Abstract View

Volume 13, Issue 11 (November 1983)

Journal of Physical Oceanography
Article: pp. 2020–2037 | Abstract | PDF (1.29M)

Ventilation, Potential-Vorticity Homogenization and the Structure of the Ocean Circulation

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(Manuscript received May 12, 1983)

DOI: 10.1175/1520-0485(1983)013<2020:VPVHAT>2.0.CO;2

ABSTRACT

A model for the vertical structure of the oceanic circulation is presented that combines elements of the theory of the ventilated thermocline, given by Luyten, Pedlosky and Stommel, with the theory of Rhines and Young for the wind driven circulation of an unventilated ocean.

Our model consists of a ventilated thermocline region above an unventilated zone in which motion is limited to pools of constant potential vorticity. The model is nonlinear and hence the presence of ventilation affects the dynamics of the unventilated motion and vice-versa.

The planetary geostrophic equations are used and so the quasi-geostrophic assumption of Rhines and Young is relaxed, allowing large isopycnal excursions.

It is shown that the presence of ventilation generally shrinks and weakens the size and vigor of the subsurface pools of homogenized potential vorticity. At the same time, within those domains, the strength of circulation in the ventilated zone is somewhat diminished as the subsurface layers carry a portion of the Sverdrup transport.

We argue that the (mathematically) consistent circulation in the absence of sub-thermocline constant potential-vorticity pools is unstable.

The non-uniqueness of the nondissipative Sverdrup dynamics is demonstrated by the ambiguity in the specification of potential vorticity in the deeper, unventilated layers. The study emphasizes the subtle importance of dissipation in

selecting a unique solution.