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An Example of Strong Modification of Semi-Diurnal Internal Tide Propagation and Energy Density by Mesoscale Currents

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Currents were measured by high-frequency radars and moored Acoustic Doppler Current Profilers in the Kauai Channel during the 2002-2003 Near-Field component of the Hawaii Ocean Mixing Experiment. These observations provide a unique data set to investigate the effects of mesoscale currents on internal tide propagation. For example, a cyclone of 55 km diameter and 100 m vertical decay scale was observed at a time when high-passed currents had much stronger semi-diurnal oscillations than phase-locked tidal currents extracted by least-square fit over the two-month record. An idealised cyclone with analytical radial and vertical profiles, assumed to be in gradient-wind balance, was constructed to provide the background current and density fields for a ray tracing model of the propagation of internal tides. M2 wave packets with initial horizontal wavelength of 50 km and vertical wavelength O(1000 m) are propagated both through an ocean at rest and through the idealised mesoscale cyclone.

Despite the lack of scale separation, especially in the vertical, the results are qualitatively consistent with observations. The surfacing time of the M2 wave packets can be delayed by up to 5 hours (about 150 degrees phase lag), resulting in incoherent signals at fixed locations over long periods of time, as the internal tides propagate through evolving mesoscale currents. M2 kinetic energy near the surface in the presence of the cyclone can become an order of magnitude stronger than in a quiescent ocean, and the vertical wavelength can be reduced by a factor of 6, leading to dramatically increased vertical shear.

These results have implications for tidal energy budgets inferred from phase-locked observations and for internal wave-induced ocean mixing.