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The Circulation Dynamics and Thermodynamics of Upper Ocean Density Fronts

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ABSTRACT

This paper extends a previous hydrodynamic circulation model of established, persistent upper ocean density fronts by including a thermodynamic or buoyancy equation in the integral treatment. An analysis is also conducted of the variables related to the kinetic and potential energy budgets in the frontal zone. A comparison of the new results with previous ones shows satisfactory agreement. The new model is used to explore three frontal types of widely different scale or rotation effect, a river plume front, a Sargasso Sea front and the Gulf Stream front. As the scale increases, the influence of rotation increases and the effect of interfacial turbulent transport diminishes. Also, with increasing scale the strength of the downstream (alongfront) flow increases while the cross-stream flow diminishes, but always shows a two-sided convergence near the surface front. The kinetic energy dissipation decreases rapidly with dissipation times of resident kinetic energy increasing from ten minutes for the river plume front to a week for the Gulf Stream front. The model results are examined in an attempt to answer three questions about the circulation dynamics. They indicate that the direction of turbulent mass entrainment is always downward, that fronts always spread, even if slowly, relative to the ambient fluid, and that the cross-stream flow near the surface front always shows a two-sided convergence.

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