Abstract View

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A Numerical Study of the Response of an Idealized Ocean to Large-Scale Surface Heat and Momentum Flux

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ABSTRACT

A numerical model of a 6-level, baroclinic ocean with a flat bottom and a regular coast line extending from 51.25S to 48.75N is integrated over 125 years of simulated time using a finite-difference analog of the primitive equations. The surface atmospheric conditions which drive the circulation, both mechanically and thermally, are prescribed and depend on latitude only. The numerical integration is done in two phases. In the first phase (100 years), the temperature is predicted from the complete thermal energy equation, while the equations of horizontal motion are linear and the vertical mean current is constant in time. In the second phase (25 years), the complete primitive equations are used, and the coefficients of eddy viscosity and eddy conductivity are reduced.

Integration of the first phase produces western boundary currents in both hemispheres, a surface counter-current at 7N, an eastward undercurrent at the equator, and a narrow band of cold surface water along the equator which is maintained by a narrow belt of strong vertical velocities of the order of 200 cm day^{-1} at the bottom of the first layer. However, the calculated undercurrent and western boundary current speeds are only 25% as strong as those observed, and in the equatorial region the calculated thermocline is too deep.

The most interesting differences in the results of the two phases occur in equatorial regions where the eastward transport by the model undercurrent nearly doubled in the second phase. By comparing the under-current transport predicted by Gill's theory, with that obtained in the first and second phases, respectively, it is shown that density stratification increases the eastward transport by a factor of 4 while increased baroclinity and nonlinear effects increase the transport an additional 75% over the stratified case.

A calculation of the different modes of poleward heat transport in the second phase shows that the mean meridional circulation transports most of the heat, and that the eddies in both the vertical shear current and the vertical mean current transport heat equatorward. An analysis of the energy balance in the second phase of the model shows that, in the mean, kinetic energy is transformed into potential energy and that this is related to the thickness of the thermal

boundary layer in the vicinity of the western boundary. There is also a positive, though small, transformation from the kinetic energy of the vertical shear flow to the kinetic energy of the vertical mean flow, which is related to the relatively large lateral eddy viscosity required by the coarse grid.

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