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The Gulf Stream and Its Frontal Structure: A Quantitative Representation

Timothy W. Kao

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

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ABSTRACT

The structure of the Gulf Stream Current is associated with the quasi-permanent density front in the western North Atlantic. The lighter mass of warmer but saltier water of the Sargasso Sea is separated from the slope water by inclined isopycnals that form the front. Recent satellite altimeter measurements have also revealed a well-defined sea-surface height change across the front. In this paper, a model of the Gulf Stream cross-sectional density and current structure is presented, using the complete dynamical and mass-conservation equations. The model postulates a forcing, at the interior ocean boundary, by a cross-stream ageostrophic circulation with inflow of light water in the upper ocean and a return flow at greater depths. The model Gulf Stream is found to develop after initial geostrophic adjustment of several inertial periods.

In the quasi-steady state, the normalized structural results constitute a single representation of the structure of all Gulf Stream sections; i.e., all sections are similar. The normalization requires only two observational inputs; (i) either a suitably defined depth of a representative isopycnal in the main pycnocline beneath the Sargasso Sea or the total sea-surface height change across the front, and (ii) the maximum downstream surface velocity of the Stream. The model can therefore be used to produce the entire cross-sectional structure of the Gulf Stream and its front from simple and limited observational inputs.

The results are compared with representative field data from (i) the Gulf Stream ’60 experiment, (ii) the Seasat altimeter experiment, and (iii) the recent Gulf Stream Current measurements by the University of Rhode Island group using the Pegasus current profiler. Quantitative agreement between the model results and the field data is found.

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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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