Geophysical Research Abstracts
Vol. 21, EGU2019-519, 2019
EGU General Assembly 2019

Glider-borne observations of turbulent energy dissipation in an anti-cyclonic mode water eddy

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Mesoscale eddies are ubiquitous in the global ocean and make up a substantial fraction of the oceanic kinetic energy. Eddies extract their energy from the general circulation via baroclinic and barotropic instabilities, and some portion of this energy ultimately cascades to small-scale turbulence and dissipation. However, the mechanisms that drive this energy cascade from the mesoscale eddy field towards turbulent dissipation remain unclear. In all ocean basins, satellite altimetry shows that mesoscale eddies drift westward until they encounter the western boundary, where they disappear from the satellite altimetric signal. This indicates that western boundaries are a prime region for mesoscale energy dissipation. Using ship, mooring and glider-borne measurements, the MerMEED project seeks to determine the mechanisms of mesoscale energy dissipation in the western boundary of the subtropical North Atlantic. Here, we present results from a 4-month glider survey between November 2017 and March 2018, within 300 km of the shelf break at ∼26ºN.

During the first half of the glider survey, we sampled an anticyclonic mode water eddy that remained in the study area until late January. During this time, the glider performed three transects across the eddy (13-23 Nov, 11-31 Dec, and 1-13 Jan). At the eddy core we observed a mode of 18 ºC water with weak stratification (N<0.001 s^{-1}), low potential vorticity (<0.5·10-9 s^{-3}) and elevated oxygen concentration (AOU $<$ 20 μmol kg^{-1}) between 150 and 500 m (25.9-26.2 kg m^{-3}); but its signal on isopycnal slopes extended down to the maximum sampling depth (1000 m). Turbulent kinetic energy dissipation rates were inferred from the fluctuations of glider-derived seawater vertical velocity, during the second and third transects. Energy dissipation was reduced at the eddy core ($\sim$0.5·10^{-9} W kg^{-1}), enhanced above within the seasonal pycnocline and the mixed layer ($>$ 5·10^{-9} W kg^{-1}), and below the eddy core (1–1.3·10^{-9} W kg^{-1}). These deep dissipation rates were elevated compared to background levels, away from direct eddy influence ($\leq$1·10^{-9} W kg^{-1}). During the third crossing, dissipation rates were enhanced at the western flank of the eddy, both within the mixed layer (10–15·10^{-9} W kg^{-1}), and below the eddy core ($\sim$1.3·10^{-9} W kg^{-1}). In the mixed layer, significant atmospheric cooling, and the advection of relatively warm water by enhanced geostrophic currents along the western eddy rim, gave rise to conditions favourable for gravitational and symmetric instabilities. Long-wavelength (100-200 m) vertical velocity fluctuations suggest that dissipation below the eddy core could be related to internal wave capture below the eddy, a possibility that was assessed using ray-tracing simulations.