Basic equations – from height coordinate to pressure coordinate (Ch. 3.1)

**Vertical coordinate**

\[ z \rightarrow \quad \text{Vertical velocity} \]

\[ w \rightarrow \]

**Total differential**

\[
\frac{D}{Dt} = \frac{\partial}{\partial t} + u \frac{\partial}{\partial x} + v \frac{\partial}{\partial y} + w \frac{\partial}{\partial z} \quad \rightarrow \quad \frac{D}{Dt} =
\]

**Pressure gradient force**

\[
- \frac{1}{\rho} \left( \frac{\partial p}{\partial x} \right)_z =
\]

**Hydrostatic balance**

\[
d\Phi = gdz = - \frac{dp}{\rho} = - \frac{RT}{p} dp
\]

\[
\frac{\partial \Phi}{\partial \rho} =
\]

**Continuity equation**

\[
\frac{1}{\delta m} \frac{D\delta m}{Dt} = 0 \quad \delta m = \frac{\delta V}{\rho} =
\]

**Thermodynamic energy equation**

\[
c_p \frac{DT}{Dt} - \alpha \frac{Dp}{Dt} = J
\]
Basic equations – from height coordinate to pressure coordinate (Ch. 3.1)

Pressure gradient force

Represent the pressure gradient force term in pressure coordinate

\[
\frac{1}{\rho} \frac{\partial p}{\partial x} \bigg|_z = \frac{\partial^2 \phi}{\partial x}\bigg|_7 = \frac{\partial p}{\partial x} \delta x + \frac{\partial p}{\partial z} M \delta z \rightarrow 0
\]

\[
\frac{\partial p}{\partial x} = \frac{\rho g}{\partial z} \delta x, \delta z \rightarrow 0
\]
Basic equations – in pressure coordinate
(Ch. 3.1)

Equations of motion scaled for the midlatitude synoptic scale motions
(conservation of momentum, Newton’s second law of motion)

Continuity equation scaled for the midlatitude synoptic scale motions
(conservation of mass)

Thermodynamic energy equation scaled for the midlatitude synoptic scale motions
(conservation of energy, the first law of thermodynamics)

Ideal gas law

Dependent variables

\( u, v, \omega, T, \Phi, \rho' \)