Abstract View

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The Dynamics of Oceanic Fronts. Part II: Shelf Water Structure Due to Freshwater Discharge

Timothy W. Kao

Department of Civil Engineering, The Catholic University of America, Washington, DC 20064

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ABSTRACT

In Part I of this series, a framework was introduced for the study of oceanic frontal dynamics. The dynamics was studied by posing an initial value problem, starting with a near-surface discharge of buoyant water with a prescribed density deficit into an ambient stationary fluid of uniform density. An essential aspect of the framework was the identification of the proper length scales: an inertial length scale L_0, a buoyancy length scale h_0 and a diffusive length scale h_v. In Part I, the horizontal and vertical dimensions were scaled by L_0 and h_0, respectively; and two dimensionless parameters were formed, *viz*., Ro = L_0/h_0 and E = $(h_v/h_0)^2$. It was shown in Part I that under this scaling, the normalized equations depended on E only for Ro sufficiently large. The solution for E small, i.e., for the almost inviscid case, was given in Part I; and the equilibrium state was discussed in a frame of reference in which the front was stationary.

In this paper, we present the solution for large E. It will be shown that a universal similarity (in the sense of a fully scaled set of governing equations without any parameter) is obtained, when the horizontal and vertical dimensions are now scaled by L_0 and h_v, respectively, for a given dimensionless depth $\bar{d}$; $\bar{d}$ constitutes the only parameter of the problem and enters it through the location of the bottom. The solution for $\bar{d} \approx 10$ is relevant to the study of the establishment of current and density structure of the shelf water subject to forcing by freshwater discharge along the coast, such as the mid-shelf region of the east coast continental shelf of North America. It is shown that when equilibrium is reached, a frontal region can be identified, which propagates steadily but slowly across the shelf. Behind the frontal region the horizontal flow field is steady. The nature of the force balance in the cross-shelf and along-shelf directions is clarified.

This paper is totally self–contained and can be read without reference to Part I.

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Headquarters: 45 Beacon Street Boston, MA 02108-3693
DC Office: 1120 G Street, NW, Suite 800 Washington DC, 20005-3826
amsinfo@ametsoc.org Phone: 617-227-2425 Fax: 617-742-8718
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