Ocean Regulation of Climate through Heat and Carbon Sequestration and Transports (ORCHESTRA)

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Project Description
We propose to conduct a large-scale research programme that will use observational and model-derived data to improve our knowledge and predictive capability concerning the Southern Ocean control of climate. We will focus on the Atlantic sector of the Southern Ocean, which is the key region where waters that feed the Atlantic Meridional Overturning Circulation (AMOC) are injected in different levels. Our project will address the following top-level, interlinked questions:

(i) What are the key surface controls on exchanges of heat and carbon across the air-sea-ice interface of the Southern Ocean, and how do these exchanges vary over time?
We will deploy autonomous vehicles equipped with new sensors to measure carbonate system parameters, together with ship and aircraft campaigns, to obtain high-resolution information on the fluxes between the atmosphere and the upper-ocean mixed layer. The use of this technology will allow critical wintertime measurements to be taken where previously this has been challenging, including in different levels of ice cover. The understanding obtained from these observational results will be used to assess and improve the representation of Southern Ocean surface processes in ocean and climate models.

(ii) What are the leading-order processes that control the rate at which heat and carbon enter the Southern Ocean interior in each of its different layers?
We will conduct targeted observational studies, dynamical analyses and process-based model experiments to determine the key ocean mechanisms that control the rates at which water masses are formed and drawn into the ocean interior, and the time-varying heat and carbon loads therein. A network of moorings, autonomous vehicles and tagged marine mammals will be designed and deployed to generate time-series of flows and climatic properties within each of these layers. We will develop and test improved model implementations the key processes, including small-scale (mesoscale and submesoscale) phenomena, internal waves and mixing, convection and subduction, bathymetric effects, and tides

(iii) What are the size, variability and controls on basin-scale heat and carbon fluxes throughout the Atlantic sector of the Southern Ocean and outwards to the global ocean, and how will these change in future?
Major ship campaigns and autonomous vehicle technology will be used alongside the expanding profiling float network to improve our quantification and understanding of these fluxes and their variability. We will produce key series and understanding of the transports, heat and carbon contents of Southern Ocean waters masses as they spread to lower latitudes, invading the different intermediate layers and flooding the abyss of the global ocean. Linked climate and ocean model experiments will be used to elucidate the key dynamics that control the fluxes and their variability.

Project Timeline
April 2016 – March 2021

Key deliverables

- Deployment of operational autonomous networks delivering real-time surface and interior heat and carbon data (2017-19)
- Major ship-based expeditions to quantify the interior fluxes of heat, carbon and other tracers through the Southern Ocean and northwards into the Atlantic overturning circulation (2017, 2018)
- Aircraft flights for determination of air-sea-ice heat and carbon fluxes in different sea ice conditions (2017,18,19)
- Improvements to UK climate/Earth System models, coded and made available to wider community (2018)
- Global air-sea fluxes climatology, optimized for the Southern Ocean, and available online (2020)
- Climate and ocean model runs demonstrating improved predictive skill, for inclusion in the IPCC process and policy development (2020).

Funding
UK NERC

Data Management
Marine data will all be submitted to BODC as is required by our funding agency. Data will be provided for SOOS portal etc via established routes.