The University of Oxford Department of Earth Sciences

EARTHSCIENCES

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Lateral Eddy Transports in the Global Ocean

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Key Words	**physical oceanography, ocean eddies, climate models**

Overview

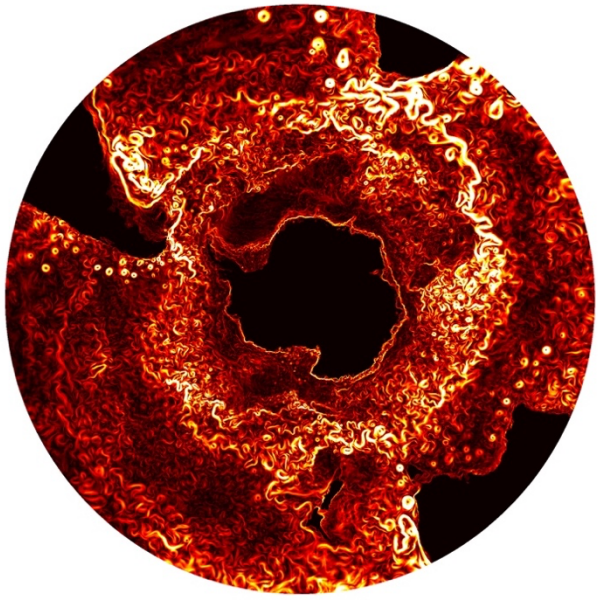
Ocean eddies account for the majority of the ocean's kinetic energy, and play a key role in transporting climatically important properties such as mass, heat, carbon and nutrients. By representing these eddies properly, the latest generation of high-resolution, eddy-resolving ocean models are expected to significantly improve our ability to represent and predict the ocean and climate. However, there is currently no observation-based three-dimensional estimate of global ocean eddy transports available for model validation.

At the same time, coarser resolution ocean models used for long-range climate simulations will rely on parameterizing the effects of ocean eddies (in terms of properties of the larger scale flow field) for the foreseeable future. The development of effective eddy parameterisations depends on a thorough understanding of the mechanisms via which eddies transport tracers, which is currently lacking.

In this project we will create the first ever observation-based three-dimensional estimate of time-mean horizontal eddy transports of heat and salt in the upper 2000 m of the global ocean. We'll do this by combining millions of temperature and salinity measurements collected by the global array of Argo profiling floats over the last 20 years with a new method for inferring the vertical structure of ocean eddies from altimeter data. We will use this new dataset to characterise and quantify the three-dimensional global ocean eddy transports of heat and salt, and develop a thorough physical understanding of how eddies accomplish these transports.

We will also work closely with collaborators at the National Oceanography Centre and UK Met Office to evaluate the skills of current eddy-permitting and eddy-resolving ocean models in simulating eddy transports. Additional CASE funding may be available from the Met Office.

The student will be co-supervised by Helen Johnson (Oxford) and Xiaoming Zhai (University of East Anglia), and will collaborate with Joe LaCasce at the University of Oslo.



Eddies apparent in an image of surface current speed in the Southern Ocean.

Methodology

Estimating eddy heat and salt transports requires observations of subsurface anomalies in horizontal velocity and in salinity and temperature. We will calculate potential temperature and salinity anomalies using the more than 2 million vertical

profiles of temperature and salinity collected by the global array of Argo profiling floats since 1999 (https://argo.ucsd.edu). We will combine these with estimates, coincident in time and space with each Argo profile, of the subsurface horizontal velocity anomalies calculated from satellite altimeter sea surface height data, using a new method based on surface mode theory. The use of surface mode theory is the key novelty of our approach – it has recently been shown to do a better job of representing velocity variations with depth than the traditional baroclinic modes, which assume a flat bottom, making it possible to estimate the 3D distribution of time-mean horizontal eddy transports of heat and salt in the global ocean for the first time.

We will compare our estimate of horizontal eddy transports with previous local estimates of eddy transport wherever possible, and with a range of state-of-the-art ocean and climate models.

Timeline

Year 1: Training in ocean dynamics, data analysis, surface mode calculation. Initial calculations required to produce a preliminary estimate of lateral ocean eddy transports.

Years 2 and 3: Continue training; refine procedure; publish 3D dataset of time-mean horizontal eddy transports of heat and salt in the upper 2000 m of the global ocean, with uncertainty estimate; produce online documentation; evaluate skills of current eddy-permitting and eddy-resolving ocean models in simulating the observed eddy transports; extended visit to collaborator and/or research cruise.

Year 4: Write publications characterizing and quantifying global ocean eddy transports, complete thesis.

Training & Skills

This project would suit a student with a strong maths, physics and/or computational background and an interest in furthering our understanding of ocean and climate dynamics. The student will receive training and guidance in working with large oceanography data sets including Argo data, satellite altimetry data and ocean and climate model output. They will acquire a thorough grounding in ocean dynamics and in the workings of the climate system. There will be opportunities to spend time visiting collaborators at other institutions (e.g. UEA, University of Oslo, NOC, Met Office), and to participate in an ocean research expedition if the student wishes.

References & Further Reading

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Further Information

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