Abstract View

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Effects of Horizontal Advection on Upper Ocean Mixing: A Case of Frontogenesis

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ABSTRACT

The wind stress on the ocean surface induces horizontal advection and vertical mixing, two mechanisms which are capable of changing the surface water density. Advection and mixing can enhance or partially destroy the effects of each other. Frontogenesis due to convergent Ekman transports forced by a wind-stress field is one example. A bulk model for the study of advection and mixing in such circumstances is constructed from a one-dimensional model. Continuity of mass requires that water masses either downwell (*convergence*) or escape laterally (*confluence*). This distinction leads to a study of two extreme cases of frontogenesis, each herein treated separately. The model reduces to two coupled highly nonlinear prognostic equations for the mixed-layer buoyancy and mixed-layer depth. Scaling of the equations leads to the definition of a mixing parameter, a nondimensional number which measures the relative importance of advection and mixing. For large-scale ocean frontogenesis, this parameter is of the order of unity, implying that mixing is as efficient as advection. If the region of denser water is referred to as the north, the numerical results are: 1) the front is never symmetric; 2) in the case of weak mixing, the density jump across the pycnocline is stronger in the south and the mixed layer is deeper at the north, 3) in the case of strong mixing, the front is limited by a southern edge with a weak horizontal gradient to the south and a strong decreasing gradient to the north; 4) strong mixing can induce frontolysis south of the front, 5) after about one month, the Ekman downwelling resulting from convergence, if any, strongly controls the rate of deepening., and 6) frontal density gradients are about three times larger in the case of confluence than in the case of convergence. Because the emphasis is on the interaction between wind advection and wind stirring, both dissipation and surface buoyancy flux are neglected. Hence, the model does not reach a steady state and does not provide a length-scale for the width of the front.

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