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Near-inertial wave interaction with coherent anticyclonic eddies – a ventilation source for oxygen minimum zones?

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More than thirty years ago the interaction between near-inertial wave (NIW) propagation and geostrophic flow was already investigated. It was theoretically shown that anticyclonic eddies can trap and enhance downward propagation of NIW energy. A critical-layer can be formed below these eddies where the associated vorticity anomaly vanishes. Today, several recent model studies point out the importance of the interaction between eddies and NIWs for the downward transport of NIW energy into the deeper ocean, where it could provide an energy source for turbulent mixing. However, observations of critical layer trapping in combination with measurements of turbulent dissipation rates are rare. Here, we present results from several multiple platform observational studies based on gliders, moorings and shipboard measurements carried out in the oxygen minimum zones (OMZ) of the Pacific and Atlantic Oceans. The investigation of several coherent anticyclonic eddies allows a detailed view on their impacts on the near-inertial energy distribution. Shipboard and moored velocity measurements in coherent anticyclonic eddies show pronounced alternating current bands with amplitudes up to 15 cm/s below the eddies, which are associated with NIWs. The strongest NIW amplitudes are found around the mixed-layer depth and at the eddy base. Much weaker amplitudes are found within the interior of the eddy, whereas at around 700 m – 1000 m depth (depends on the individual eddy) they vanish completely. Additionally, microstructure measurements show enhanced dissipation rates associated to the high amplitudes of the NIWs. This suggests that a critical-layer is formed at the eddy base where near-inertial energy accumulates and is dissipated leading to enhanced mixing. This elevated mixing can potentially be associated to an oxygen flux from the deeper more oxygenated water into the OMZ core. As around 15% of the OMZ areas are covered with anticyclonic eddies, this mechanism could contribute to the ventilation of the OMZ from below, which has so far not been considered.

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