DFD10-2010-000956

Abstract for an Invited Paper
for the DFD10 Meeting of
the American Physical Society

Ocean circulation and surface buoyancy fluxes: Dynamics and energetics

ROSS GRIFFITHS, The Australian National University

Convection forced by differential buoyancy or flux conditions at a horizontal surface has unusual characteristics. If the flow has adjusted to steady boundary conditions, there is no net heat transport through any level. This form of convection is of interest for its potential relevance to the global meridional overturning circulation of the oceans. However, debate continues about the behaviour of the convection at very large (geophysical) Rayleigh numbers, the role of diffusion and turbulent mixing, and whether surface buoyancy fluxes play a significant role in the ocean circulation. Laboratory experiments and numerical solutions reveal the pattern of convection in a simple box, where flow involves a thermal boundary at the surface, a descending plume of dense water and a box-scale overturning. A heuristic model predicts overturning rates consistent with measurements. This dynamical model also shows that diapycnal (vertical) mixing powered by mechanical energy input to the stratified interior from other sources such as winds and tides, can be balanced by effects of turbulent entrainment into the localized descending currents. A complementary approach is to investigate the energy transformation pathways in the flow, and this reveals that the rate of generation of available potential energy by surface buoyancy fluxes (for a Boussinesq fluid) must be equal to the rate of irreversible turbulent mixing. The relationship between the power input to turbulence and the rate of mixing is poorly known. Thus both dynamical and energetic approaches point to the possibility of an ocean overturning forced by buoyancy and governed by a balance between surface buoyancy fluxes and turbulent mixing.