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

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

$$\emptyset = 45^o N$$
$$\Omega = 7.292\times10^{-5}s^{-1}$$
$$2\Omega\sin\emptyset \sim 1\times10^{-4}s^{-1}$$

$$|\mathrm{u,v}|\sim 10\ m\ s^{-1}$$
$$|\mathrm{w}|\sim 10^{-2}\ m\ s^{-1}$$
$$|\delta\mathrm{x}, \delta y|\sim 10^{6}\ m$$
$$|\delta z|\sim 10^{4}\ m$$
$$|\delta p/\rho|\sim 10^{3}\ m^2 s^{-2}$$
$$|\delta t|\sim|\delta x/u|\sim 10^{5}\ s$$

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

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

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

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

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

$$|2\Omega\,\mathrm{v}\sin\emptyset| \sim$$

$$|2\Omega\,\mathrm{w}\cos\emptyset| \sim$$

$$|\nu\nabla^2\mathrm{u}\,| \sim$$

Geostrophic wind – from the first order balance, diagnostic

$$\mathrm{u_g} = \boxed{\qquad}$$

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

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

$$\emptyset = 45^o N$$
$$\Omega = 7.292\times10^{-5} s^{-1}$$
$$2\Omega \sin \emptyset \sim 1\times10^{-4} s^{-1}$$

$$|\mathrm{u,v}| \sim 10\ m\ s^{-1}$$
$$|\mathrm{w}| \sim 10^{-2}\ m\ s^{-1}$$
$$|\delta \mathrm{x}, \delta y| \sim 10^6\ m$$
$$|\delta z| \sim 10^4\ m$$
$$|\delta p/\rho| \sim 10^3\ m^2 s^{-2}$$
$$|\delta t| \sim |\delta x/u| \sim 10^5\ s$$

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

Geostrophic wind – from the first order balance, diagnostic

$$\mathrm{v_g} = \boxed{}$$

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

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

$$\emptyset = 45^o N$$
$$\Omega = 7.292\times10^{-5} s^{-1}$$
$$2\Omega \sin\emptyset \sim 1\times10^{-4} s^{-1}$$

$$|u, v| \sim 10\ m\ s^{-1}$$
$$|w| \sim 10^{-2}\ m\ s^{-1}$$
$$|\delta x, \delta y| \sim 10^6\ m$$
$$|\delta z| \sim 10^4\ m$$
$$|\delta p/\rho| \sim 10^3\ m^2 s^{-2}$$
$$|\delta t| \sim |\delta x/u| \sim 10^5\ s$$

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

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

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

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

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

10^{-7} 10^{-5} 10^{1} 10^{1} 10^{-3} 10^{-15}

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

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

Equations of motion scaled for the midlatitude synoptic scale motions

(how many unknowns and how many equations?)

zonal *meridional* *vertical*