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Observations of near-inertial wave interactions within coherent mesoscale eddies

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Based on an extensive dataset obtained from multiple individual ship-based samplings of mesoscale eddies (2006-2023), interactions between mesoscale eddies and internal waves are analyzed. Theory predicts that anticyclonic mesoscale eddies shift the effective Coriolis frequency for near-inertial waves (NIW) locally in regions of strong relative vorticity towards subinertial frequencies, leading to trapping of NIW in their core and accelerated downward propagation to a critical layer at the eddy base where mixing is eventually enhanced. In contrast, cyclones might expel NIW through the same but reverse effect. In both cases, and independent of their relative vorticity, increased mixing is expected in regions of strong vertical geostrophic shear at the rims due to critical layer processes. We are able to confirm these theoretical predictions in the observed dataset in composites of several eddies in the subtropics of the southern and northern Hemisphere. Velocity measurements in coherent anticyclonic eddies repeatedly show pronounced alternating current bands with amplitudes up to 15 cm/s, likely associated with convergence of downward propagated NIW. Increased vertical shear at the eddy base of anticyclones indicates energy accumulation in a critical layer. Low (< 1) Richardson numbers and dissipation rates from microstructure measurements, complemented by fine-scale parameterizations, indicate enhanced dissipation rates at the base of anticyclones. For cyclones, slightly increased dissipation rates are more likely to be observed at the eddy rim where geostrophic shear is strong. In all computed frequency spectra, it is evident that the NIW frequency band undergoes modification based on the relative strength of the mesoscale eddies. There is a notable high variability in the internal wave field overall, with the effects of mesoscale eddies particularly pronounced in anticyclones. These eddies serve as conduits for energy into the deeper ocean and play a pivotal role in local mixing processes.

Hauptautoren: SCHÜTTE, Florian (FB1 - Physikalische Ozeanographie); SCHULZ, Marco (FB1 - Physikalische Ozeanographie); DENGLER, Marcus (GEOMAR); FISCHER, Tim (GEOMAR)

Vortragende(r): SCHÜTTE, Florian (FB1 - Physikalische Ozeanographie)

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