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# Entrainment into slope currents, interior mixing, and a coupled solution for the global overturning circulation

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We couple a simple analysis of the sinking, spreading and mixing of dense slope currents with a modified form of Munk's (1966) abyssal recipe for vertical advection-diffusion balance throughout the ocean interior to arrive at a complete solution for the zonally-integrated meridional overturning of the global ocean. The solution is related to the 'filling-box' of Baines  Turner (1969), which is forced by an unstable buoyancy flux to a turbulent plume from a small source, hence is unsteady. In the oceans, this buoyancy flux is that resulting from cooling over approximately one half of the ocean surface, but we take advantage of laboratory and numerical demonstrations of extreme asymmetry and turbulence in "horizontal convection" to describe the slope currents (or plumes) as sinking from points at the surface. We add interior vertical mixing and an equal stabilizing buoyancy flux distributed over the ocean surface (such that there is no net heat input), and find a steady solution. In this solution, the interior buoyancy flux by vertical mixing at any depth must be sufficient to balance the buoyancy flux carried through that depth by the plumes. In steady state the dominant plume must always fall through the full depth of the basin.

In order to apply the model most simply to the global ocean, we assume a single dominant sinking plume (which is the outflow from the Weddell Sea) and a heat transport of 2 PW as previously estimated for each hemisphere. The simple but powerful solution successfully predicts the observed overturning mass flux, the top-to-bottom density difference, the thermocline depth, and the measured vertical diffusivity (of order $10^{-5}$ $m^2s^{-1}$).