Abstract View

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Deep Ocean Response to Hurricanes as Revealed by an Ocean Model with Free Surface. Part I: Axisymmetric Case

Simon W. Chang

Naval Research Laboratory, Washington, DC 20375

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ABSTRACT

An axisymmetric, hydrostatic ocean model containing a rigid bottom and a free surface is constructed to study the barotropic and baroclinic response in the upper and deep ocean to a wind stress corresponding to a stationary tropical cyclone. The numerical model covers a domain of 800 km and 1475 m in *r*- and *z*-directions, respectively, with a uniform radial resolution of 20 km and a stretched vertical resolution from 5 to 54 m. The vertical mixing is parameterized based on a local Richardson number and a mixing length.

The model ocean is spun up with the wind stress of Hurricane Eloise. A strong tangential circulation develops that extends to the ocean floor with a maximum speed of 1.2 m s^{-1} at the surface. The circulation on the *r*-*z* plane, which also extends to the ocean floor, oscillates with time with a maximum upwelling of 0.1 cm s^{-1} at the center. Surface height has a maximum depression of 57 cm. The deep overturning causes density changes deep in the ocean. A maximum temperature decrease of 3°C occurs in the mixed layer at the center; a maximum temperature increase of 0.45°C is found just below the thermocline at a radius of 200 km. The recovery of both the mass and momentum fields is very slow during the spindown. Inertial oscillations dominate in the spindown even in the deep ocean. Adjustments between the momentum and mass fields seem to converge to a state quite different from the prestorm state.

Direct comparison with observations is difficult because the model is only two-dimensional. Nevertheless, recent observations seem to suggest the existence of the barotropic response in the deep mean. The model suggests that the observed rapid response in the deep ocean is caused by the barotropic pressure gradient force, which arises from the storm-induced perturbation of the free surface.

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