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Volume 11, Issue 3 (March 1981)

Journal of Physical Oceanography
Article: pp. 355–375 | Abstract | PDF (1.42M)

Model Studies of the Wind-Driven Transient Circulation in the Middle Atlantic Bight. Part 1: Adiabatic Boundary Conditions

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(Manuscript received February 4, 1980, in final form December 22, 1980)

DOI: 10.1175/1520-0485(1981)011<0355:MSOTWD>2.0.CO;2

ABSTRACT

A numerical model of the wind-driven transient ocean circulation in the Middle Atlantic Bight is described. The model incorporates realistic topography and covers the continental shelf between the coast and the 200 m isobath from Cape Hatteras to the southern tip of Nova Scotia. The traditional shallow-water dynamics are used, i.e., the vertically integrated and linearized equations for the flow of a homogeneous fluid driven by atmospheric pressure and wind stress fluctuations and damped by a quadratic bottom stress. The equations are integrated in time using a simple modification of Platzman's (1972) finite-difference scheme, with a 12.7 km grid spacing. At the coast, normal flow is required to vanish; at non-coastal boundaries, the equivalent surface elevation is held fixed.

Several classes of initial value experiments are used to study the free and forced modes of this model, and the damped flow driven by a spatially uniform and stationary wind stress and by an idealized travelling synoptic-scale wind-stress pattern. The numerical experiments indicate that several time scales are important in the regional adjustment process. These are an inertial time scale dependent on the regional long-wave propagation speed, a local frictional time scale dependent on the strength of the depth-averaged velocity field, and a longer time scale which reflects the adjustment process within the entire model. The transient response within the Middle Atlantic Bight proper from Cape Cod to Cape Hatteras to an alongshore wind stress is clearly dominated by friction and rotation. The effective spinup time scale for a 2 dyn cm^{-2} wind stress is about 10 h at New York. This is sufficiently short in comparison to the 4–10 day lime scales characterizing atmospheric transients that the storm-driven currents should be quasi-steady. Within the deeper Gulf of Maine basin, the effective spinup time scale is much longer and the normal modes of the basin excited by the wind forcing are only weakly damped in time.

A comparison of model and observational data on current and sea level variability indicates that the model response is more realistic within the Middle Atlantic Bight section of the model domain. Differences within the Gulf of Maine are due primarily to the specific boundary condition imposed on the upcoast (Scotian shelf) boundary.

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