Abstract View

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A Three-Layer Model for the Wind-Driven Circulation in a Subtropical–Subpolar Basin. Part III: Potential Vorticity Analysis

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ABSTRACT

Recent progress in thermocline theory is linked and demonstrated by a wind-driven three-layer numerical model. The dynamic balances of the circulation of the model are studied through examination of potential vorticity budgets. Potential vorticity balances of two cases of the subcritical state have been calculated over the entire basin and along trajectories. Vorticity budget analysis clearly shows several zones of different dynamics in the gyre scale circulation. High potential vorticity water masses in the subtropical western boundary region are shown to be created by strong lateral momentum mixing and bottom friction implemented in the model. These water masses move into the subtropical gyre interior in the form of high potential vorticity tongues. Within the gyre interior the potential vorticity of the water parcels can be either quasi-conservative (within a regime of weak forcing/diffusion) or slowly modified by local forcing/diffusion. The potential vorticity dynamics in the subpolar gyre shows a similar feature but generally with different sign for the source/sink terms. Along-trajectory analysis of a case of the supercritical state shows clearly four zones of different potential vorticity dynamics, i.e., the frontal zone, the outcropping zone, the subduction zone, and the western boundary zone. These concrete numerical examples illustrate the dynamics of the fundamental regimes in the gyre-scale circulation as discussed in the recently proposed theories of the thermocline.