Arctic mass, freshwater and heat fluxes in high-resolution global coupled climate models

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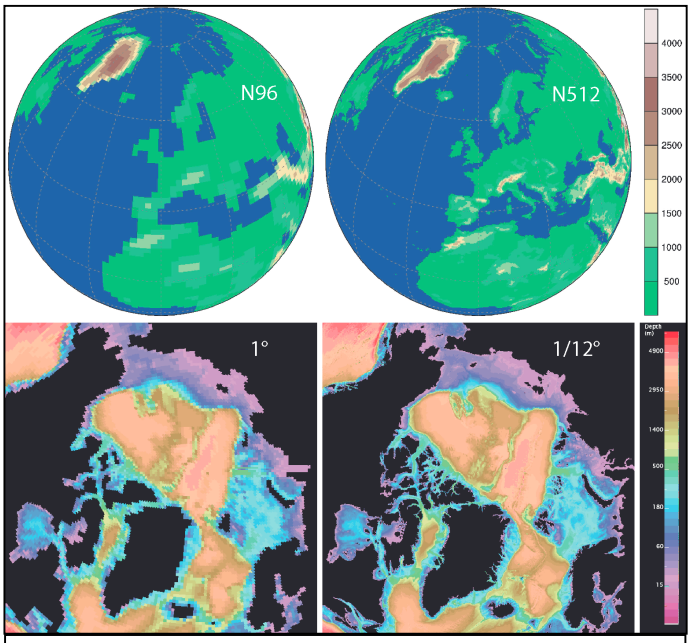
The Arctic is changing rapidly, which will have implications for the rest of the planet. For example, the recent loss of Arctic sea ice may impact on the mid-latitude atmospheric circulation. Understanding these changes requires trustworthy climate model predictions of the Arctic. However, the trust we can place in climate models depends on their ability to represent fundamental processes in the climate system. Such fundamental processes include the atmospheric and oceanic fluxes of freshwater, heat and mass into and out of the Arctic.



Top: Land-sea mask (ocean colour is shown for grid-boxes with land fraction <50%) and orography (m) for a lower (N96, ~130 km) and higher (N512, ~25 km) resolution atmospheric model. **Bottom**: Arctic ocean bathymetry (m) in a 1° and 1/12° resolution ocean model.

The main goal of this PhD project is to evaluate the atmospheric and oceanic Arctic fluxes in a new generation of high-resolution coupled global climate models using recently available observational estimates. A particular focus will be the sensitivity of Arctic fluxes to model resolution both in the atmosphere and the ocean. Increasing model resolution holds great promise for representing the Arctic climate more realistically. In the atmosphere, the benefits of higher resolution have been demonstrated. This includes improving the position of the North Atlantic storm track thought to be important for atmospheric transports into the Arctic [*Zappa et al.*, 2013]. Similarly, ocean transports are sensitive to model resolution, since they occur through four narrow straits (Fram, Davis, Bering Straits; Barents Sea Opening) which are only crudely resolved in coarse ocean models.

The climate models used in this project are from the PRIMAVERA[1] project, which are comprised of a multi-model ensemble with controlled increases in horizontal resolution. PRIMAVERA simulations have resolutions of down to 25km grid spacing in the atmosphere and ¼° in the ocean. This corresponds to a four to five fold increase in resolution over typical climate models in the Fifth Coupled Model Intercomparison Project (CMIP5).

The initial objective will be to use observational estimates to evaluate the PRIMAVERA coupled ocean-ice-atmosphere climate models. [*Bacon et al.*, 2015] have recently developed a method to calculate Arctic fluxes, applicable both to measurements and models. Modelled fluxes will also be compared with available independent

[1] **PR**ocess-based climate s**IM**ulation: **A**d**V**ances in high resolution modelling and **E**uropean climate **R**isk **A**ssessment, EU Horizon 2020 project

observation-based estimates, for example from inverse modelling of ocean boundary fluxes [*Tsubouchi et al.*, 2012] and atmospheric reanalyses. Later parts of the project will analyse the decadal variability of fluxes into the Arctic, including how high-resolution climate models represent key processes such as Bjerknes compensation between atmospheric and oceanic transports [*Shaffrey and Sutton*, 2006].

Training opportunities:
This project is a collaboration between two prominent UK research institutions in atmosphere, ocean and climate science and will provide a wide range of training and networking opportunities. The student will be based at the University of Reading with extended research visits to the National Ocean Centre in Southampton.

Student profile:
The student should have a natural science background from subjects like meteorology, oceanography, physics or mathematics, with demonstrated strong analytical skills and a keen interest to study the physical processes of the Arctic climate system. The student will also need to have or acquire the necessary programming and data analysis skills required for the quantitative analysis of large climate datasets.

Funding particulars:
The project has CASE support from the National Oceanography Centre.

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