MS6L_11499

XXI International Congress of Theoretical and Applied Mechanics
Warsaw, Poland, August 15–21, 2004

Turbulent Horizontal Convection and the Global Thermohaline Circulation of the Oceans

Ross Griffiths, Graham Hughes, Julia Mullarney

Australian National University, Canberra, Australia

Our laboratory and numerical experiments show that convection in a long box driven by differential heating at a single horizontal boundary can be turbulent. A convective mixed layer forms within a stable thermocline, deepens toward the end of the box, penetrates through the depth of the thermocline at the end, and feeds into a turbulent plume. The mean 'sinking' occurs at one end and, in the rotating case, involves unsteady chimney structures. Using an analytical model with zero net buoyancy flux and depth-dependent vertical velocity in the interior we correctly predict the mass transport and density structure for both the experiments and the meridional overturning circulation of the ocean. The ocean prediction is consistent with data when we assume a vertical diffusivity equal to that measured in the open oceans. Thus the much larger diffusivity inferred by others and energy input from winds and tides are not required, and the overturning circulation can be driven by the surface heat fluxes.

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