Abstract View

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The Development of the Barotropic Radiation Field of an Eddy over a Slope

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ABSTRACT

Low-frequency current measurements near the shelf break south of Nova Scotia indicate that the presence of topographic waves on the continental slope, and rise is associated with large-scale shoreward excursions and formation of eddies by the Gulf Stream. Two linear, inviscid, barotropic theories are formulated to model the development of the radiation field associated with such an eddy. Examples are drawn from observations of the interaction between Eddy I and surrounding waters during July–October 1976.

The fist model represents the eddy as an impulsive vorticity disturbance on constant exponential topography. Solutions are derived for three different initial distributions corresponding to a point source, a doublet and an isolated circular vortex. Results indicate that 1) after an initial burst of ultralong waves, the radiation field is reduced to a slowly dispersing set of short (50–200 km), low-frequency (periods: 10–25 days) waves which is consistent with observations at the shelf break; 2) the measured variations in wave period can be used to identify the temporal origin of the wave field, which coincides with the formation of Eddy I by a strong meander of the Gulf Stream over the outer continental rise; 3) the observed modulation of wave amplitude at the 1000 m isobath is consistent with forcing by an isolated barotropic vortex with a diameter of 70 km; and 4) the distribution of wave kinetic energy over the slope/rise region is controlled by opposing factors of topographic amplification and radial dispersion.

The second model allows for slow variations (WKB) of the topographic parameter on a realistic parabolic slope. Refraction in the WKB field of monochromatic radiation produces the observed offshore orientations of the wavenumber vector and focusing of wave energy over the continental slope. This effect may also explain the absence of a strong reflected topographic wave component in the low-frequency data set. Using a discrete set of WKB solutions to model the full dispersive wave field gives an estimate for the average upslope kinetic-energy distribution which compares favorably with deep-water measurements from two mooring periods. The decay rate for warm-core eddy energy ($\sim 10^{13}$ J day^{-1}), inferred from observed energy densities and linear dispersion, is consistent with published estimates for cold-core rings in the Sargasso Sea. Bottom frictional dissipation is unimportant over the continental rise but limits the longshore propagation of energy to scales of order 100 km near the shelf break.

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