Abstract View

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Numerical Simulation of Internal Kelvin Waves and Coastal Upw

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ABSTRACT

Two three-dimensional primitive equation numerical ocean models are applied to the problem of internal Kelvin waves and coastal upwelling in the Great Lakes. One is the Princeton Ocean Model (POM) with a terrain-following (sigma) vertical coordinate, and the other is the Dietrich/Center for Air Sea Technology (DIECAST) model with constant z-level coordinates. The sigma coordinate system is particularly convenient for simulating coastal upwelling, while the z-level system might be better for representing abrupt topographic changes. The models are first tested with a stratified idealized circular lake 100 km in diameter and 100 m deep. Two bottom topographies are considered: a flat bottom and a parabolic depth profile. Three rectilinear horizontal grids are used: 5, 2.5, and 1.25 km. The POM was used with 13 vertical levels, while the DIECAST model was tested with both 13 and 29 vertical levels. The models are driven with an impulsive wind stress imitating the passage of a weather system.

In the case of the flat-bottom basin, the dynamical response to light wind forcing is a small amplitude internal Kelvin wave. For both models, the speed of the Kelvin wave in the model is somewhat less than the inviscid analytic solution wave speed. In the case of strong wind forcing, the thermocline breaks the surface (full upwelling) surface thermal front appears. After the wind ceases, the edges of this thermal front propagate cycl the lake, quite similar to an internal Kelvin wave. In the case of parabolic bathymetry, Kelvin wave propagation is modified by interaction with a topographic wave and a geostrophic circulation. In bo horizontal resolution gives higher wave and frontal speeds. Horizontal resolution is much more critic upwelling case than in the Kelvin wave case. Vertical resolution is not as critical.

The models are also applied to Lake Michigan to determine the response to strong northerly winds c
along the eastern shore. The results are more complex than for the circular basin, but clearly show
of cyclonically propagating thermal fronts. The resulting northward warm front propagation along t
compares favorably with observations of temperature fluctuations at municipal water intakes after a
the model frontal speed was less than the observed speed.