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Propagating Long Waves on Oceanic Density Fronts: An Analytic Model

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ABSTRACT

An analytic model of long, propagating free-wave perturbations to an established upper ocean density front is developed. The primary purpose of the model is to illuminate basic frontal wave mechanisms for possible subsequent use in more sophisticated numerical models. The models is of the barotropic class but has ageostrophic dynamics because of the basic state adopted, essentially Stommel's model of the Gulf Stream with uniform potential vorticity and order one Rossby number. The model assumes inviscid dynamics apart from a narrow dissipative zone adjacent to the surface front. The latter exerts a bulk effect on the large inviscid zone, especially in generating small, bur finite, cross-stream flow in the basic state. For zero cross-flow the resulting waves are stable, have downstream phase speeds that are slow compared to the current speed and that increase with frequency, and have anomalous dispersion. The phase speeds compare well with the analysis of observations of propagating Gulf Stream meanders buy Halliwell and Mooers. For finite cross-flow the waves grow slowly in the downstream direction when flow is out of the current and decay when flow is into the current. The rates of growth or decay are independent of wavelength. Corresponding net growth or decay in the wave kinetic energy is produced by action of the cross-correlation wave Reynolds stress against the lateral shear of the basic state current.

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