Patchy turbulence and mixing over the mid-Atlantic ridge

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Introduction

Mixing deep water up towards the sea surface in the open ocean is vital for supplying nutrients to the sea surface and in the transport of heat and carbon through Earth's climate system. The turbulence driving this mixing in the open ocean comes predominantly from internal waves. Analogous to waves on the ocean surface, internal waves move along the interfaces between different density layers in the ocean. About 80% of the internal wave energy is derived from the interaction between tidal flows and steep seabed topography (e.g. mid ocean ridges, seamounts and the slopes close to the continents). The dependence on tides means that the mixing will vary on tidal timescales (hours to weeks), while the relationship with the seabed means that the horizontal distribution of the internal wave mixing will correlate with ocean depth (e.g. Waterhouse et al. 2014). Thus we expect to see tidal- and bathymetry-driven patchiness in where upward mixing of deep ocean water occurs.

We have recently completed a research voyage in the North Atlantic, and our data show clearly that tidally-driven internal waves over the mid Atlantic Ridge increase turbulence and mixing over the ridge compared to in the deeper basin to the west of the ridge. There is the opportunity now to take this basic contrast much further by using more of the cruise data to quantify the patchiness in the mixing both spatially (along- and across-ridge) and temporally (e.g. the spring-neap tidal cycle).

Project Summary

The project will allow the first detailed investigation of the temporal and spatial patchiness of turbulence and mixing over the mid Atlantic ridge and in the adjacent, deeper basins. A set of turbulence data has been collected using lowered acoustic currents meters during a research cruise in summer 2016, which will form the basis of the PhD research. The student will also be able to use data from a research cruise to the mid Atlantic ridge in winter 2017/18, including turbulence data using free-fall microstructure sensors. Knowledge of the patchiness of mixing will be able to be extrapolated globally using datasets of ocean bathymetry and physical structure, leading to a new quantification of how tides and bathymetry affect the variability in ocean turbulence and determine the areas where deep waters reach towards the sea surface. The enhanced turbulence over the topography is potentially important in affecting how water masses get transformed from one density class to another and how nutrients are supplied to the surface, sunlit ocean and sustain growth of phytoplankton (Williams & Follows, 2011).

The student will become a part of a collaboration of ocean scientists from the Universities of Liverpool, Southampton and Bangor and from the National Oceanography Centre. The University of Liverpool offers courses in numerical analyses, ocean physics and ocean biogeochemistry that can augment undergraduate training towards application to this challenging multidisciplinary problem.

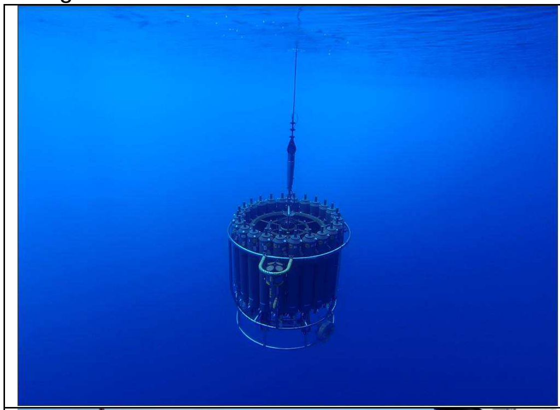
References

Sharples, J., et al. (2007). "Spring-neap modulation of internal tide mixing and vertical nitrate fluxes at a shelf edge in summer." Limnology and Oceanography **52**(5): 1735-1747.

Waterhouse, A. F., et al. (2014). "Global Patterns of Diapycnal Mixing from Measurements of the Turbulent Dissipation Rate." Journal of Physical Oceanography **44**(7): 1854-1872.

Williams, R.G. and M.J. Follows, 2011: Ocean Dynamics and the Carbon Cycle: Principles and Mechanisms. Cambridge University Press, ISBN: 9780521843690.

Images:

	**Fig. 1**. The main instrument package returning to the surface ocean after carrying out a measurements down to 5 km deep. The acoustic current meter (with 4 transducers) can be seen attached to the side of the instrument frame.
	**Fig. 2.** Deploying a free-fall microstructure sensor to measure turbulence in the Atlantic Ocean. The instrument uses technology similar in principle to a record player stylus to measure tiny fluctuations in currents caused by turbulent eddies.