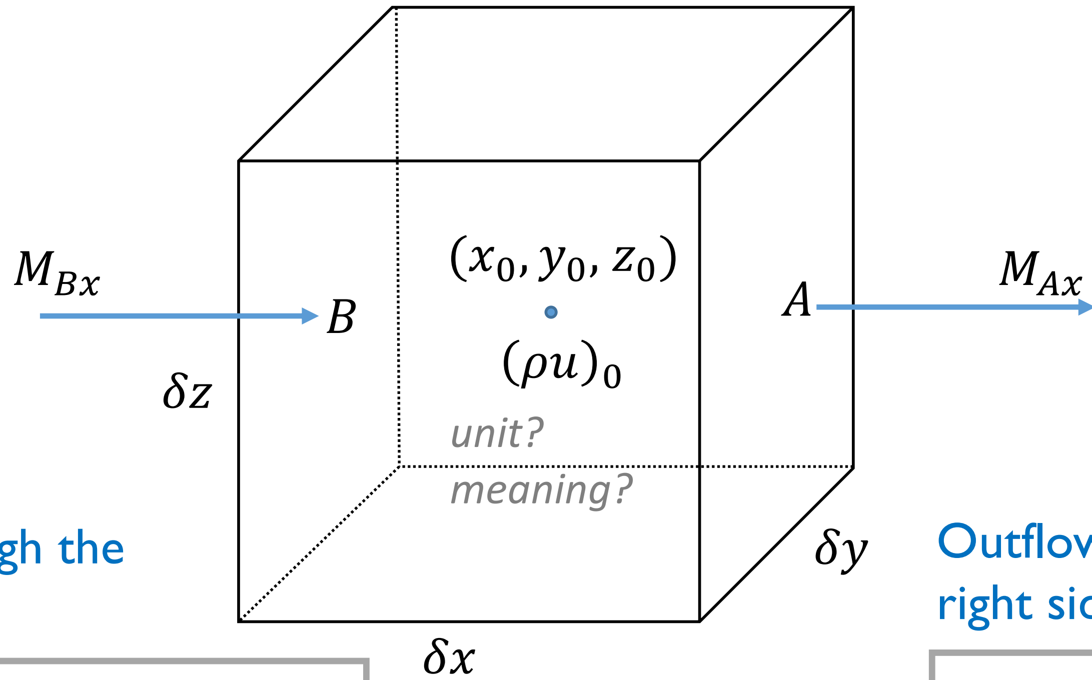
Continuity equation
(Ch. 2.5)



Inflow of mass through the left side (B)

$M_{Bx} =$ ☐

Outflow of mass through the right side (A)

$M_{Ax} =$ ☐

unit?

Net mass inflow (In minus Out, x-direction)

$M_x =$ ☐

Net mass inflow per unit volume (considering all direction), which is local density change

$$\frac{M_x + M_y + M_z}{\delta V} = \boxed{} = \frac{\partial \rho}{\partial t}$$

Continuity equation
(Ch. 2.5)

Continuity equation (mass conservation)

$$\frac{\partial \rho}{\partial t} \quad \boxed{} = 0$$

$$\frac{\partial \rho}{\partial t} \quad \boxed{}$$
$$\boxed{} = 0$$

using divergence operator

$$\frac{\partial \rho}{\partial t} + \boxed{} = 0$$

using total derivative of density

$$\boxed{}\frac{D\rho}{Dt} + \boxed{} = 0$$

Decomposition of total density

total=basic state + perturbation

$$\rho(x, y, z, t) = \rho_0(z) + \rho'(x, y, z, t)$$

decomposition

$$\frac{1}{\rho}\frac{D\rho}{Dt} = \frac{1}{(\rho_0 + \rho')}\frac{D(\rho_0 + \rho')}{Dt} \approx \boxed{}\frac{D(\rho_0 + \rho')}{Dt}$$

$$\approx \boxed{}$$

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Scale analysis of the continuity equation

after decomposition

$$\frac{1}{\rho_0}\left(\frac{\partial \rho'}{\partial t} + \vec{U} \cdot \nabla \cdot \rho'\right) + \boxed{} = 0$$

$$\frac{1}{\rho_0}\left(\frac{\partial \rho'}{\partial t} + u\frac{\partial \rho'}{\partial x} + v\frac{\partial \rho'}{\partial y} + w\frac{\partial \rho'}{\partial z}\right) + \boxed{} = 0$$

$$|u, v| \sim 10\ m\ s^{-1}$$
$$|w| \sim 10^{-2}\ m\ s^{-1}$$
$$|\delta x, \delta y| \sim 10^{6}\ m$$
$$|\delta z| \sim 10^{4}\ m$$
$$|\delta t| \sim |\delta x/u| \sim 10^{5}\ s$$
$$|\rho'/\rho_0| \sim 10^{-2}$$

Continuity equation scaled for midlatitude synoptic scale motions

$$\boxed{} = 0$$

using divergence operator

$$\boxed{} = 0$$