Abstract View

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On the Role of Interior Mixing and Air-Sea Fluxes in Determining the Stratification and Circulation of the Oceans

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ABSTRACT

The problem of determining the (eastern boundary) basic stratification and the buoyancy-driven circulation of the oceans is addressed. A global integral constraint relating the interior stratification and the air-sea heat fluxes is derived, based on the condition that the total mass of water of given density is constant in a steady state ocean. This constraint is then applied to two simple analytic models: The first is a continuous nonlinear diffusive model of the lower mid-depth and bottom circulation below the influence of the wind-driven circulation. It shows the tendency of the vertical density profile to look like an exponential profile in the presence of mixing. The integral constraint is used to relate the stratification and circulation of the bottom and mid-depth waters to the air-sea heat fluxes at the surface, where the deep densities outcrop. The second model is a layered one of the wind-driven circulation, mid-depth, and bottom water. The eastern boundary stratification of the model is determined from the air-sea heat fluxes, using the integral constraint and a parameterization of the mixing processes in layer models. A two gyre mid-depth circulation is found, driven by the cross-isopycnal diffusive velocities and affected by the variations in the depth of the main thermocline above it. The bottom circulation in both models is similar to that of the Stommel-Arons model.

Air-sea heat fluxes affect the deep buoyancy-driven flows not by direct cooling or heating, but through the formation of water masses that sink and spreak in the deep ocean. Thermal boundary conditions for the interior thermocline problem seem to require specification of the air-sea heat fluxes in addition to the specification of the density distribution at the base of the Ekman layer. Cross-isopycnal mixing processes are a crucial part of the dynamics, although numerically small. Together with the air-sea heat fluxes, they determine the basic vertical stratification of the wind-driven and deep circulation.

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