

Scale analysis of the equations of motion (Chs. 1.6 and 2.4)

$$\frac{Du}{Dt} - \frac{uv \tan \phi}{a} + \frac{uw}{a} = -\frac{1}{\rho} \frac{\partial p}{\partial x} + 2\Omega v \sin \phi - 2\Omega w \cos \phi + v \nabla^2 u$$

$$\begin{aligned} \phi &= 45^\circ N \\ \Omega &= 7.292 \times 10^{-5} \text{ s}^{-1} \\ 2\Omega \sin \phi &\sim 1 \times 10^{-4} \text{ s}^{-1} \end{aligned}$$

$$\left| \frac{Du}{Dt} \right| \sim \boxed{} \sim \boxed{}$$

$$|u, v| \sim 10 \text{ m s}^{-1}$$

$$|w| \sim 10^{-2} \text{ m s}^{-1}$$

$$|\delta x, \delta y| \sim 10^6 \text{ m}$$

$$|\delta z| \sim 10^4 \text{ m}$$

$$|\delta p / \rho| \sim 10^3 \text{ m}^2 \text{ s}^{-2}$$

$$|\delta t| \sim |\delta x / u| \sim 10^5 \text{ s}$$

$$\left| \frac{uv \tan \phi}{a} \right| \sim$$

$$\left| \frac{uw}{a} \right| \sim$$

$$\left| \frac{1}{\rho} \frac{\partial p}{\partial x} \right| \sim$$

$$g = 9.81 \text{ m s}^{-2}$$

$$|2\Omega v \sin \phi| \sim$$

$$|2\Omega w \cos \phi| \sim$$

$$|v \nabla^2 u| \sim$$

Geostrophic wind – from the first order balance, diagnostic

$$u_g = \boxed{}$$

Scale analysis of the equations of motion (Chs. 1.6 and 2.4)

$$\frac{Dv}{Dt} - \frac{u^2 \tan \phi}{a} + \frac{vw}{a} = -\frac{1}{\rho} \frac{\partial p}{\partial y} - 2\Omega u \sin \phi + v\nabla^2 v$$

$$\phi = 45^\circ N$$

$$\Omega = 7.292 \times 10^{-5} s^{-1}$$

$$2\Omega \sin \phi \sim 1 \times 10^{-4} s^{-1}$$

$$|u, v| \sim 10 m s^{-1}$$

$$|w| \sim 10^{-2} m s^{-1}$$

$$|\delta x, \delta y| \sim 10^6 m$$

$$|\delta z| \sim 10^4 m$$

$$|\delta p / \rho| \sim 10^3 m^2 s^{-2}$$

$$|\delta t| \sim |\delta x / u| \sim 10^5 s$$

$$g = 9.81 m s^{-2}$$

Geostrophic wind – from the first order balance, diagnostic

$$V_g = \square$$

Scale analysis of the equations of motion (Chs. 1.6 and 2.4)

$$\frac{Dw}{Dt} - \frac{u^2 + v^2}{a} = -\frac{1}{\rho} \frac{\partial p}{\partial z} - g - 2\Omega u \sin \phi + v \nabla^2 w$$

$$\phi = 45^\circ N$$

$$\Omega = 7.292 \times 10^{-5} s^{-1}$$

$$2\Omega \sin \phi \sim 1 \times 10^{-4} s^{-1}$$

$$|u, v| \sim 10 m s^{-1}$$

$$|w| \sim 10^{-2} m s^{-1}$$

$$|\delta x, \delta y| \sim 10^6 m$$

$$|\delta z| \sim 10^4 m$$

$$|\delta p / \rho| \sim 10^3 m^2 s^{-2}$$

$$|\delta t| \sim |\delta x / u| \sim 10^5 s$$

$$g = 9.81 m s^{-2}$$

Hydrostatic balance

$$\frac{1}{\rho} \frac{\partial p}{\partial z} = \boxed{}$$

Hydrostatic balance (Ch. 2.4.3)

total=basic state (resting atmosphere) + perturbation

$$p(x, y, z, t) = p_0(z) + p'(x, y, z, t)$$

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

hydrostatic balance in the resting atmosphere



vertical momentum equation before scaling

$$\frac{Dw}{Dt} - \frac{u^2 + v^2}{a} = -\frac{1}{\rho} \frac{\partial p}{\partial z} - g - 2\Omega u \sin \phi + v \nabla^2 w$$

decomposition

$$-\frac{1}{\rho} \frac{\partial p}{\partial z} = -\frac{1}{(\rho_0 + \rho')} \frac{\partial (p_0 + p')}{\partial z} \approx$$



after the decomposition

$$\frac{Dw}{Dt} - \frac{u^2 + v^2}{a} = -\frac{1}{\rho_0} \frac{\partial p_0}{\partial z} - g - 2\Omega u \cos \phi + v \nabla^2 w$$

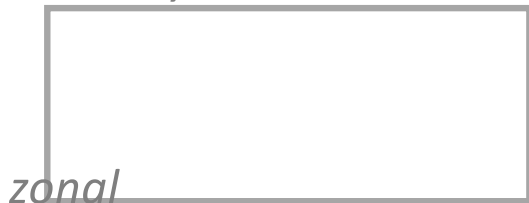
$$|\delta p' / \rho_0| \sim 10^3 \text{ m}^2 \text{ s}^{-2}$$

$$|\rho' / \rho_0| \sim 10^{-2}$$

$$10^{-7} \quad 10^{-5} \quad 10^1 \quad 10^1 \quad 10^{-3} \quad 10^{-15}$$

Equations of motion scaled for the midlatitude synoptic scale motions

(how many unknowns and how many equations?)



zonal



meridional



vertical