Abstract View

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On the Dynamics of Wind-Driven Lake Currents

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ABSTRACT

Two time-dependent "vertical cross section models" are analyzed and applied to wind-driven currents in Lake Ontario. The models are: 1) a linear frictionless, two-level model, and 2) a numerical model which includes both friction and nonlinear terms. They predict current and temperature under the assumption that all variables except pressure are independent of the longshore coordinate. The longshore pressure gradient is computed from the condition that the volume transport normal to the cross section is zero.

First, the quasi-static response of the linear frictionless model is studied to isolate the effects of topography and stratification on the structure of the coastal currents. It predicts that the vertically averaged longshore current is independent of both rotation and stratification, being in the direction of the wind where the water is shallower than average and opposite the wind in the deep water. Under homogeneous conditions, the strongest currents are confined to a thin (~ 3 km wide for Lake Ontario) region near the shore. The effect of stratification is to increase the width of this "costal jet" region and cause the flow to be more confined to the surface layer.

These qualitative results of the linear model are also true for the numerical model, but the latter gives more realistic current magnitudes. The main differences between the two models are due to friction which has a relatively straightforward damping effect on both the quasi-geostrophic and inertial oscillation components of the flow. The damping of the geostrophic mode, however, is smaller in cases where stratification is important, because it decreases the effect of bottom friction.

The models give realistic magnitudes for both horizontal and vertical motion in Lake Ontario and can explain many of the differences between the spring and summer current regimes.

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