Near-inertial waves interacting with a coherent anticyclone off Peru

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Motivation

The interaction between near-inertial wave propagation and geostrophic flow was already investigated by Kunze (1985). Anticyclones can trap and enhance downward propagation of near-inertial wave energy. A critical-layer can be formed below these eddies where the associated vorticity anomaly vanishes. Several recent model studies point out the importance of this eddy near-inertial wave interaction for the downward transport of near-inertial energy into the deeper ocean. There it could provide an energy source for small scale dissipation. However, observations of critical layer trapping are rare.

Figure 1: Mean sea surface temperature in Jan/Feb 2013 off Peru from MODIS in color (left). On the right, water depth (grey contours), 200 m isolines, glider tracks (dashed lines), CTD stations (black circles) and the two mooring positions (blue squares).

Experiment

A multi-platform observational study based on several gliders, moorings and shipboard measurements was carried out off Peru in January / February 2013 to investigate the interaction between mesoscale eddies and near-inertial waves.

Eddy formation

A coherent anticyclone formed in the study area allowing detailed investigation of its impact on the near-inertial energy distribution.

Figure 2 (left column): depth averaged horizontal circulation for eight periods based on vrADCPS (blue), moored ADCP (red) and glider drift inferred velocities (black). The middle and right columns show the temporal evolution of the along and cross-shore velocity components vrADCPS (red), vrADCP (blue) respectively along the grey transects (left column) and transects 1, 2, 3 and 4 (right column).

Eddy generation mechanism

Marshall and Tansley [2001] propose that the separation of a barotropic boundary current at a vertical sidewall takes place when r < L = (U/β)^1/2. Using a modified condition for flow separation of a barotropic boundary current accounting for topographic beta, it is shown that the conditions for flow separation is indeed fulfilled.

Figure 3: Left bottom slope in color and depth (grey). The radius of the topographic curvature and the 400 m isobath are shown in black. The three black crosses indicate the position of the eddy centre at three different time periods (Jan 22 - 27, Feb 3 and Feb 7 - 11). The right panel shows the effective beta (eβ eff) (black) and the resulting length scale L = (eβ eff)^1/2 (red) along the 400 m isobath.

Near-inertial waves

Enhanced near-inertial energy (NIE) is found at the eddy base possibly due to downward propagation of NIE within the anticyclone and NIW accumulation at a critical layer below.

Figure 4: Along-shore velocity (upper panel) and cross-shore velocities (lower panel) through the eddy observed by vessel mounted ADCPs. To middle panel show the position of the transects and the depth averaged near-surface velocity.

Figure 5: Cross-shore velocity component from moored ADCP measurements between 50 - 300m (a) low passed (6 days), (b) NIW bandpassed (1.5-3 days) and RCM measurements at (c) 407 m and (d) 703m both NIW bandpassed.

Discussion

What are the sinks of NIE at the critical depth? Kunze et al. (1995) suggest three possible pathways: into (1) mean flow, (2) untrapped waves or (3) dissipation.

Figure 14: Ray paths (left panel) and the convective solution of (3) high peak for a normally-swaying effective Coriolis frequency. TheNIW bandpassed current component is added (dashed) to the effective Coriolis frequency to form the effective Coriolis frequency at a critical depth. This frequency is equal to the inertial frequency. Consistent with previous studies, the amplitude envelopes of the waves between 11°S and 11°N (thin solid line).

Kunze, 1985

Kunze et al, 1995

References:
