Abstract View

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Establishment of Deep Ocean Circulation Driven by Deep-Water Production

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ABSTRACT

A linear, two-layer baroclinic model of deep circulation driven by deep water production is formulated. In distinction to the Stommel-Arons model where a uniform middepth upwelling is prescribed, the present model determines upwelling internally by inclusion of a Newtonian damping term in the continuity equation. Analytical solutions for the steady state are derived using the equatorial beta-plane approximation, which show that the coefficient of damping in the upwelling term determines the nature of the flow. With a large damping coefficient, the deep western boundary current from the deep-water source region does not cross the equator, but rather separates along it. The current reaches the eastern boundary and then flows poleward in both hemispheres as an eastern boundary current. In the limit of very weak damping, the flow spins up to the Stommel-Arons state, with the western boundary current crossing the equator and with poleward flows in the interior. Numerical experiments on the spherical coordinates confirm the results of analytical theory for the steady state. They also show that the flow is first set up by a Kelvin wave along the western-equatorial-eastern boundary layers; then, in the case of weak damping, the eastern boundary current disperses as long Rossby waves to set up the poleward interior flow of the Stommel-Arons model.