Coriolis parameter

$$f = 2\Omega \sin\phi$$

Ideal gas law

$$p = \rho RT$$

Potential temperature

$$\theta = T\left(\frac{p}{p_0}\right)^{-R/c_p}$$

Buoyancy frequency

$$N^2 = \frac{g}{\theta}\frac{\partial\theta}{\partial z}$$

Atmospheric angular momentum

$$M = (\Omega R + u)R$$

Phase speed of a wave

$$c_x = \frac{\upsilon}{k} \qquad c_y = \frac{\upsilon}{l}$$

Group velocity of a wave

$$c_{gx} = \frac{\partial\upsilon}{\partial k} \qquad c_{gy} = \frac{\partial\upsilon}{\partial l}$$

Stoke's theorem

$$\int_S \left(\nabla \times \vec{V}\right)\cdot d\vec{A} = \int_C \vec{V}\cdot d\vec{l}$$

Primitive equations (filtered)

$$\frac{du}{dt} = fv - \frac{\partial\Phi}{\partial x}$$

$$\frac{dv}{dt} = -fu - \frac{\partial\Phi}{\partial y}$$

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

$$\frac{\partial u}{\partial x} + \frac{\partial v}{\partial y} + \frac{\partial\omega}{\partial p} = 0$$

$$\frac{dT}{dt} - \omega S_p = \frac{J}{c_p}$$

$$S_p = -\frac{T}{\theta}\frac{\partial\theta}{\partial p}$$

Shallow water equations

$$\frac{du}{dt} = fv - g\frac{\partial h}{\partial x}$$

$$\frac{dv}{dt} = -fu - g\frac{\partial h}{\partial y}$$

$$\frac{dh}{dt} = -H_0\left(\frac{du}{dx} + \frac{dv}{dy}\right)$$

Quasi-geostrophic equations

$$\frac{du_g}{dt} = fv_a + \beta y v_g$$

$$\frac{dv_g}{dt} = -fu_a - \beta y u_g$$

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

$$\frac{\partial u_a}{\partial x} + \frac{\partial v_a}{\partial y} + \frac{\partial\omega}{\partial p} = 0$$

$$\frac{d}{dt}\left(-\frac{\partial\Phi}{\partial p}\right) - \omega\sigma = \frac{R}{p}\frac{J}{c_p}$$

$$\sigma = -\frac{RT_0}{p\theta}\frac{\partial\theta}{\partial p}$$

$$\frac{d\zeta_g}{dt} = -f_0\left(\frac{\partial u}{\partial x} + \frac{\partial v}{\partial y}\right) - \beta v_g$$

Isentropic (Ertel) potential vorticity

$$Q = -g(\zeta + f)\left(\frac{\partial\theta}{\partial p}\right)$$

Rossby potential vorticity

$$P = \left(\frac{\zeta + f}{h}\right)$$

Quasi-geostrophic potential vorticity

$$q \equiv \frac{1}{f_0}\nabla^2\Phi + f + \frac{\partial}{\partial p}\left(\frac{f_0}{\sigma}\frac{\partial\Phi}{\partial p}\right)$$

Constants

Radius of Earth	$a = 6.370\times10^{6}$ m
Planetary rotation rate	$\Omega = 7.292\times10^{-5}$ rad s^{-1}
Acceleration due to gravity	$g = 9.81$ ms^{-2}
Gas constant for dry air	$R = 287$ J K^{-1} kg^{-1}
Gas constant for water vapor	$R_{v} = 461$ J K^{-1} kg^{-1}
Heat capacity (at constant pressure)	$c_p = 1005$ J K^{-1} kg^{-1}
Latent heat of condensation	$L = 2.5\times10^{6}$ J kg^{-1}
Scale height (troposphere)	$H = 7600$ m
Dry adiabatic lapse rate	$\Gamma_d = 9.8$ K km^{-1}
Moist adiabatic lapse rate	$\Gamma_m = 6.5$ K km^{-1}
Typical Coriolis parameter	$f_0 \sim 1\times10^{-4}$ s^{-1}
Typical beta parameter	$\beta \sim 1\times10^{-11}$ m^{-1}s^{-1}