Abstract View

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Free Surface Effects on the Near-Inertial Ocean Current Response to a Hurricane: A Revisit

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ABSTRACT

Free surface effects induced by an idealized hurricane based on observed air–sea variables in Hurricane Frederic are revisited to examine the barotropic and baroclinic response. Over five inertial periods comparisons between a one-layer and a 17-level model indicate a difference of 6–8 cm s^{-1} in the depth-averaged current and sea level oscillations of 4–5 cm. In a one-layer simulation, the surface slope geostrophically balances the depth-averaged current, whereas the 17-level model simulations indicate a near-inertially oscillating current of 7–8 cm s^{-1} found by removing the depth-averaged flow from the geostrophic currents induced by the surface slope. Surface undulations are driven by the depth-averaged nonlinear terms in the density equation, that is, $[u\rho_x]$, $[v\rho_y]$, and $[w\rho_z]$.

Based on fits of the 17 levels of demodulated horizontal velocities at 1.03*f* (*f* the Coriolis parameter) to the eigenfunctions, maximum amplitudes of the barotropic and first baroclinic modes are 7 and 58 cm s^{-1}, respectively. The barotropic mode amplitude is consistent with the current found by removing the depth-averaged flow from the geostrophic current that contributes 2%–3% to the energy in the near-inertial wave pass band. Vertical velocity eigenfunctions at the surface indicate that the barotropic mode is at least 50 to 80 times larger than the baroclinic mode. Surface displacements by the barotropic mode have amplitudes of ±4 cm, explaining 90% to 95% of the height variations. The first baroclinic mode contributes about 0.2–0.4 cm to the free surface displacements. The weak barotropic near-inertial current provides a physical mechanism for the eventual breakup of the sea surface depression induced by the hurricane's wind stress and surface Ekman divergence.

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