Basic equations, scaled for synoptic-scale

In (x, y, z) coordinates

Equations of motion

$$\frac{\partial u}{\partial t} = -u\frac{\partial u}{\partial x} - v\frac{\partial u}{\partial y} - w\frac{\partial u}{\partial z} - \frac{1}{\rho}\frac{\partial p}{\partial x} + fv + F_{rx}$$

$f = 2\Omega\sin\phi$, "Coriolis parameter"

$$\frac{\partial v}{\partial t} = -u\frac{\partial v}{\partial x} - v\frac{\partial v}{\partial y} - w\frac{\partial v}{\partial z} - \frac{1}{\rho}\frac{\partial p}{\partial y} - fu + F_{ry}$$

hydrostatic equation replaces $\frac{Dw}{Dt}$ equation

$$\frac{\partial p}{\partial z} = -\rho g$$

Continuity equation

$$\frac{\partial u}{\partial x} + \frac{\partial v}{\partial y} + \frac{\partial w}{\partial z} + w\frac{d}{dz}(\ln \rho_0) = 0$$

Thermodynamic energy equation

$$\frac{\partial T}{\partial t} = -u\frac{\partial T}{\partial x} - v\frac{\partial T}{\partial y} - w\frac{\partial T}{\partial z} + \frac{\dot{Q}}{c_p} + \frac{1}{c_p\rho}\frac{Dp}{Dt}$$

Moisture equation

$$\frac{\partial q}{\partial t} = -u\frac{\partial q}{\partial x} - v\frac{\partial q}{\partial y} - w\frac{\partial q}{\partial z} + \dot{E} - \dot{P}$$

Ideal gas law

$$p = \rho RT$$