Geophysical Research Abstracts
Vol. 15, EGU2013-12563, 2013
EGU General Assembly 2013

Vortex waves and vertical motion in oceanic eddies

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Oceanic eddies are present anywhere in the World Ocean. They modulate the surface and internal dynamics and contain most of the ocean kinetic energy. Eddies eventually transport phytoplankton and modify the flux of nutrients from the deep ocean into the sunlit layers, affecting the primary production in the open ocean surface waters. The conceptual models generally used to explain the impact of eddies on the marine ecosystem link vortex growth and decay to the shoaling or deepening of isopycnal surfaces, and relate observed primary production variations to corresponding nutricline displacements. Here I analyse the evolution of a cyclonic eddy through combined satellite-in situ observations and a higher order dynamical approximation. I show that vortex azimuthal oscillations dominate the semi-geostrophic vertical velocity field. These waves are compatible with the propagation of potential vorticity disturbances on the radial gradient of the potential vorticity associated with the basic-state eddy, known in literature as vortex Rossby waves (VRW). VRW have been widely analysed in theoretical studies, laboratory experiments, and numerical models, but difficult to measure directly in the oceans. Synthetic Lagrangian trajectories within the eddy indicate that VRW drive vertical oscillations at the base of the euphotic layer in a range of frequencies for which intense biogeochemical responses are expected. These findings open a new perspective on the vertical fluxes of nutrients at mesoscale and point to a revision of conventional conceptual models of biophysical interactions in oceanic eddies.