Energy Integrals

David A. Randall

Department of Atmospheric Science
Colorado State University, Fort Collins, Colorado 80523

$$\rho c_p \frac{dT}{dt} = \omega + Q$$
$$\rho \frac{d\mathbf{V}}{dt} = -\nabla p - f\,\mathbf{k} \times \rho \mathbf{V} - g\,\mathbf{k}\,\rho \tag{1}$$

$$\rho \frac{dK}{dt} = -\mathbf{V} \cdot \nabla p - gw\rho$$
$$= -\omega + \frac{\partial p}{\partial t} - gw\rho \tag{2}$$

$$= -\omega + \frac{\partial p}{\partial t} - \rho \frac{d\Phi}{dt}$$

$$\rho \frac{d}{dt}(K + \Phi) = -\omega + \frac{\partial p}{\partial t} \tag{3}$$

$$\rho \frac{d}{dt}(K + \Phi + c_p T) = \frac{\partial p}{\partial t} + Q \tag{4}$$

$$\frac{\partial}{\partial t}\left[\rho\left(K + \Phi + \mathrm{cT} - \frac{p}{\rho}\right)\right] + \nabla \cdot [\rho \mathbf{V}(K + \Phi + c_v T)] = Q \tag{5}$$

$$\frac{\partial}{\partial t}[\rho(K + \Phi + c_v T)] + \nabla \cdot [\rho \mathbf{V}(K + \Phi + c_v T)] = Q \tag{6}$$