

## Geostrophic Wind Example

The surface pressure in Decorah is 1002 mb, and the surface pressure in Othertown, WI is 997 mb. Othertown is 300 km due east of Decorah.

1. Calculate the pressure gradient between Decorah and Othertown in Pa / m.

**Solution**

$$\begin{aligned}\Delta P &= 997 \text{ mb} - 1002 \text{ mb} \\ &= -5 \text{ mb} \\ &= -5 \text{ mb} \times 0.1 \\ &= -0.5 \text{ kPa}\end{aligned}$$

$$\Delta x = 300 \text{ km}$$

$$\frac{\Delta P}{\Delta x} = \frac{-0.5 \text{ kPa}}{300 \text{ km}}$$

$$\approx -0.001667 \text{ Pa / m}$$

2. Initially at rest over Decorah, a one-liter parcel accelerates down the pressure gradient. How fast will it be traveling one hour after it begins to move?

**Solution**

The magnitude of the acceleration is

$$\frac{1}{\rho} \frac{\Delta P}{\Delta x} = \frac{1}{1.22} \left[ \frac{\text{m}^3}{\text{kg}} \right] 0.001667 \left[ \frac{\text{kg} \cdot \text{m} \cdot \text{sec}^{-2}}{\text{m}^3} \right] = 0.001366 \text{ m} \cdot \text{sec}^{-2}$$

The velocity after one hour is

$$0.001366 \left[ \frac{\text{m}}{\text{sec}^2} \right] \times 1 \text{ hour} \times 60 \left[ \frac{\text{min}}{\text{hour}} \right] \times 60 \left[ \frac{\text{sec}}{\text{min}} \right] = 4.919 \text{ m} \cdot \text{sec}^{-1} = 10.92 \text{ mi} \cdot \text{hr}^{-1}$$

3. Assuming the parcel attains geostrophic balance, calculate its geostrophic speed  $V_g$ .

**Solution**

In geostrophic balance, the magnitude of the acceleration per unit mass of the parcel due to the pressure gradient is equal to that due to the Coriolis effect. Therefore,

$$\begin{aligned}2\Omega V_g \sin \phi &= \frac{1}{\rho} \frac{\Delta P}{\Delta x} \\ V_g &= \frac{1}{2\Omega \sin \phi} 0.001366 \text{ m} \cdot \text{sec}^{-2} \\ &= \frac{0.001366 \text{ m} \cdot \text{sec}^{-2}}{(1.458 \times 10^{-4} \text{ sec}^{-1})(0.6861)} \\ &= 16.66 \text{ m/sec} \\ &= 36.98 \text{ mi/hr}\end{aligned} \quad \left| \begin{array}{l} 2\Omega = 1.458 \times 10^{-4} \text{ sec}^{-1}; \\ \phi = 43.32^\circ = 0.756 \text{ radians} \\ \sin \phi = 0.6861 \\ 1 \text{ m} \cdot \text{sec}^{-1} = 2.22 \text{ mi} \cdot \text{hr}^{-1} \end{array} \right.$$