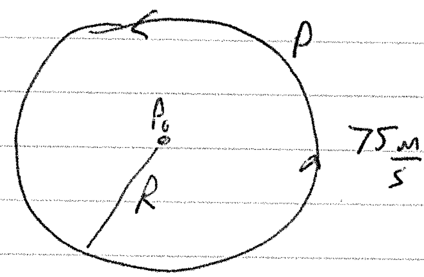
6.4 Hurricane Katrina 26 N 58.1 W



$P_0 = 907$ kPA
$R = 20$ km

a) Calculate $\Delta P = P - P_0$ and P for cyclostrophic, geostrophic, gradient wind flows.

Cyclostrophic Flow: $\frac{\partial P}{\partial n} = -\rho \frac{V^2}{R}$ $\Rightarrow \Delta n \approx R$ as well

$\Delta P = -(P_0 - P) = \rho V^2$

$\rho \approx 1.3$ kg/m³
$V = 75$ m/s

$\boxed{\Delta P = 1.3 \frac{kg}{m^3} \cdot 75^2 \frac{m^2}{s^2} = 73.1 \times 10^2 \text{ PA} = 73.1 \text{ mb}}$

$\Rightarrow \boxed{P = 980.1 \text{ mb}}$

Geostrophic Flow Balance: $fV = -\frac{1}{\rho}\frac{\partial P}{\partial n}$

$f = 2\Omega \sin\phi = 6.38 \times 10^{-5}\ s^{-1}$

$\Delta P = fV\rho \cdot \Delta n = 6.38 \times 10^{-5} \frac{1}{s} \cdot 75 \frac{m}{s} \cdot 1.3 \frac{kg}{m^3} \cdot 20 \times 10^3 m$

$\boxed{\Delta P = 124.3 \text{ PA} = 1.2 \text{ mb}}$ $\Rightarrow$ not much!

Gradient Wind Flow: $\frac{\partial P}{\partial n} = \rho\left(\frac{V^2}{R} + fV\right) = 981.3$ mb

General Equation for balance

b) The gradient and cyclostrophic flows are closest to the likely actual value $\Rightarrow$

Problem 6.6 ⇒ Balanced flow @ 40°N, $\left|\frac{1}{\rho}\frac{\partial P}{\partial n}\right| = 1.5 \times 10^{-3} \frac{m}{s^2}$

$[f = 2\Omega \sin\phi = 9.35 \times 10^{-5}\ s^{-1}]$

a) Find the geostrophic wind speed ⇒

$$V = \frac{1}{f}|P_G| = 16\ \frac{m}{s} \quad \text{Geostrophic wind speed}$$

b)

Gradient Flow $\qquad R = 750\ km$

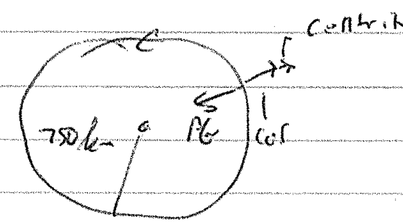
$$V = -\frac{fR}{2} + \left(\frac{f^2R^2}{4} - \frac{R}{\rho}\frac{\partial P}{\partial n}\right)^{1/2}$$

$$V = -\left[\frac{9.35 \times 10^{-5} s^{-1} * 750 \times 10^3 m}{2}\right] +$$

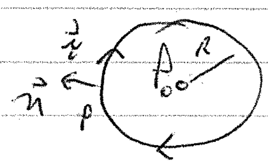
$$\left[[\,]^2 + 750 \times 10^3 m\, 1.5 \times 10^{-3} \frac{m}{s^2}\right]^{1/2}$$

$$V = -35 \frac{m}{s} + \left[2354.4\right]^{1/2} = 13.52 \frac{m}{s}$$

48.52

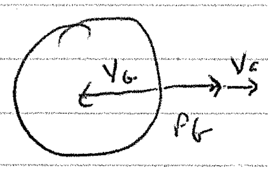


C) Find the $\vec{P}_G$ max for an anticyclone and V_G.

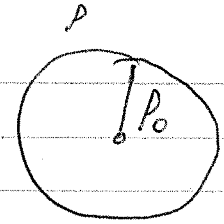


$$\frac{\partial P}{\partial n} \Rightarrow \qquad V = -\frac{fR}{2} - \left(\frac{f^2R^2}{4} - \frac{R}{\rho}\frac{\partial P}{\partial n}\right)^{1/2}$$

Must have ≥ 0



Problem 6.6 continued



Condition for the radical $\Rightarrow$

$$\frac{f^2R^2}{4} - \frac{R}{\rho}\frac{\partial P}{\partial n} \geq 0$$ So V is not imaginary.

Let's use absolute values to deal with this.

$$\frac{f^2|R|^2}{4} - \frac{|R|}{\rho}\left|\frac{\partial P}{\partial n}\right| \geq 0$$

$$\boxed{\frac{1}{\rho}\left|\frac{\partial P}{\partial n}\right| \leq \frac{f^2|R|}{4}}$$ Numerically,

$$\boxed{\frac{1}{\rho}\left|\frac{\partial P}{\partial n}\right| \leq 1.639\times10^{-3}\ \frac{m}{s^2}}$$

The corresponding $\boxed{V_G = \frac{1}{f}\,|PG| = 17\ \frac{m}{s}}$

Problem 6.7

a) In class we derived

Rossby #

$$\frac{V_{bal}}{V} = 1 + \frac{V}{fR} = 1 + R_o$$

where V is the geostrophic wind.

Using $f = 1 \times 10^{-4}\ s^{-1}$,

flow	V(m/s)	R(m)	R_o	V_G (m/s)
Dust devil	10	10	10^4	10^5
Tornado	100	500	2×10^3	2×10^5
Hurricane	50	1×10^4	50	2550
Synoptic Cyclone	10	1×10^6	0.1	11 m/s

b) Most extreme.

c) For the coriolis force to balance the pressure gradient force the wind speed would have to be greatly unrealistic, except for the Synoptic Cyclone case.