Simulated RBC

The governing equations in nondimensional form are

$$\frac{\partial u}{\partial t} = -\hat{\mathbf{V}} \cdot \nabla u - \frac{\partial \phi}{\partial x} + \left(\frac{\mathrm{Pr}}{\mathrm{Ra}}\right)^{1/2} \nabla^2 u, \qquad (1)$$

$$\frac{\partial v}{\partial t} = -\hat{\mathbf{V}} \cdot \nabla v - \frac{\partial \phi}{\partial y} + \left(\frac{\mathrm{Pr}}{\mathrm{Ra}}\right)^{1/2} \nabla^2 v, \qquad (2)$$

$$\frac{\partial w}{\partial t} = -\hat{\mathbf{V}} \cdot \nabla w - \frac{\partial \phi}{\partial z} + (T - \bar{T}) + \left(\frac{\mathrm{Pr}}{\mathrm{Ra}}\right)^{1/2} \nabla^2 w, \qquad (3)$$

$$\frac{\partial T}{\partial t} = -\hat{\mathbf{V}} \cdot \nabla T + \frac{1}{(\mathrm{Ra}\ \mathrm{Pr})^{1/2}} \nabla^2 T, \qquad (4)$$

$$\frac{\partial u}{\partial x} + \frac{\partial v}{\partial y} + \frac{\partial w}{\partial z} = 0. \qquad (5)$$

$$\frac{\partial \bar{E}}{\partial t} = -\frac{\partial \overline{wE}}{\partial z} - \frac{\partial \overline{w\phi}}{\partial z} + \overline{wT} - \epsilon + \left(\frac{\mathrm{Pr}}{\mathrm{Ra}}\right)^{1/2} \frac{\partial^2 \bar{E}}{\partial z^2}, \qquad (8)$$

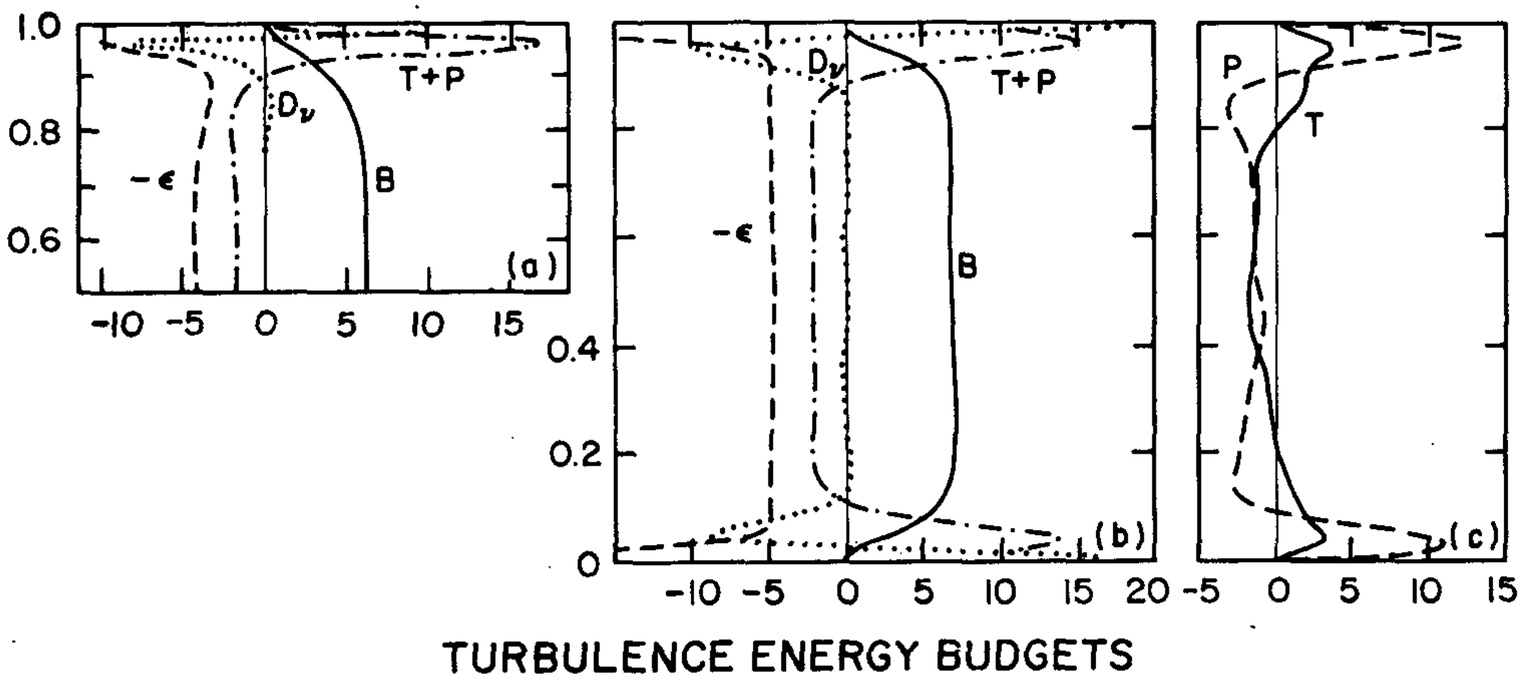

FIG. 5. Profiles of the turbulence kinetic energy budges from (a) Deardorff and Willis' (1967) laboratory experiment, and (b) and (c) our direct numerical simulation of Rayleigh–Bénard convection. The symbols $T, P, B, -\epsilon, D_\nu$ represent turbulent transport, pressure transport, buoyant production, molecular dissipation and molecular diffusion, respectively.

Moeng and Rotunno (1990)