Abstract View

Volume 11, Issue 11 (November 1981)

Journal of Physical Oceanography
Article: pp. 1548–1566 | Abstract | PDF (1.41M)

Simulation and Verification of Lake Ontario's Mean State

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(Manuscript received August 1, 1980, in final form August 21, 1981)

DOI: 10.1175/1520-0485(1981)011<1548:SAVOLO>2.0.CO;2

ABSTRACT

A numerical dynamic model based on primitive equations has been developed for Lake Ontario. Many experimental tests for parameter selections and alternative formulations of physical processes in the model were carried out. Two simulations, both repeated in July and December 1972, one under constant atmospheric forcing and the other under hourly time-dependent, spatially varying atmospheric forcing, are presented here. With constant southwesterly wind parallel to the major axis of the lake, as was the case in both July and December 1972, the steady-state lake circulation forms a typical two-gyre wind-driven pattern with currents flowing with the wind in both coastal regions and return flow in the middle of the lake. The monthly mean currents of the hourly time-dependent variable-forcing simulation of December have a pattern similar to that of the constant-forcing case, while the men currents of the July time-dependent variable-forcing simulation yield a single cyclonic circulation pattern with currents flowing against the mean wind in the north shore, which is totally different from the constant-forcing steady-state result. Both the monthly mean model currents of the time-dependent variable-forcing simulations agree very well with the monthly mean currents observed over Lake Ontario during the International Field Year for the Great Lakes (IFYGL).

When the lake density is nearly homogeneous, with negligible thermal effects, as in December, the lake response is mostly barotropic. The induced circulation consists of dominantly wind-driven currents adjusted to the bottom topography with a thin Ekman layer on top of the geostrophically balanced currents in deep layers. Further simplification of the dynamics is a consequence of the linear nature of the model's behavior. The means of the time-dependent variable-forcing simulation merge to form the constant-forcing steady-state circulation. In July, however, the lake is stratified and both the wind-driven and thermal-driven currents are important. It seems that the final circulation pattern in a lake depends mostly on the relative strengths of the thermally affected mechanisms and the wind-driven mechanism. Dominance of the former generally results in a one-gyre circulation pattern, while dominance of the latter results in a two-gyre circulation pattern. In a constant-forcing model, most of the thermally affected mechanisms, such as the rectified effect, the coastal mixing, dome-shaped isotherms, and horizontal and vertical density gradients, are obscured by the fully developed wind-driven steady-state currents. Employing such a model to simulate the stratified lake is definitely inadequate and misleading because only the time-dependent variable-

forcing simulation results in a mean, single-gyre circulation pattern that matches the observations, while the constant-forcing still produces an unrealistic two-gyre circulation pattern for July 1972 (during IFYGL).

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