevant references:

Moat, B. I., S. A. Josey and B. Sinha (2013) Impact of Barents Sea winter air-sea exchanges on Fram Strait dense water transport, *Journal of Geophysical Research (Oceans),* **119**, 1009-1021. DOI: 10.1002/2013JC009220.
Dokken, T. M., K. H. Nisancioglu, C. Li, D. S. Battisti and C. Kissel (2013) Dansgaard-Oeschger cycles: Interactions between ocean and sea ice intrinsic to the Nordic seas, *Paleoceanography*, 28, 491-502. DOI:10.1002/palo.20042.

Lique, C., A. M. Treguier, B. Blanke and N. Grima (2010) On the origins of water masses exported along both sides of Greenland: A Lagrangian model analysis, *Journal of Geophysical Research (Oceans),* **115**, C05019, doi:10.1029/2009JC005316.