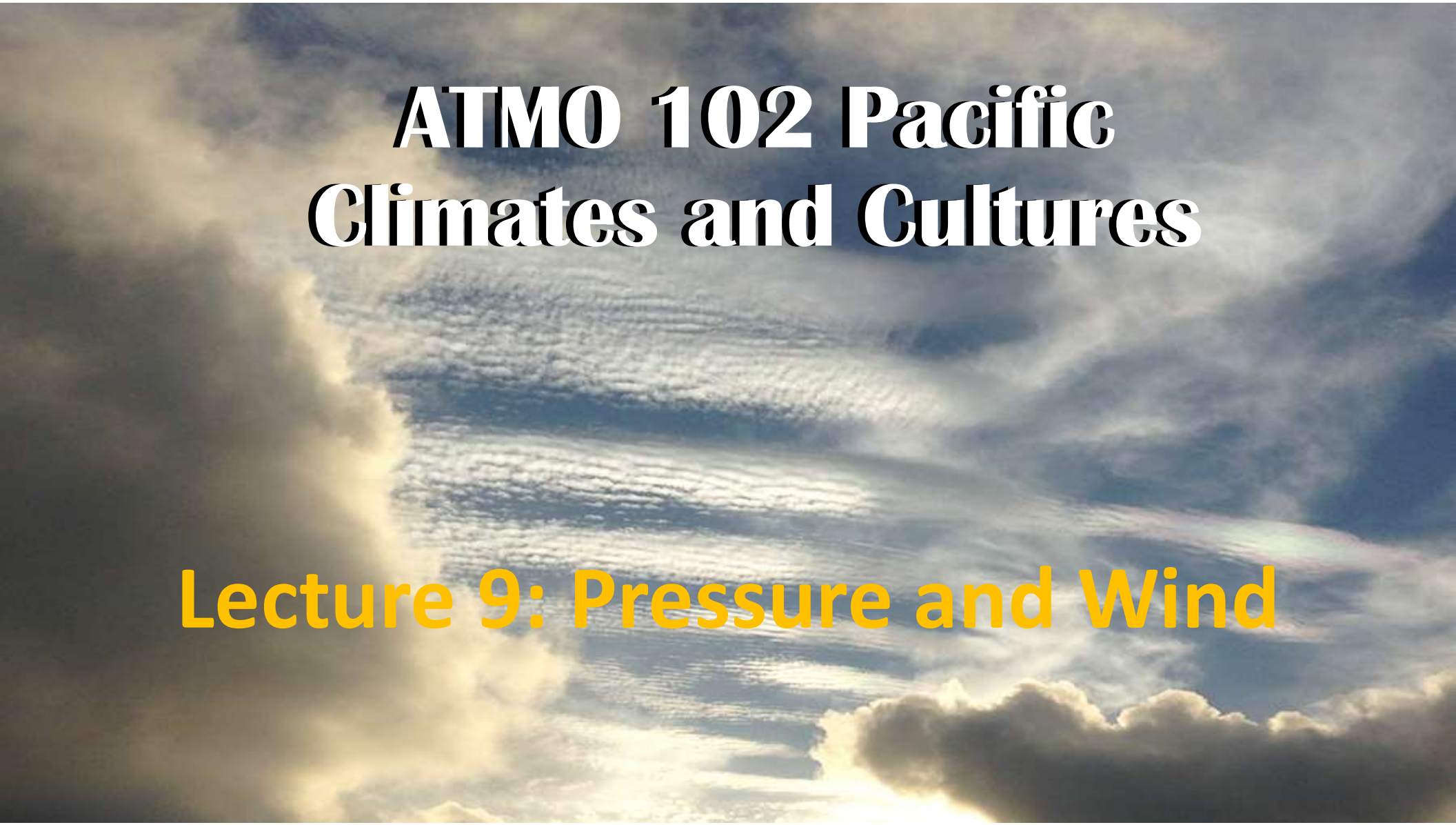


ATMO 102 Pacific Climates and Cultures

Lecture 9: Pressure and Wind

Pressure and Wind

- **AIR PRESSURE**
  - is the pressure exerted by the weight of the air above.

1. **Horizontal differences in pressure causes winds**

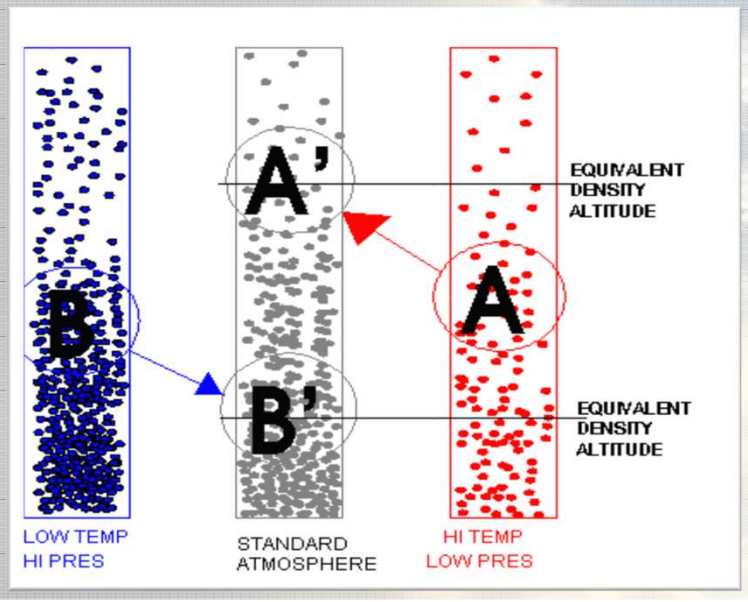
2. Horizontal differences in pressure are caused by differences in heating

3. ***Winds flow from regions of high pressure to regions of low pressure***

4. Horizontal differences in P lead to the ***PRESSURE GRADIENT FORCE***

Influence of Temperature and Water Vapor

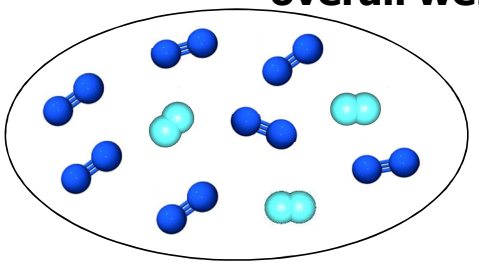
- **(A) Warm Air**
  - Fast moving molecules
  - Typically less dense
  - **LOW PRESSURE**
- **(B) Cold Air**
  - Slow moving molecules
  - Typically more dense
  - **HIGH PRESSURE**



- **The addition of water vapor actually makes air LIGHTER (less Dense)!!!!**

Molecular weights of N_2 (14) and O_2 (16) are greater than H_2O (10)

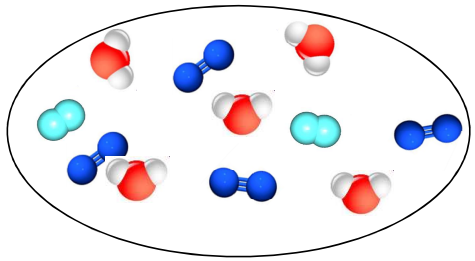
If you "substitute" some of the N_2 and O_2 with H_20 the overall weight of air will be less!



N_2: 7 * 14 = 98

O_2: 3 * 16 =48

Total = 146



N_2: 4 * 14 = 56

O_2: 2 * 16 =32

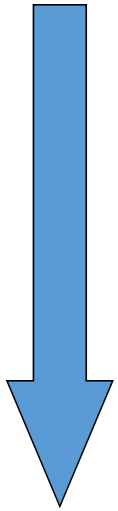
H_2O: 5 * 10 = 50

Total = 138

Influence of Temperature and Water Vapor

- **SUMMARY**

HIGH PRESSURE

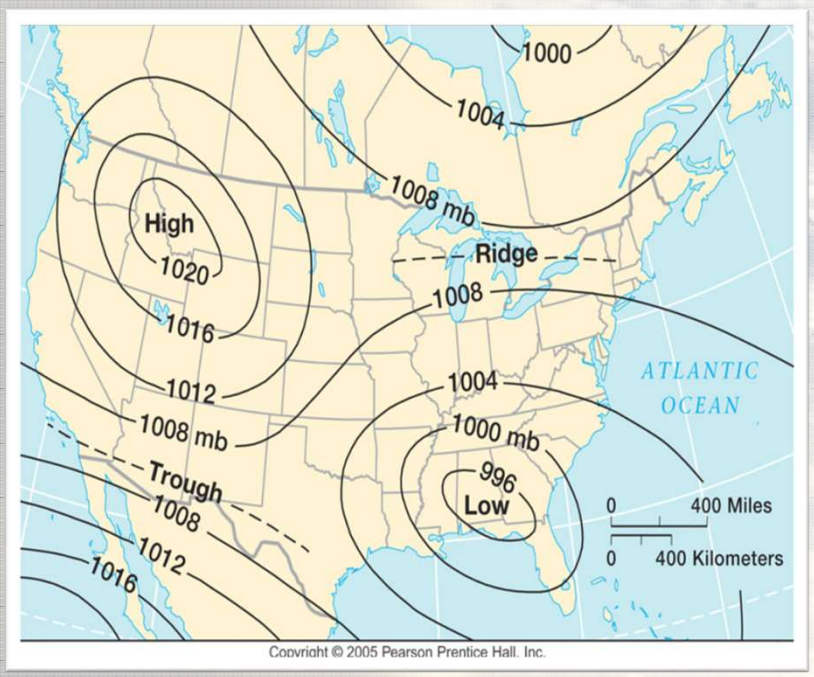


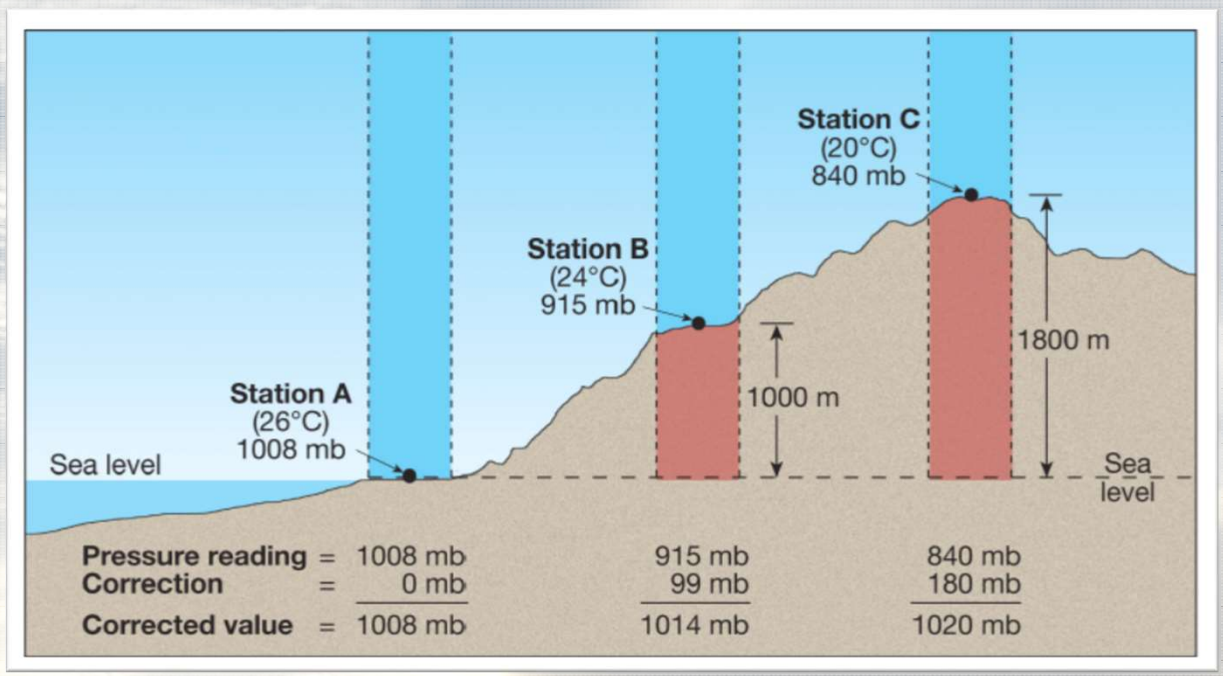
LOW PRESSURE

- **Cold**, **dry** air masses produce High Surface Pressures
- **Cold**, **humid** air masses are less “high” than cold, dry
- **Warm**, **dry** air masses are less “low” than warm, humid
- **Warm**, **humid** air masses produce Low Surface Pressures

Isobars – A Map View of Pressure

- Contours (lines or curves) of constant **PRESSURE**
- They are **corrected** for altitude to equivalent **Sea Level Pressure (SLP)**





What is Wind?

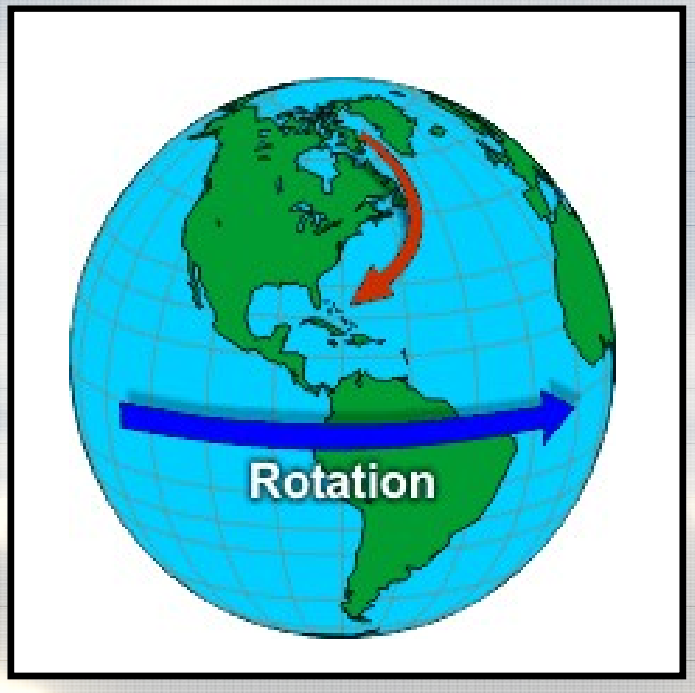
- Wind is nature's attempt at balancing ***inequalities*** in pressure
  - **Unequal heating of the Earth's surface** generates these inequalities.
  - **Solar radiation** is the ultimate source of energy for Wind
- **Wind** ***is the result of horizontal differences in air pressure!***
- Air flows from areas of **HIGH** pressure to areas of **LOW** pressure

HIGH → **LOW**

Factors Affecting Winds

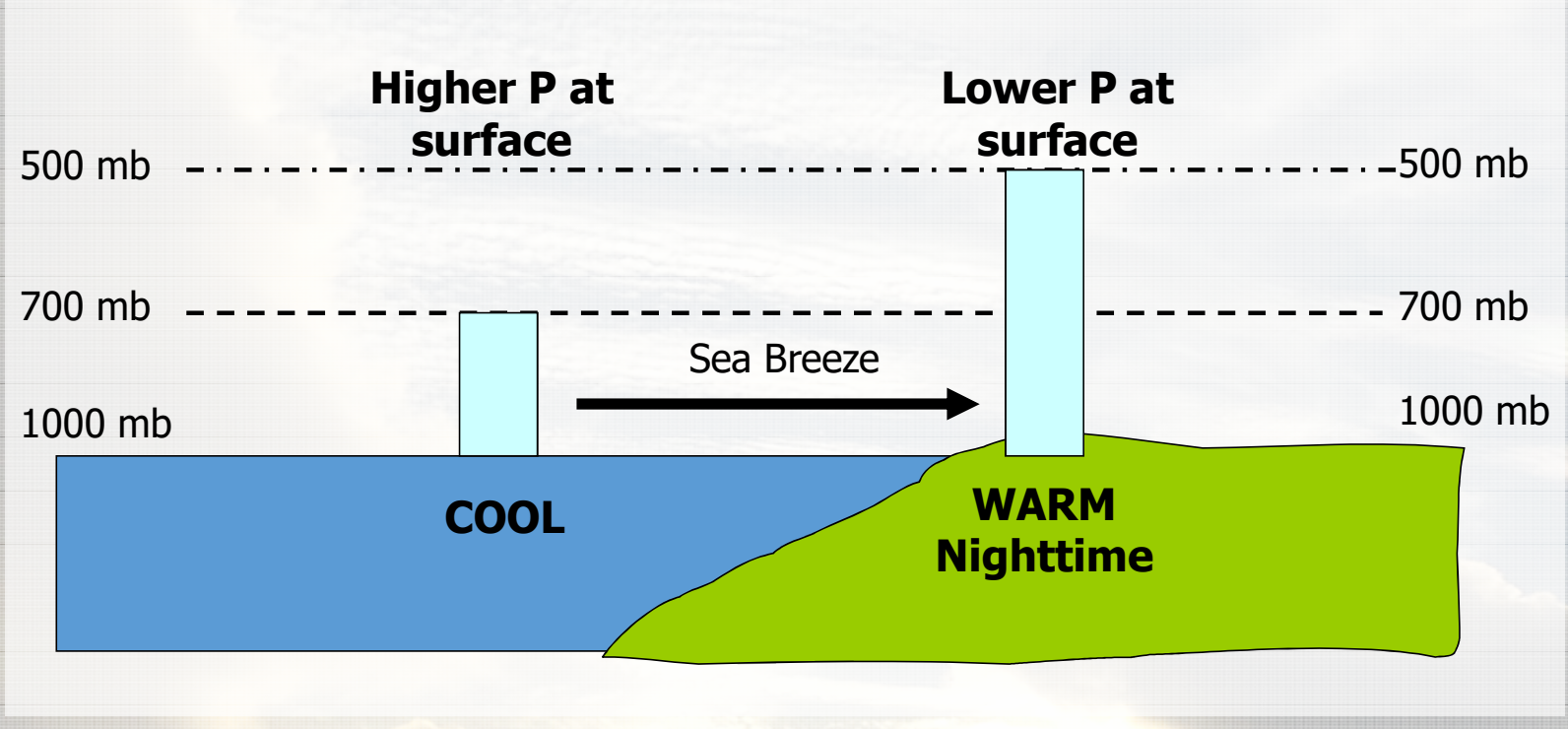
- If the Earth did NOT **rotate** and if there was NO **friction** wind would flow in a straight line from High to Low pressure

- **Main forces that affect wind**
  1. Pressure Gradient Force
  2. Coriolis Force
  3. *Centripetal force*
  4. Friction
  5. *Gravity*



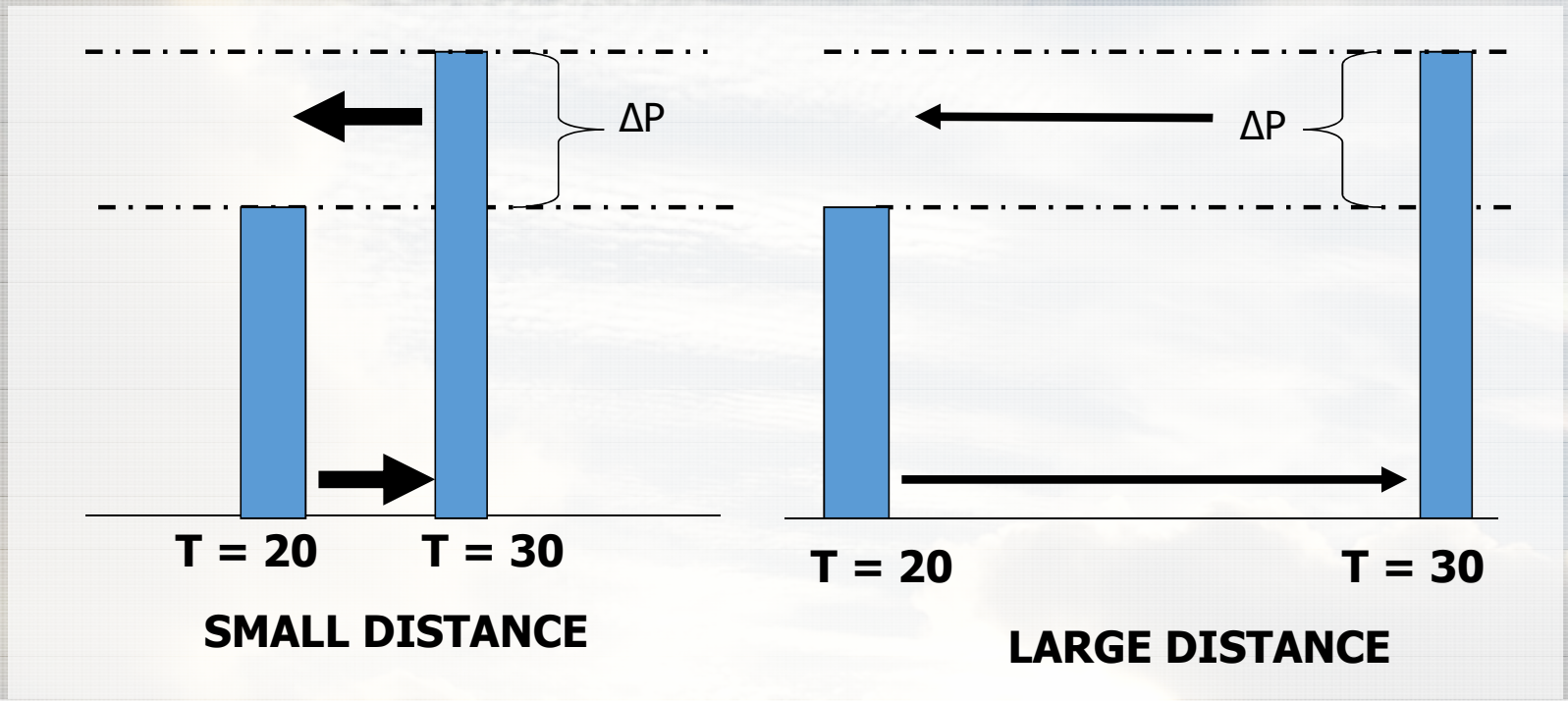
Pressure Gradient Force

- Horizontal Pressure Differences (HPD)
- Winds flow from **High** pressure to **Low** pressure if only affected by HPD



Pressure Gradient Force – HPD

- **STRONGER** when **isobars** are closer together
- Same **CHANGE** in Pressure (ΔP)
- When given Pressure Heights, the PGF points from regions of High Pressure to regions of Low Pressure



Isobars & PGF – More

Winds if we ONLY knew the PGF.

If the isobars are further or closer together…

WIND IS SLOW

1004 mb

1008 mb

1012 mb

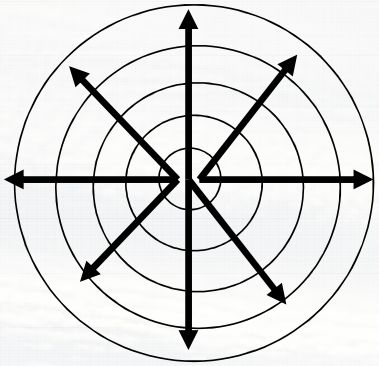
1016 mb

1020 mb

PGF

Change in P over large distance:

SMALL PGF



For a conical hill, the PGF points in all direction

WIND IS FAST

992 mb

996 mb

1000 mb

1004 mb

1008 mb

1012 mb

1016 mb

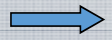
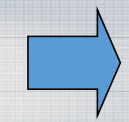
1020 mb

PGF

Change in P over small distance:

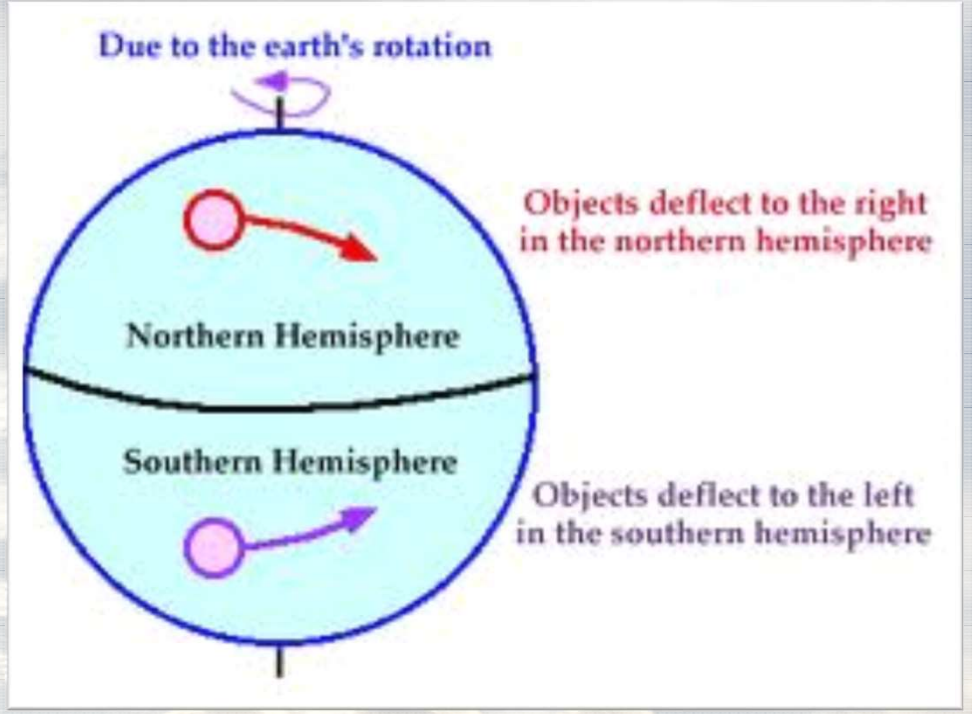
LARGE PGF

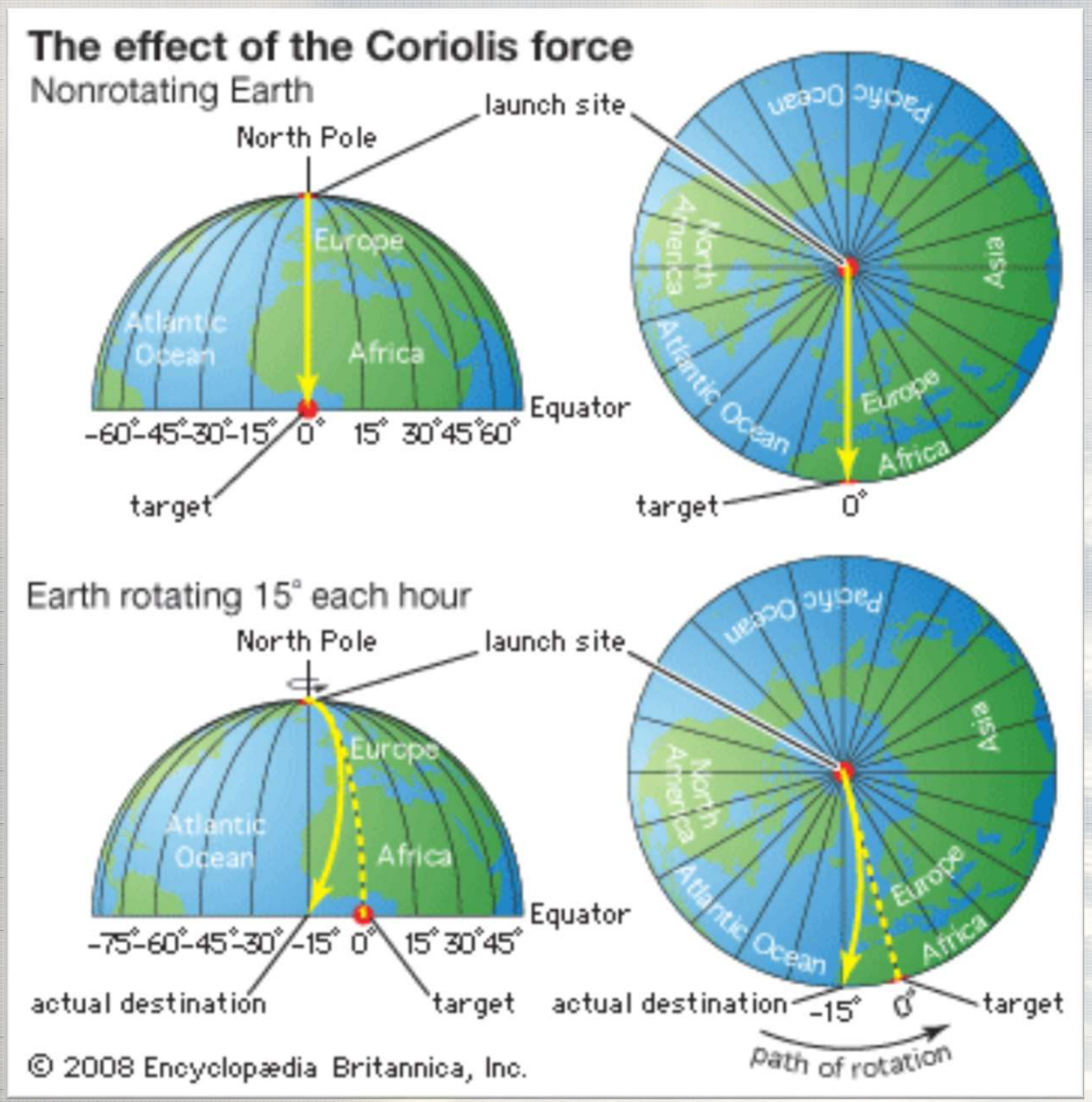
PGF Summary

- Change in P over large distance = **small PGF** 
- Change in P over small distance = **large PGF** 
- PGF is at **right angles** to isobars
- Causes wind to **START MOVING**
  - However… two forces cause wind speed and direction to be different than predicted by the PGF
    - **Coriolis (rotation of the Earth)**
    - **Friction**

Coriolis Force

- Results from the **rotation of the Earth**
- Causes the PGF to cross isobars **NOT** at right angles.
- Winds curve to the **RIGHT in the Northern Hemisphere**
- Winds curve to the **LEFT in the Southern Hemisphere**

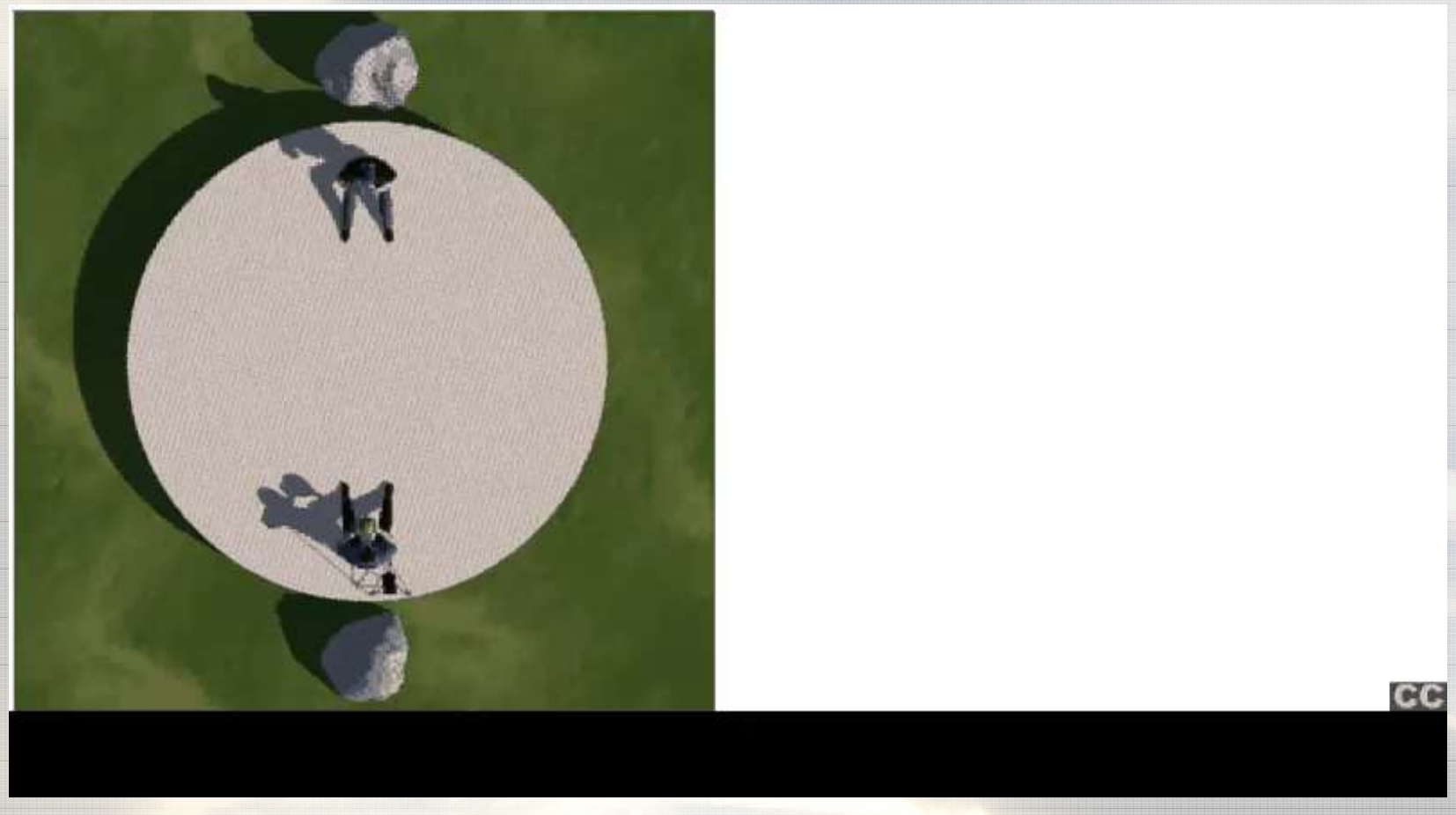




Coriolis Example

- On a non-rotating Earth, the rocket would travel straight to it's target.
- Earth rotates **15 deg per hour**….
- Even though the rock travels in **STRAIGHT** line, when we plot it's path on the surface it follows a path that **CURVES to the RIGHT**!

Coriolis Visualization



Coriolis Summary

1. Always Deflects a moving body (wind) to the right in the Northern Hemisphere

2. Only affects wind direction, not speed

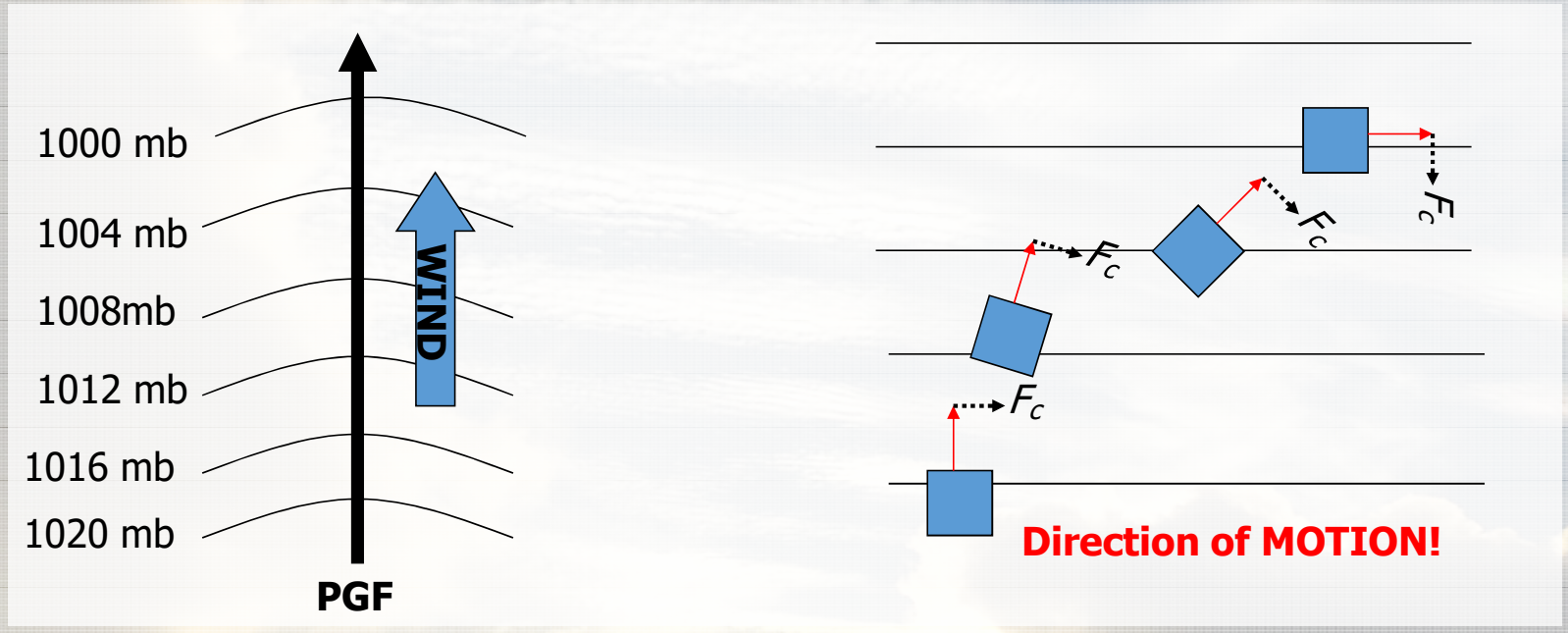
3. Is affected by **wind speed** (the stronger the wind, the greater the deflecting force)

4. Is **strongest** at the poles and **nonexistent** at the equator… **latitude dependent**

These two determine the MAGNITUDE of the Coriolis Force

Winds Aloft and Geostrophic Flow

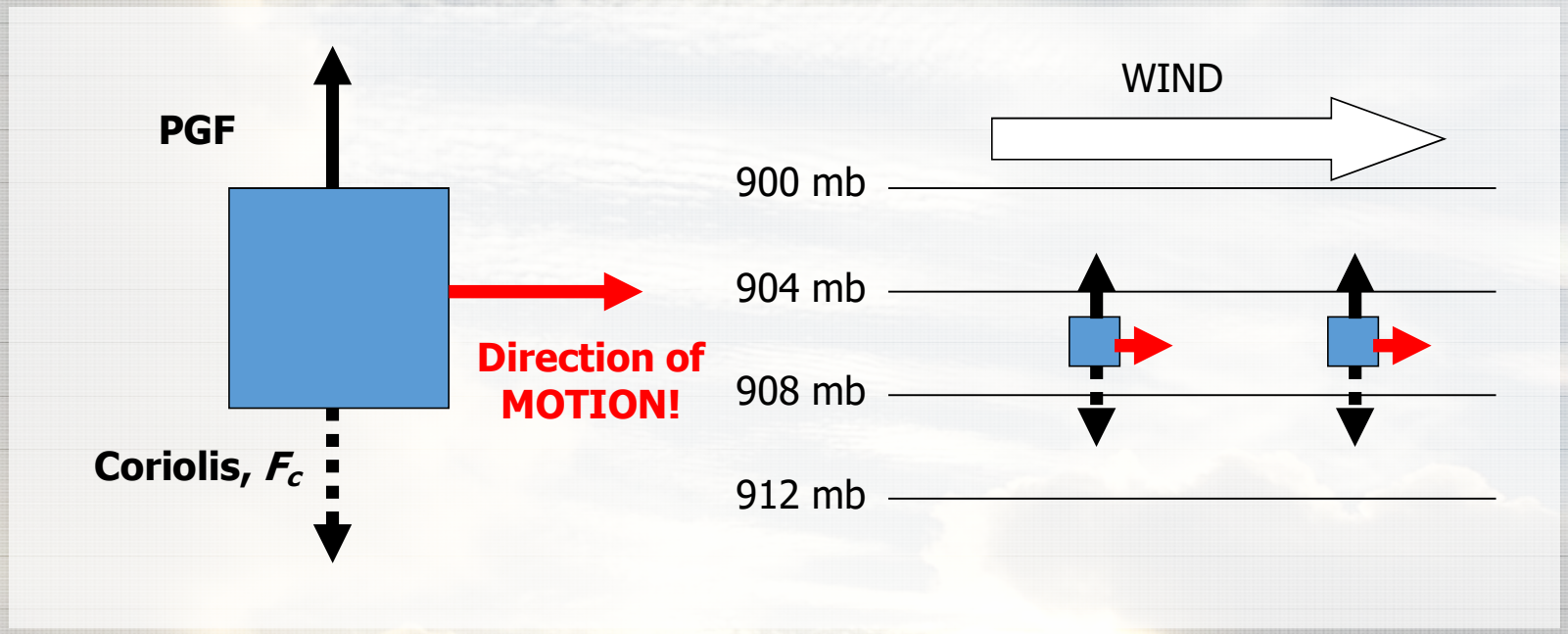
- Where friction doesn't play a role!!
- **When only the PGF and Coriolis Forces (F_c) affect an air parcel**



Winds Aloft & Geostrophic Flow

- An air parcel is at equilibrium only if PGF acts in the opposite direction to the Coriolis force (no net force).

- Therefore in **Geostrophic Flow**, winds run parallel to isobars in a straight path

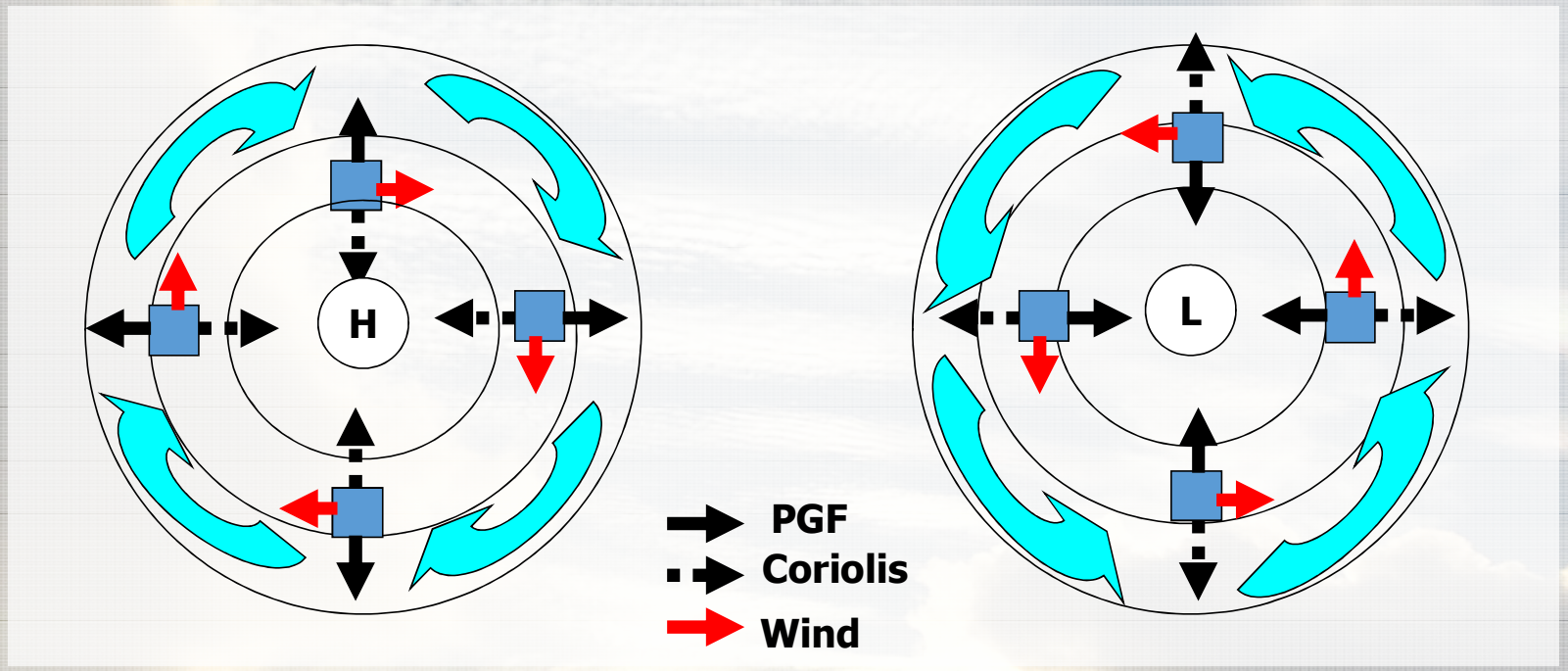


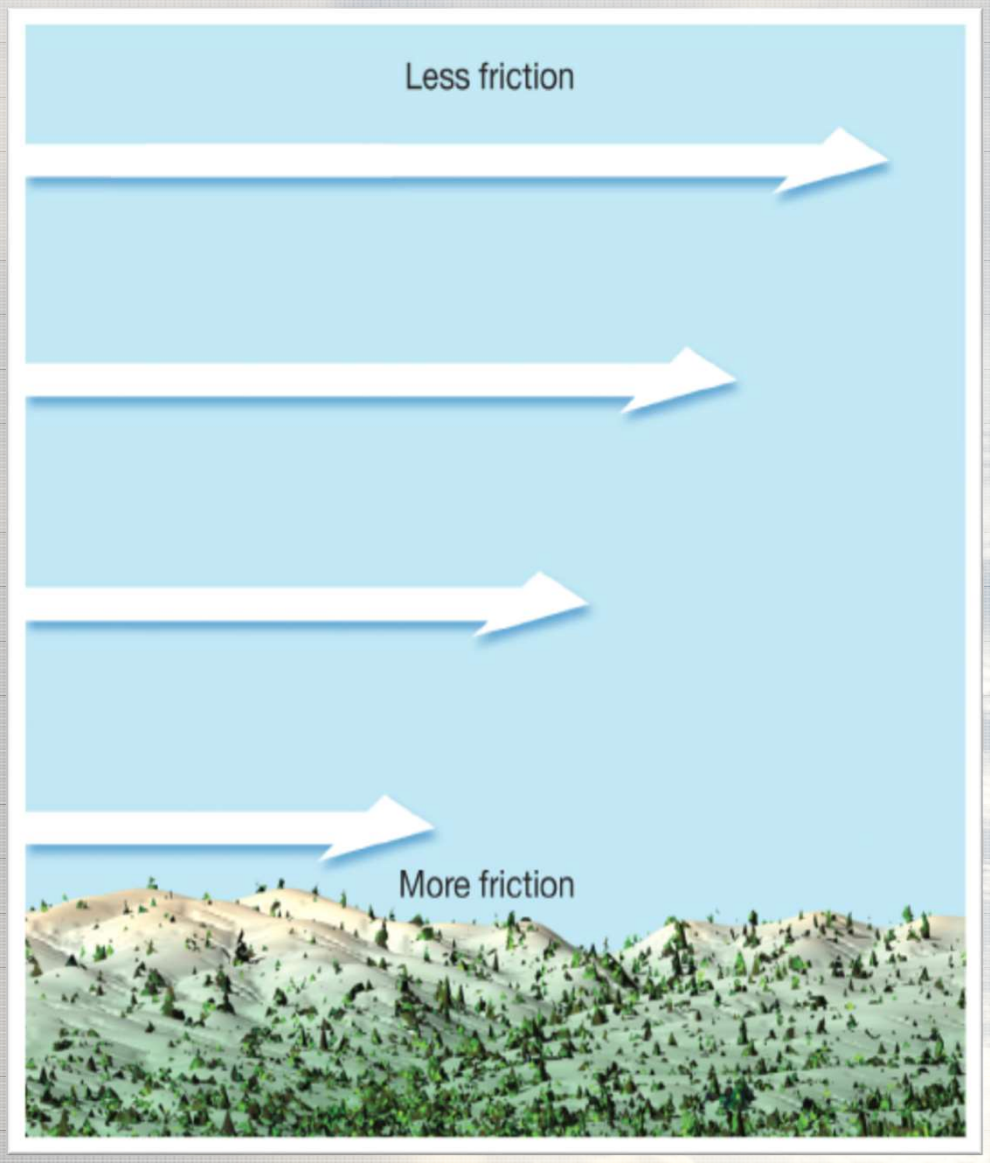
Curved Flow and Gradient Wind

- **Gradient Wind** – winds that follow curved paths around high and low pressure cells.

- Speed of the wind depends on how **close** the isobars are

Northern Hemisphere!



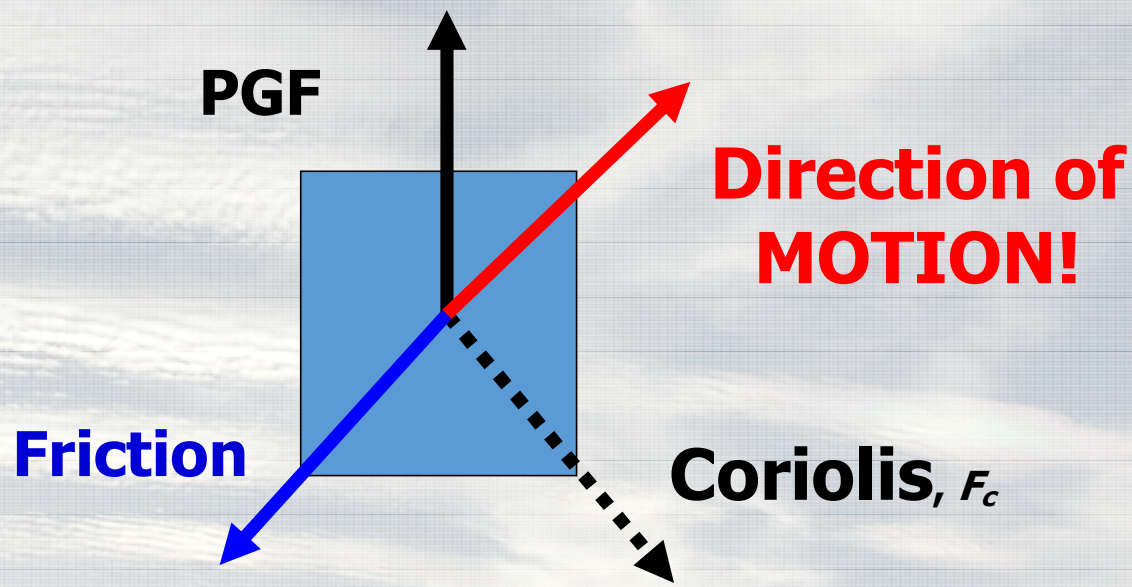


Friction

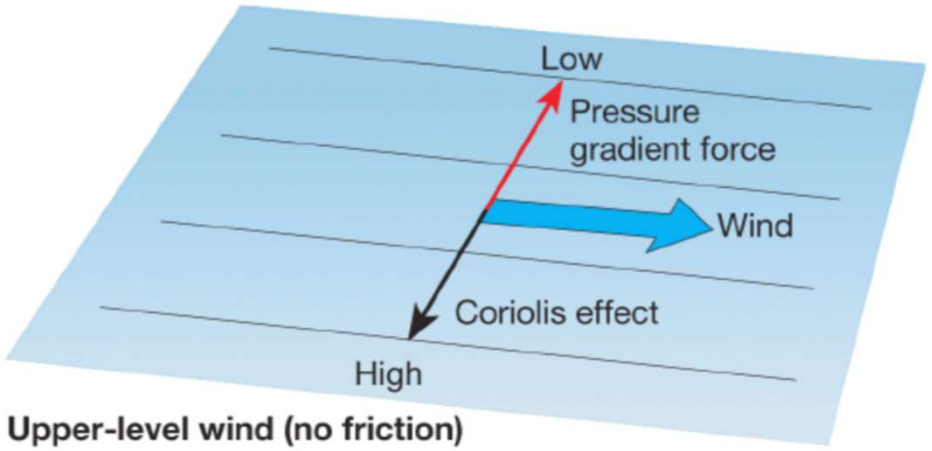
- Applied to wind within **1 to 1.5 km** of the surface
- Friction **ALWAYS** acts in the direction **OPPOSITE** the direction of motion!!!!
- **Friction affects air at the surface more than air aloft.**

Adding Friction to PGF and Coriolis

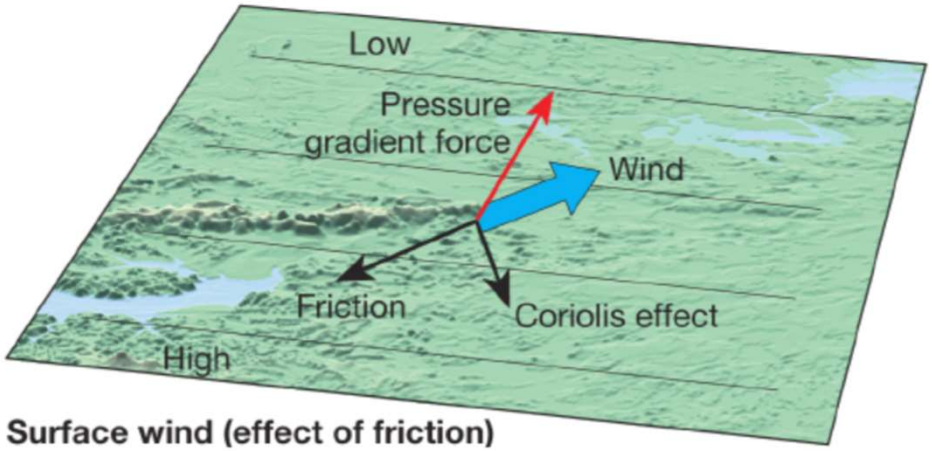
- **Geostrophic Flow and Friction**
  - Causes parcel to slow down
  - Coriolis decreases in strength
- **Friction** causes wind to lean towards the direction of the PGF



Adding Friction to PGF and Coriolis



Upper-level wind (no friction)

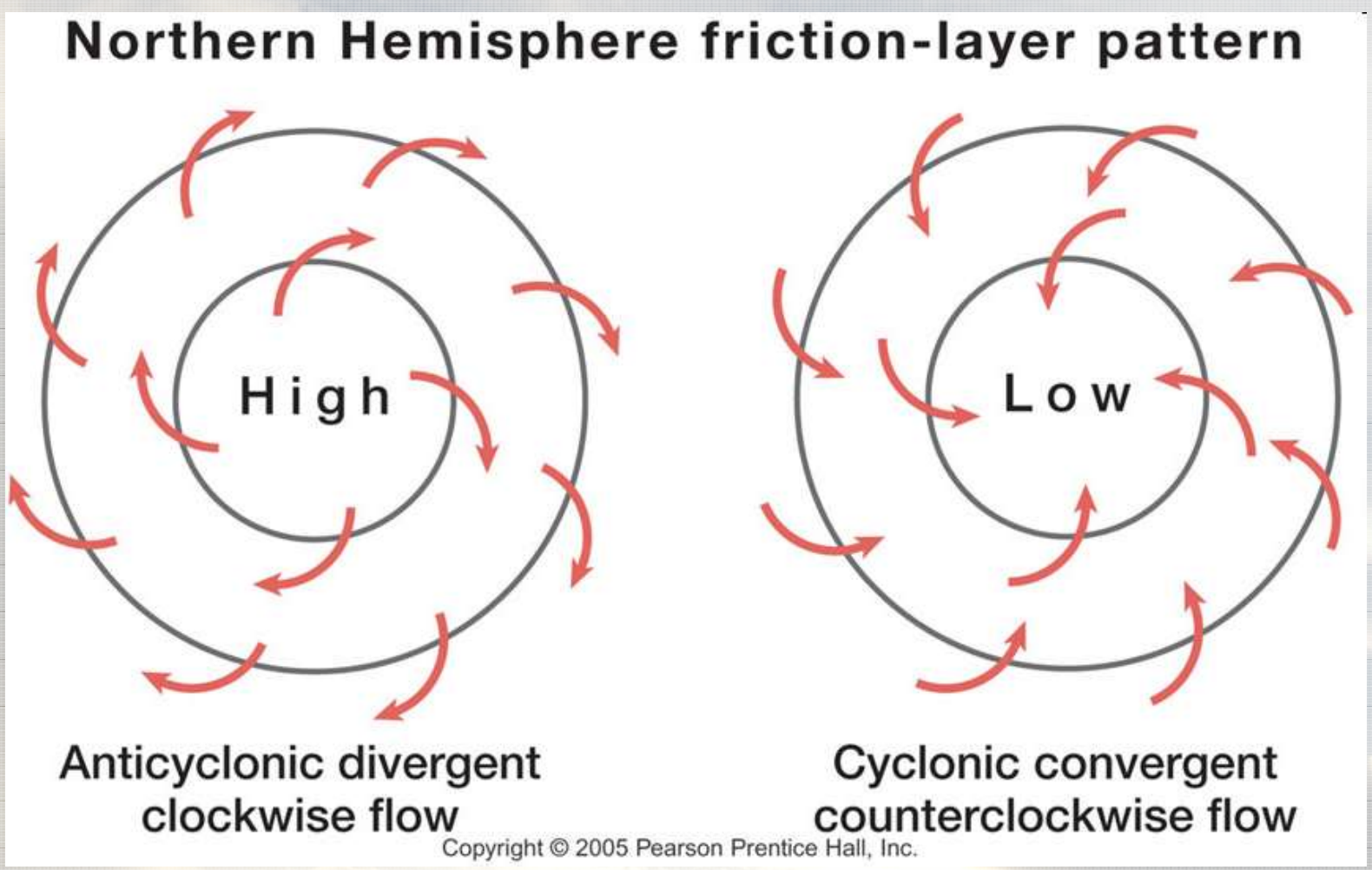


Surface wind (effect of friction)

- The addition of friction causes the wind **to lean toward the PGF force** (or in the direction of the low pressure) in both hemispheres.

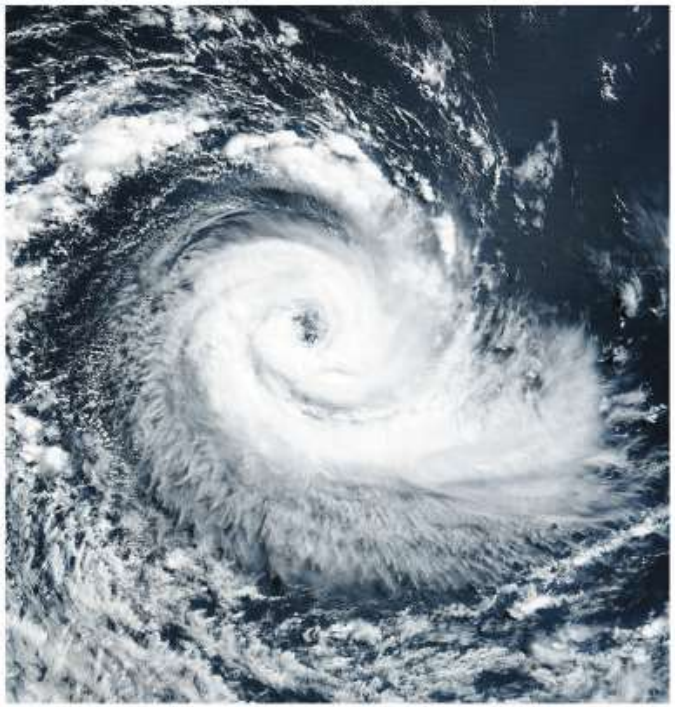
- Because the **Coriolis Force pulls wind to the right in the NH and to the left in the SH** we see opposite wind directions when comparing the NH to the SH.

Surface Winds – PGF + Coriolis + Friction



Lows in Different Hemispheres

(a)



(b)

CCW - Northern Hemisphere

CW - Southern Hemisphere