Abstract View

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Regional Eddy Vorticity Transport and the Equilibrium Vorticity Budgets of a Numerical Model Ocean Circulation

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ABSTRACT

The dynamical balances of the mean flow of a numerical model ocean general circulation experiment are examined through evaluation of regional vorticity budgets. The instantaneous flow is strongly time dependent and the effect of eddy terms in the mean budgets is of primary interest. Budgets have been computed over volumes ranging in size from less than that of a typical model eddy up to an entire wind-driven gyre, using time series of 5 and 10 year durations. The statistical reliability of terms in the budgets varies significantly with the region size; over regions the size of an eddy or smaller the reliability is often poor, but over the selected larger regions it is satisfactory. The final analysis regions are selected by requiring that each be identified clearly with some part of the mean flow and that cancellation of the locally dominant terms within each region be minimized whenever possible.

The primary mechanism for balancing the wind-stress curl vorticity input in each half basin is found to be horizontal transport of relative vorticity by the eddies across the zero wind-stress curl latitude that separates the distinct flow systems of the two half basins. However, net meridional eddy vorticity transport is generally unimportant away from the half-basin boundary latitude. Eddy horizontal transports over the analysis regions, away from the western part of the zero wind-stress curl latitude, also tend to be small. The transport flow budgets and upper layer budgets tend to be similar. The deep-layer flow is qualitatively different from these flows, a separate set of analysis regions is needed to study it, and the deep budgets are different in several respects. Away from the boundary currents and internal jets the volume integral analog of the classical geostrophic balance—vortex stretching balancing advection of planetary vorticity—holds very well. In particular, over the interior of each gyre, the net input of vorticity by the, wind balances the loss by advection of planetary vorticity to better than 10%. This result is quite different from the conclusion that would he drawn from examination of the vorticity balance at a point over much of the interior, where the divergence of the eddy relative vorticity flux is often large (but of limited statistical reliability). The eddy heat-flux divergence plays an important role in establishing the interfacial vertical velocity contribution to vortex stretching in some of the regions, and appears essential in forcing one of the deep flow currents. No simple summary of the bound current and jet region budgets can be offered, except that mean nonlinear transport often dominates eddy horizontal transport and that frictional effects can be quite small. These results are compared with classical wind-driven ocean circulation ideas and the strengths and limitations of this type of analysis for studying eddy-mean flow interaction are discussed.

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