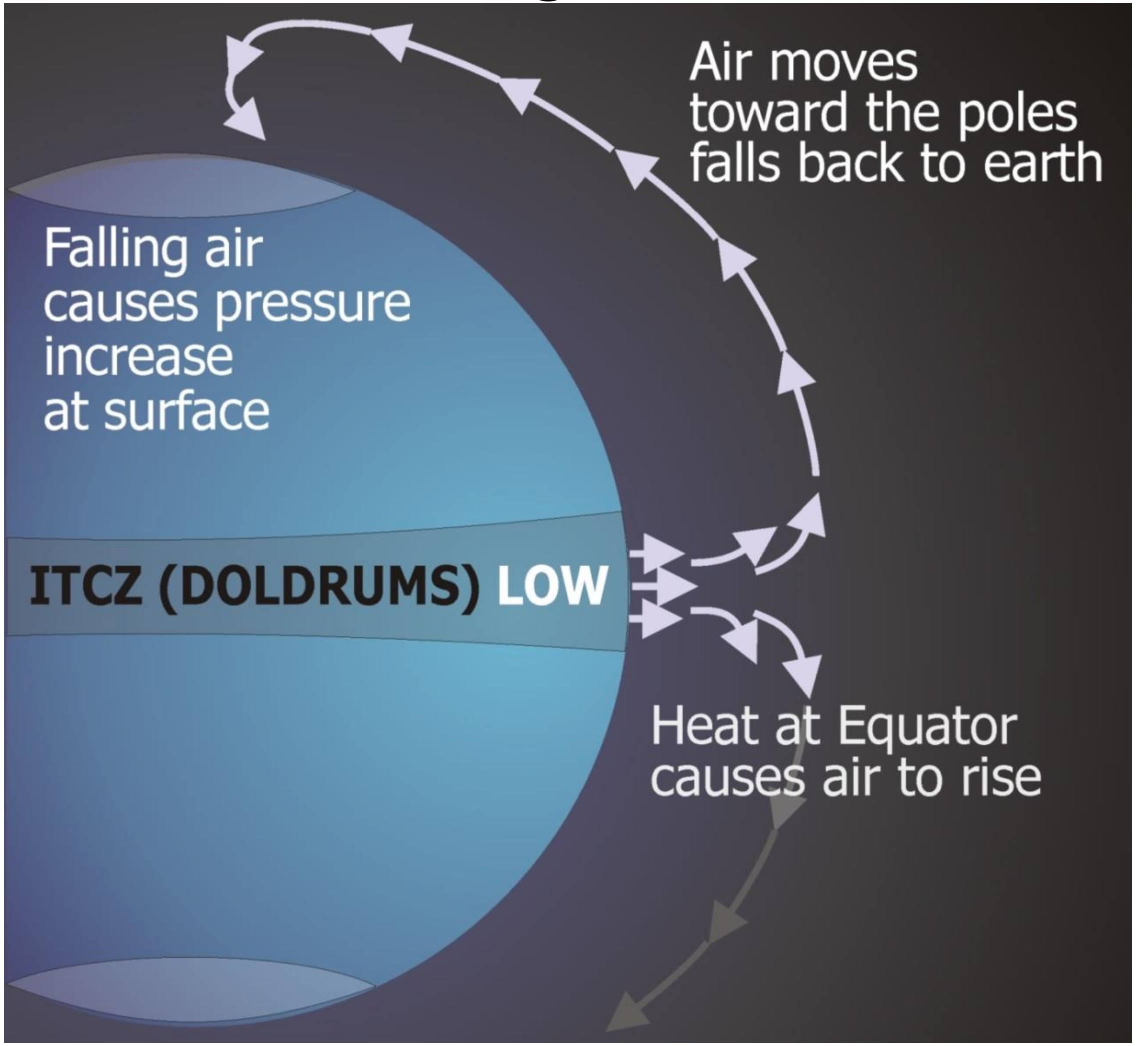
LLI BASIC WEATHER CONCEPTS
CHAPTER TWO
WIND, PRESSURE

- Be familiar with global wind patterns.
- Understand barometric pressure.
- Know the factors that affect the wind.
- Predict the circulation of winds around highs and lows.
- Determine the direction to a low.
- Understand winds aloft and how they differ from surface winds.

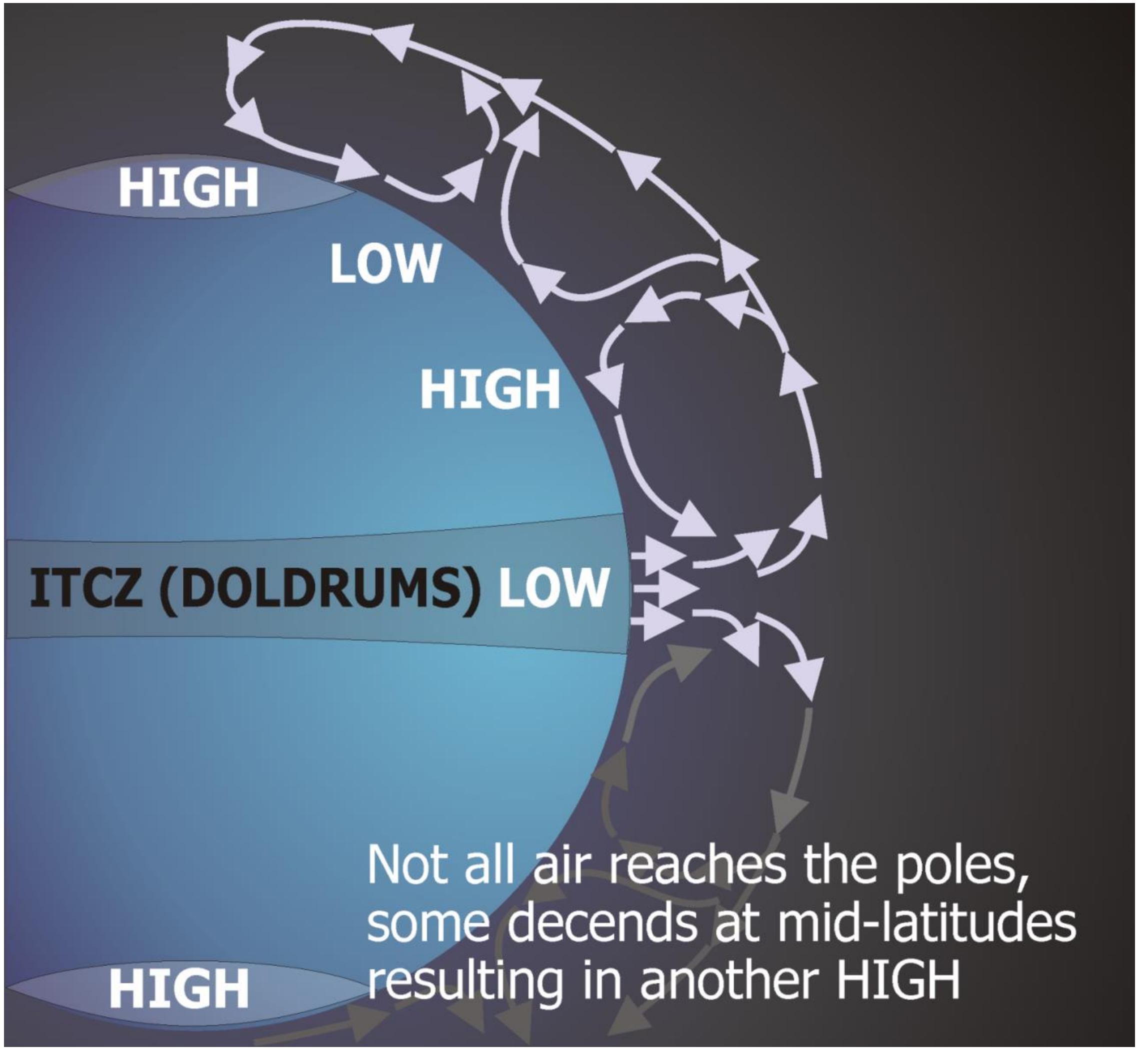
Equator→Pole Air Flow

warm equatorial air rises, then moves to cooler mid-latitude regions then sinks



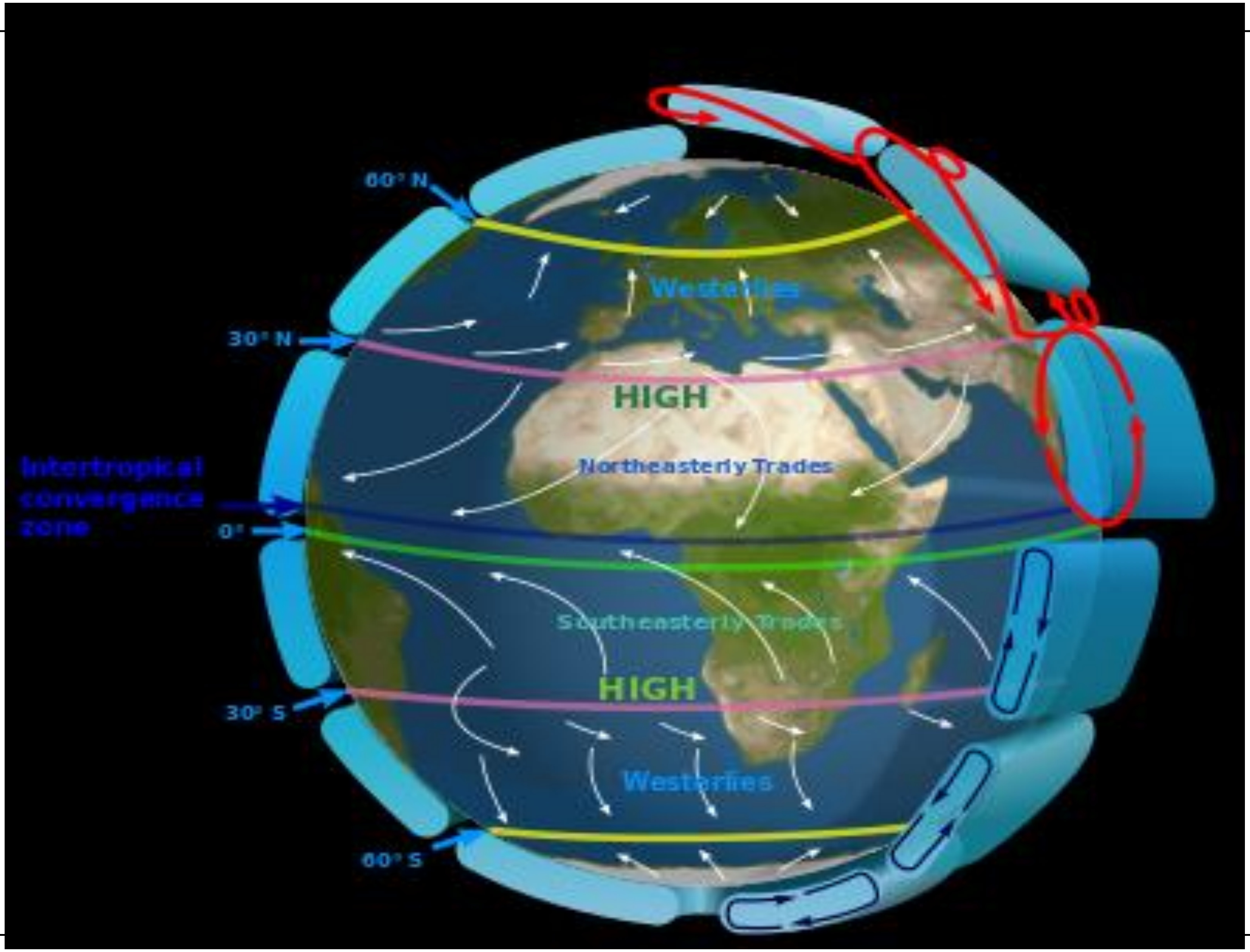
Mid-latitude High

note each higher latitude region is colder until Pole is reached

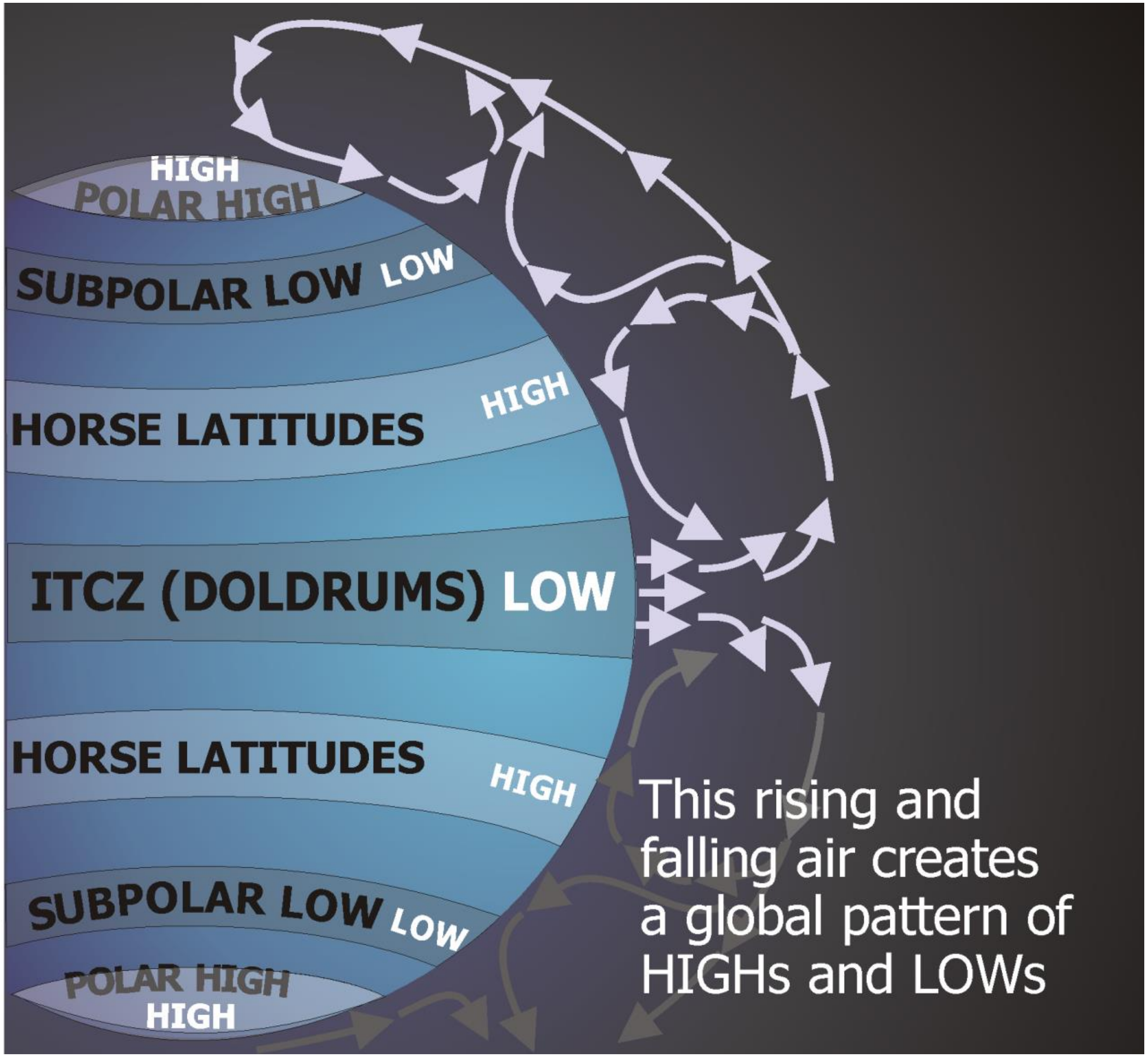


What is a Hadley Cell?

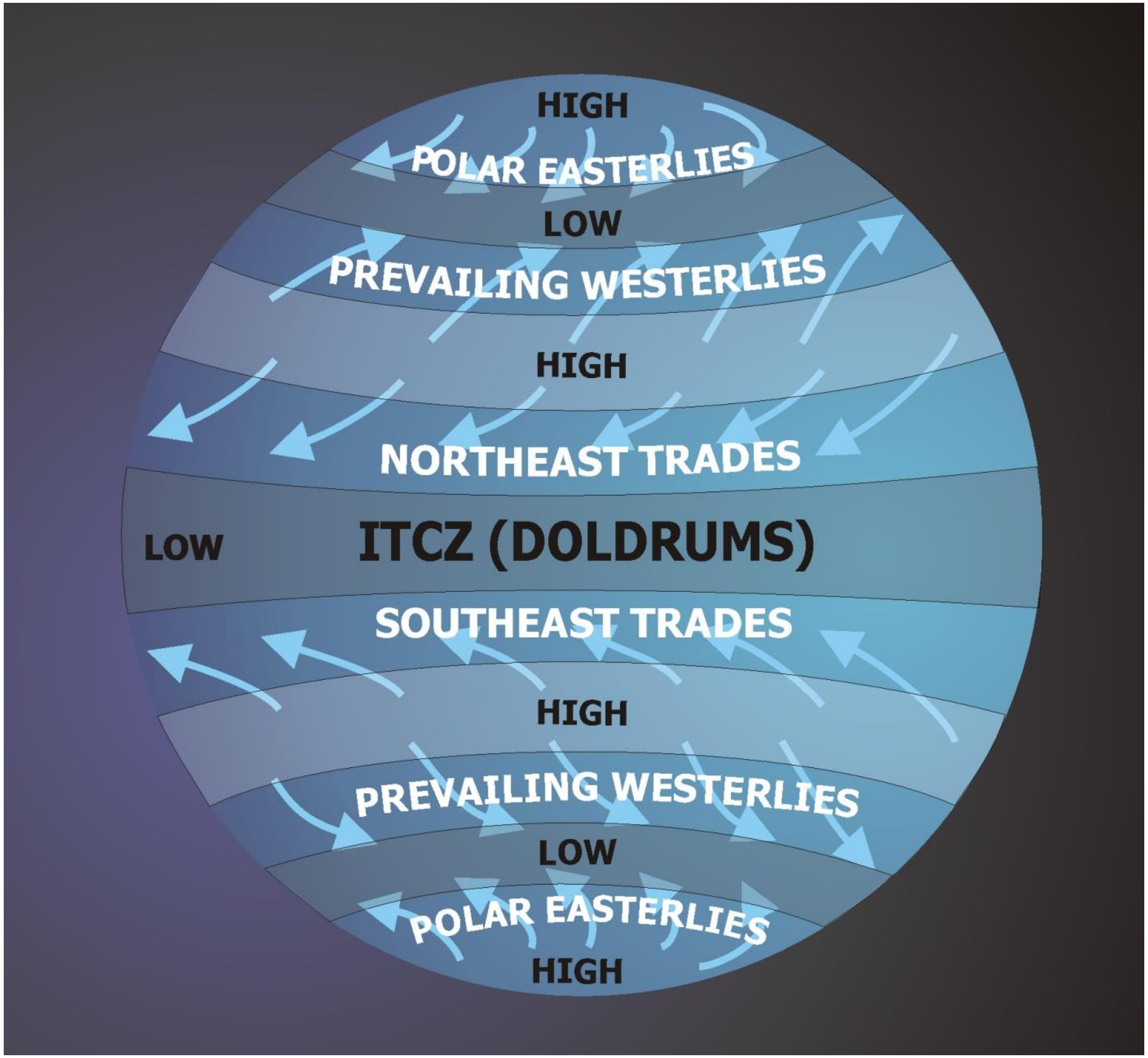
The Hadley cell, named after George Hadley, is a global scale tropical atmospheric circulation that features air rising near the equator, flowing poleward at 10–15 kilometers above the surface, descending in the subtropics, and then returning equatorward near the surface. This process maintains the Global Energy Balance preventing the equator from becoming hotter and polar regions becoming colder.



Global Highs and Lows



Global Winds

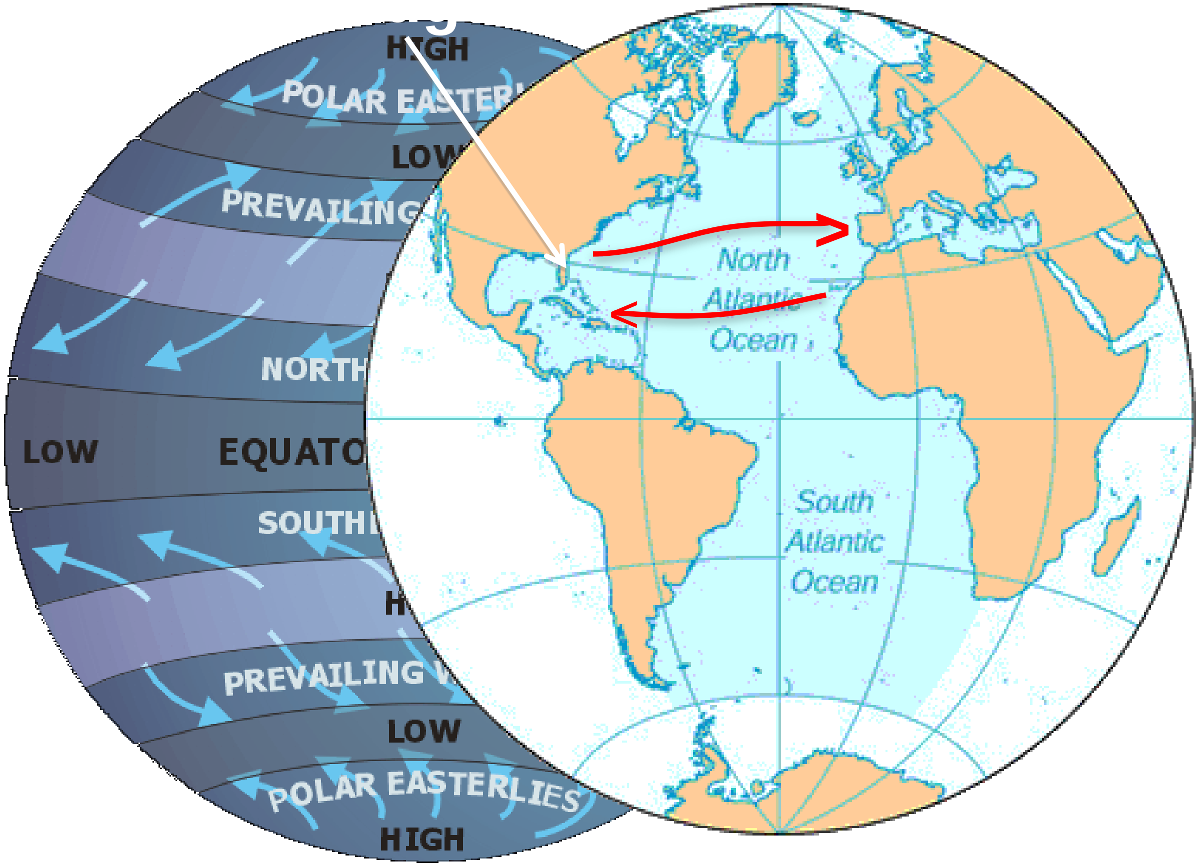


Video of Atmospheric Circulation

- **Global Atmospheric Circulation 1:54 mins.**

- https://www.youtube.com/watch?v=DHrapzHPCSA

European Explorers used Tradewinds



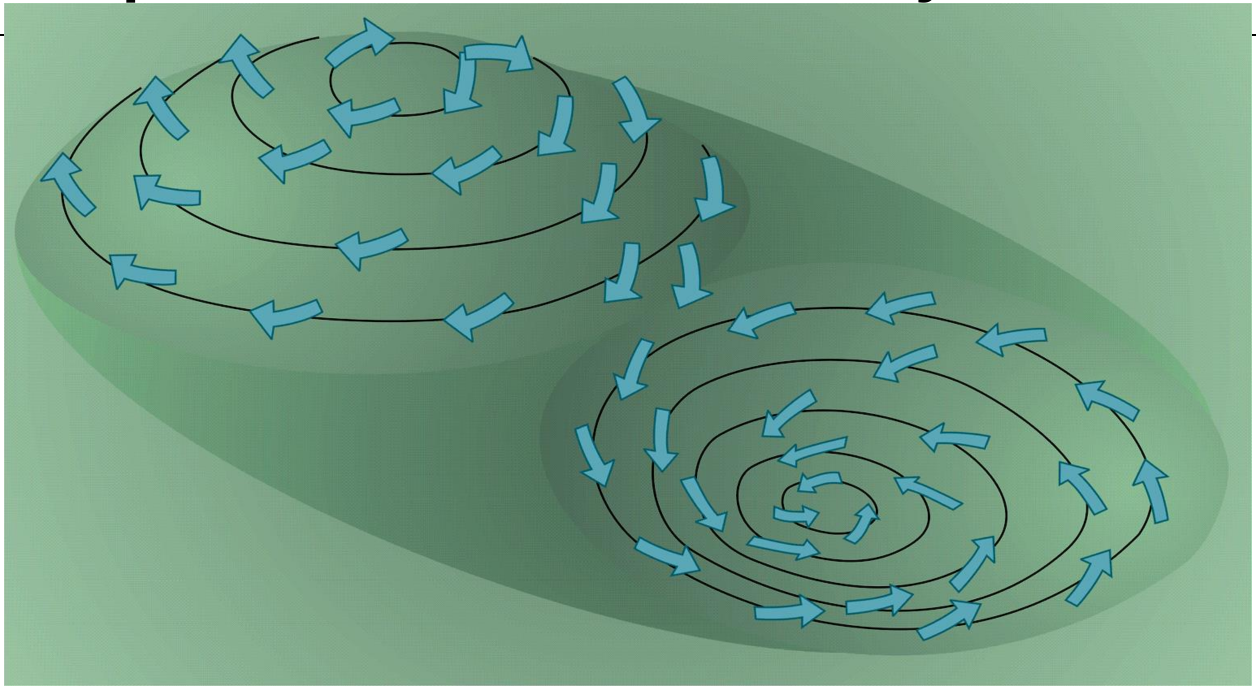
Land Masses Modify Global Pattern

Key Points to Remember about Heat and Pressure

- **Heat: energy (heat) is always transferred from WARM to COLD**
- **Pressure: pressure always flows from HIGH to LOW**

Pressure Differences

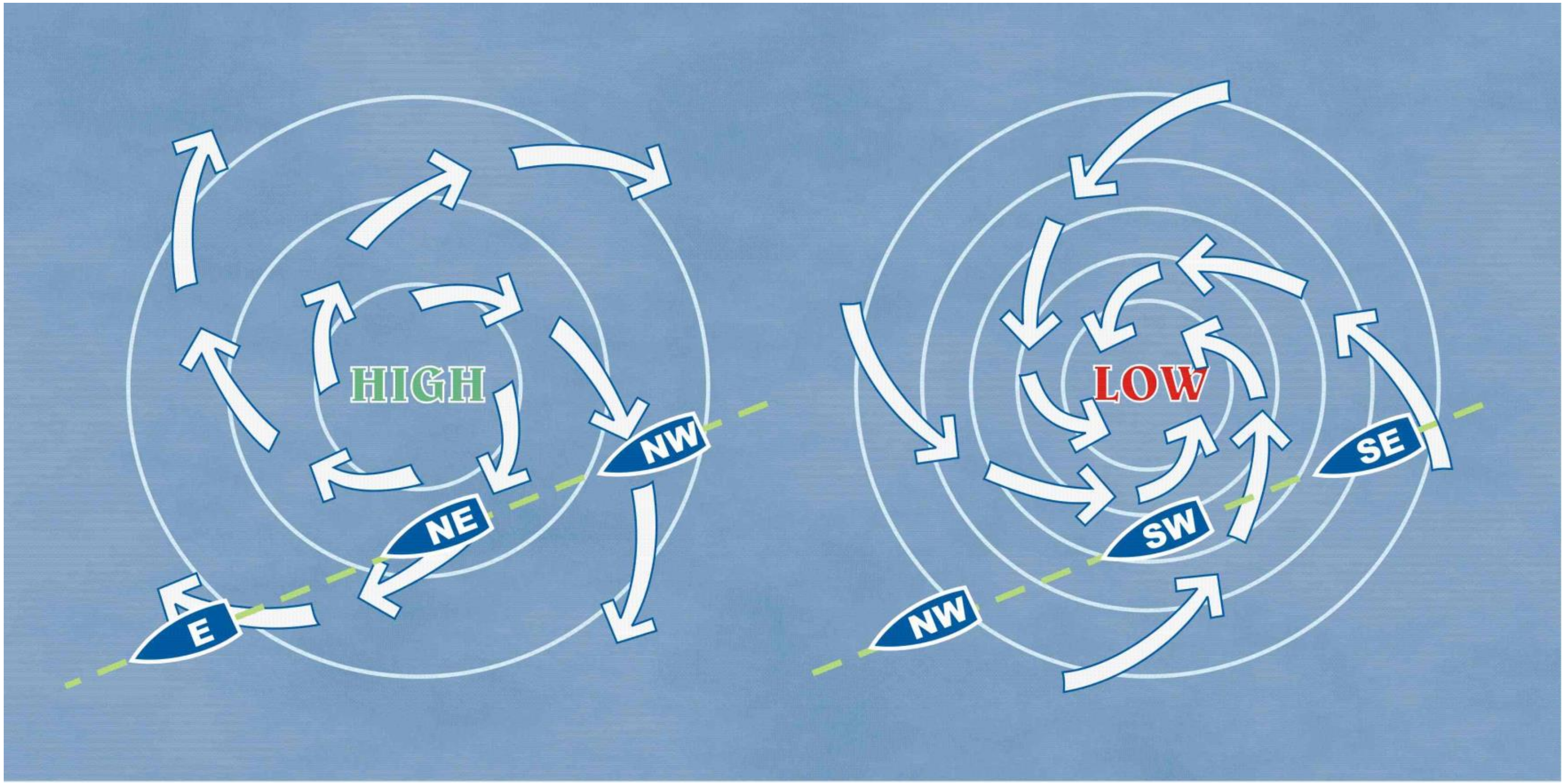
- HIGH pressure areas – like Hills
- LOW pressure areas – like valleys



Earth's rotation causes winds to turn rather than travel straight from high to low

Winds around Highs and Lows

highs-clockwise, lows counterclockwise

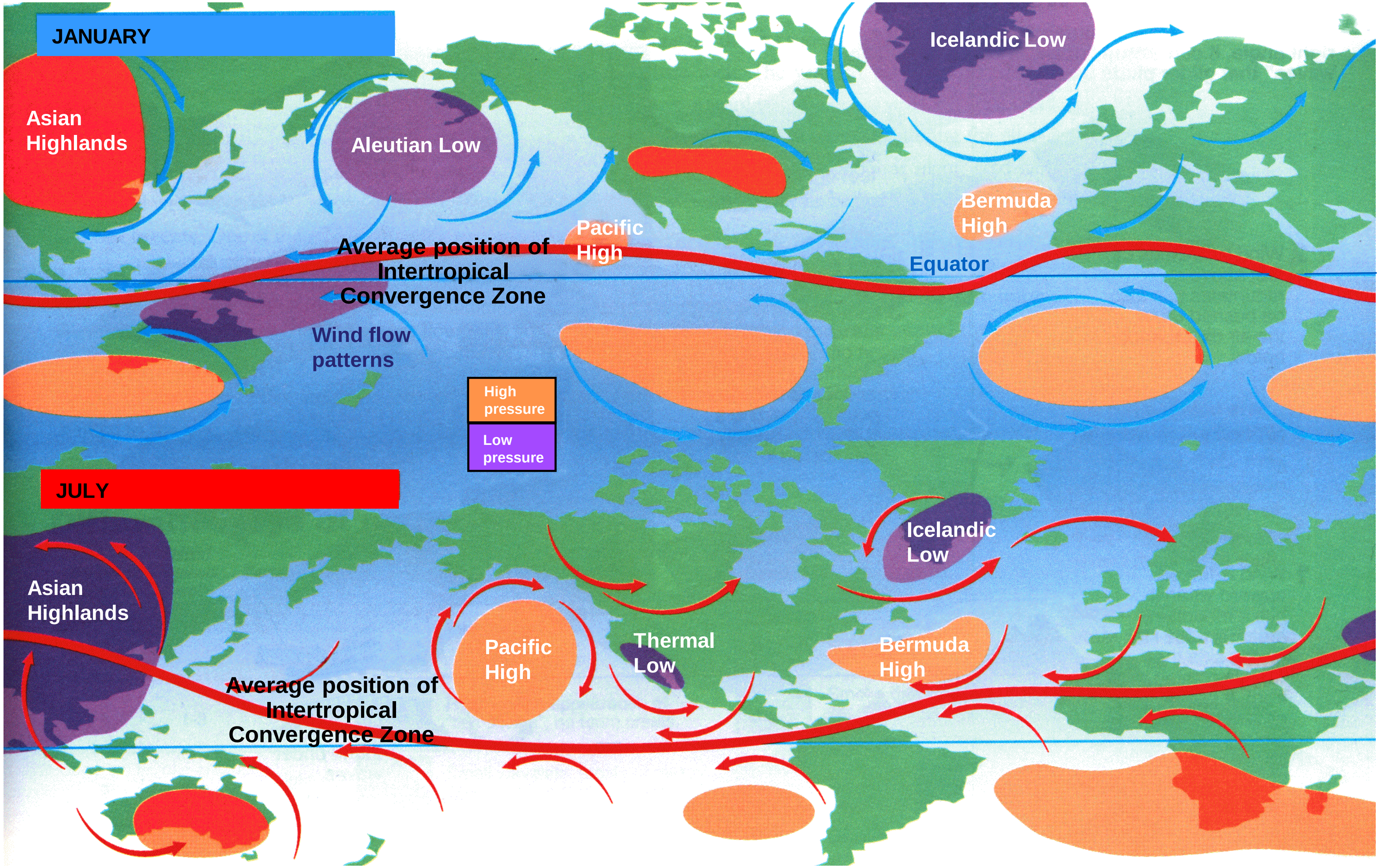


Movement of Air in Low Pressure and High Pressure Regions

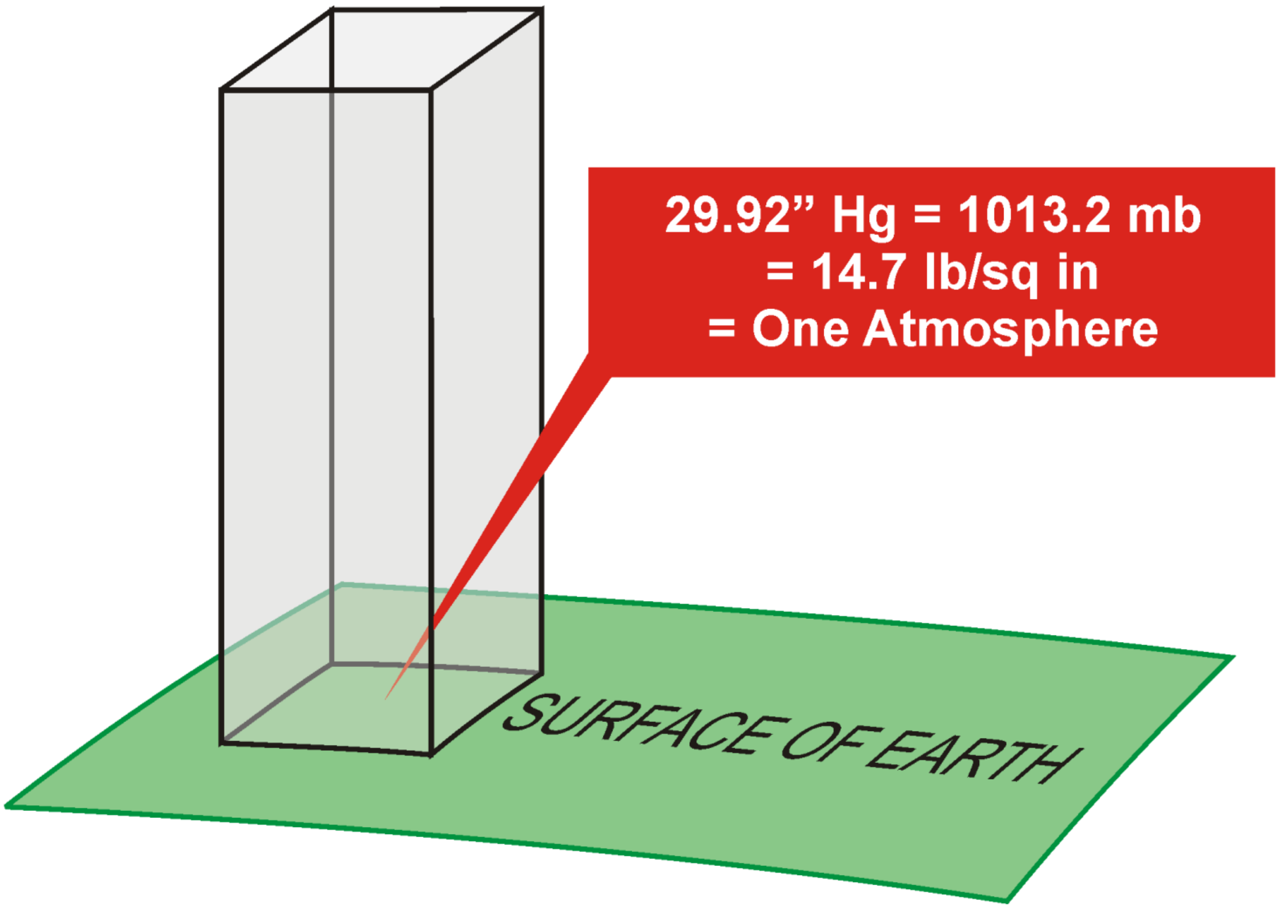
- **Air molecules* move counterclockwise (in the Northern Hemisphere) and rise in a low pressure area.**
- **Air molecules move clockwise and fall in a high pressure area (in the Northern Hemisphere)**

- ***There is no such thing as an "air molecule" but it's easier to say than an "atmospheric mixture of 78% Nitrogen, 20% Oxygen, and lesser amounts of carbon dioxide, water, hydrogen and inert gases!**

Major Pressure Patterns

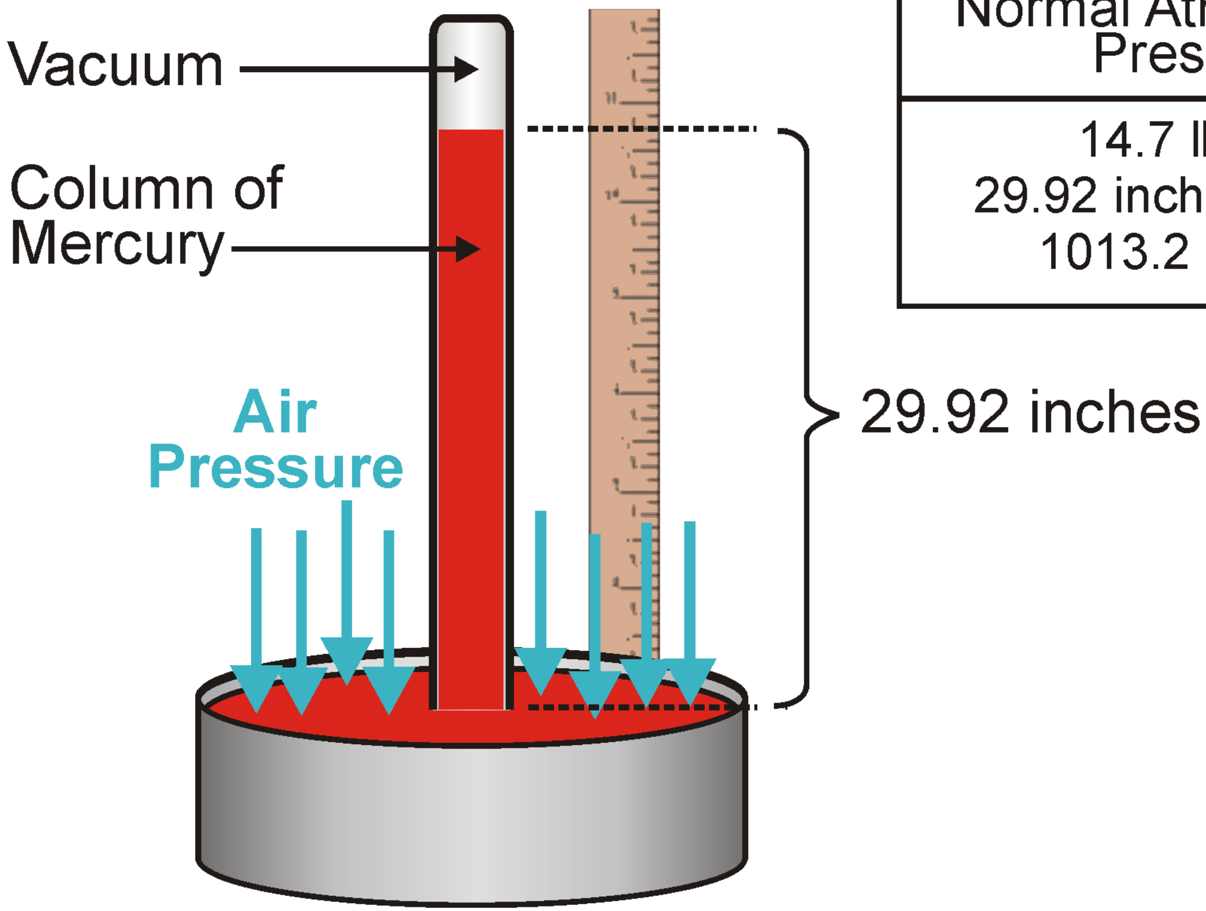


Atmospheric Pressure



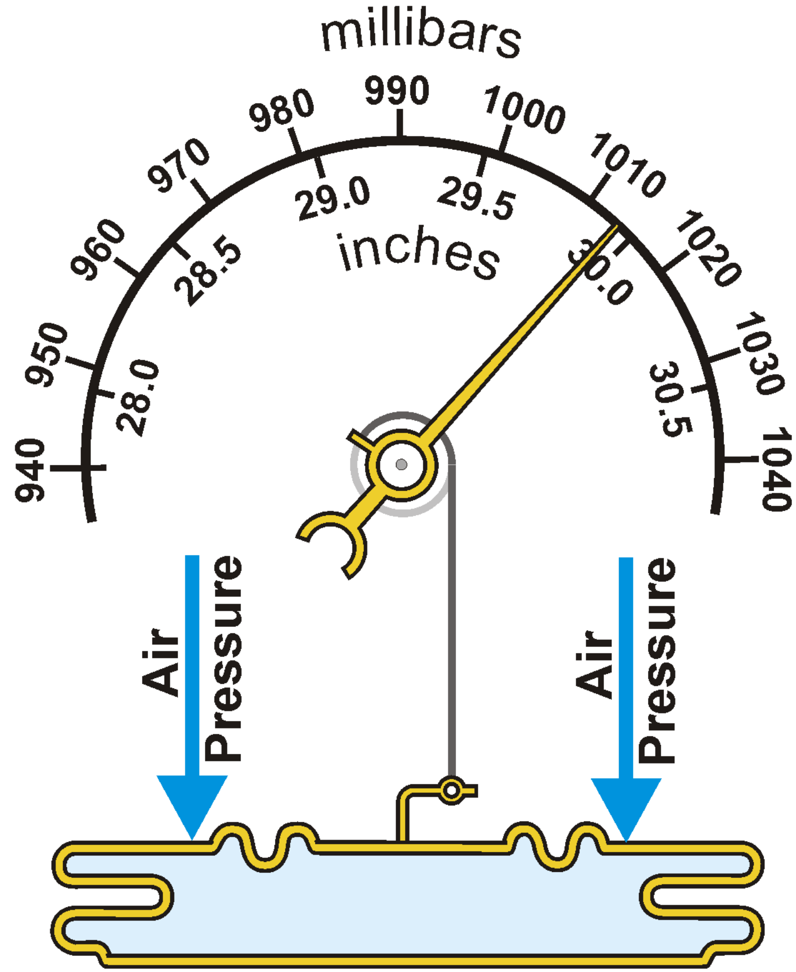
F = M x a
Newton's 1st Law
F=force
M= mass
a= acceleration
(Earth's Gravity)

Mercury Barometer



Normal Atmospheric Pressure
14.7 lb/sq in 29.92 inches mercury 1013.2 millibars

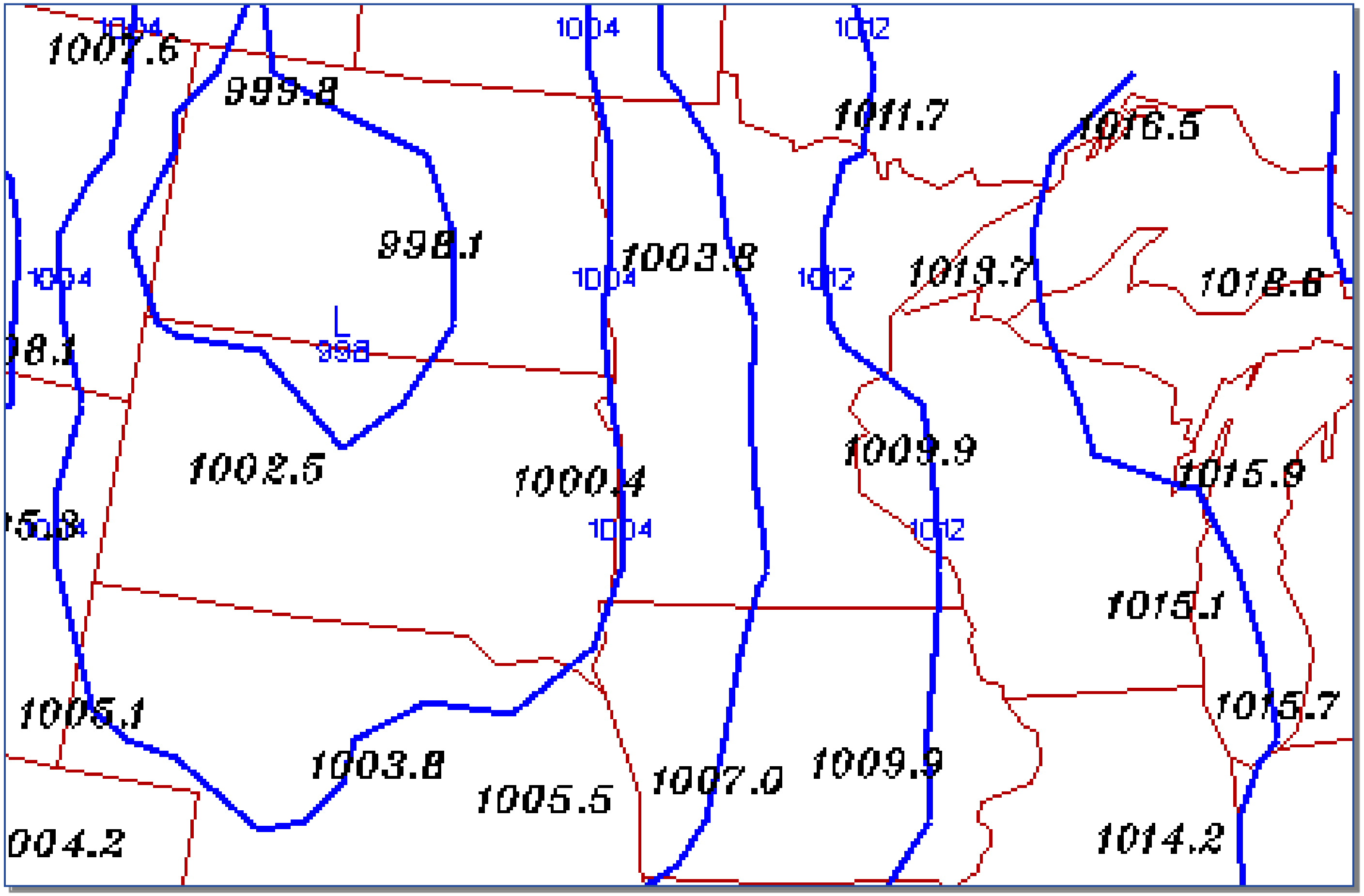
Aneroid Barometer



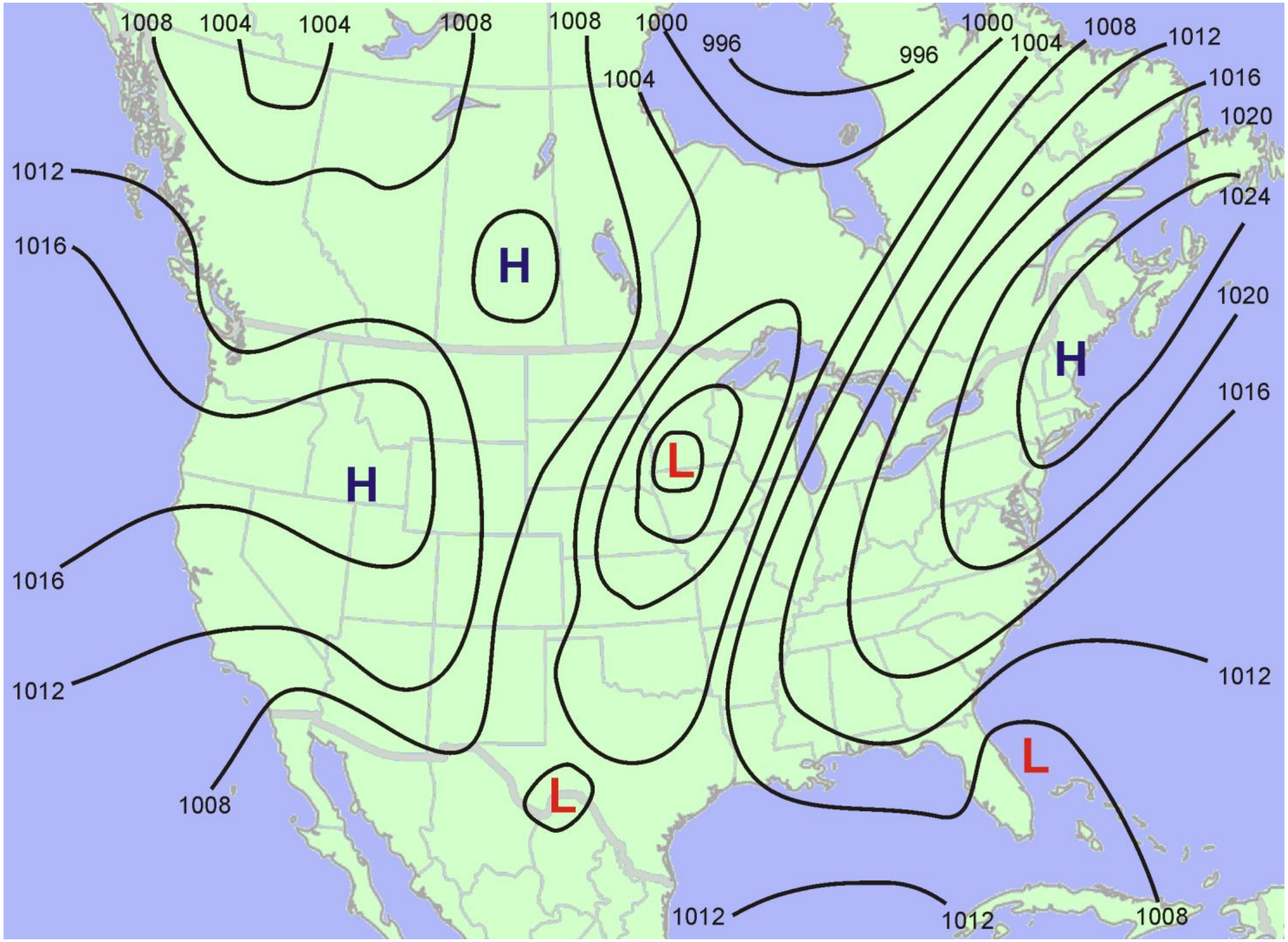
Normal Atmospheric Pressure
14.7 lb/sq in 29.92 inches mercury 1013.2 millibars

Sealed Cell
Partial Vacuum

Station Reports and Isobars



Isobars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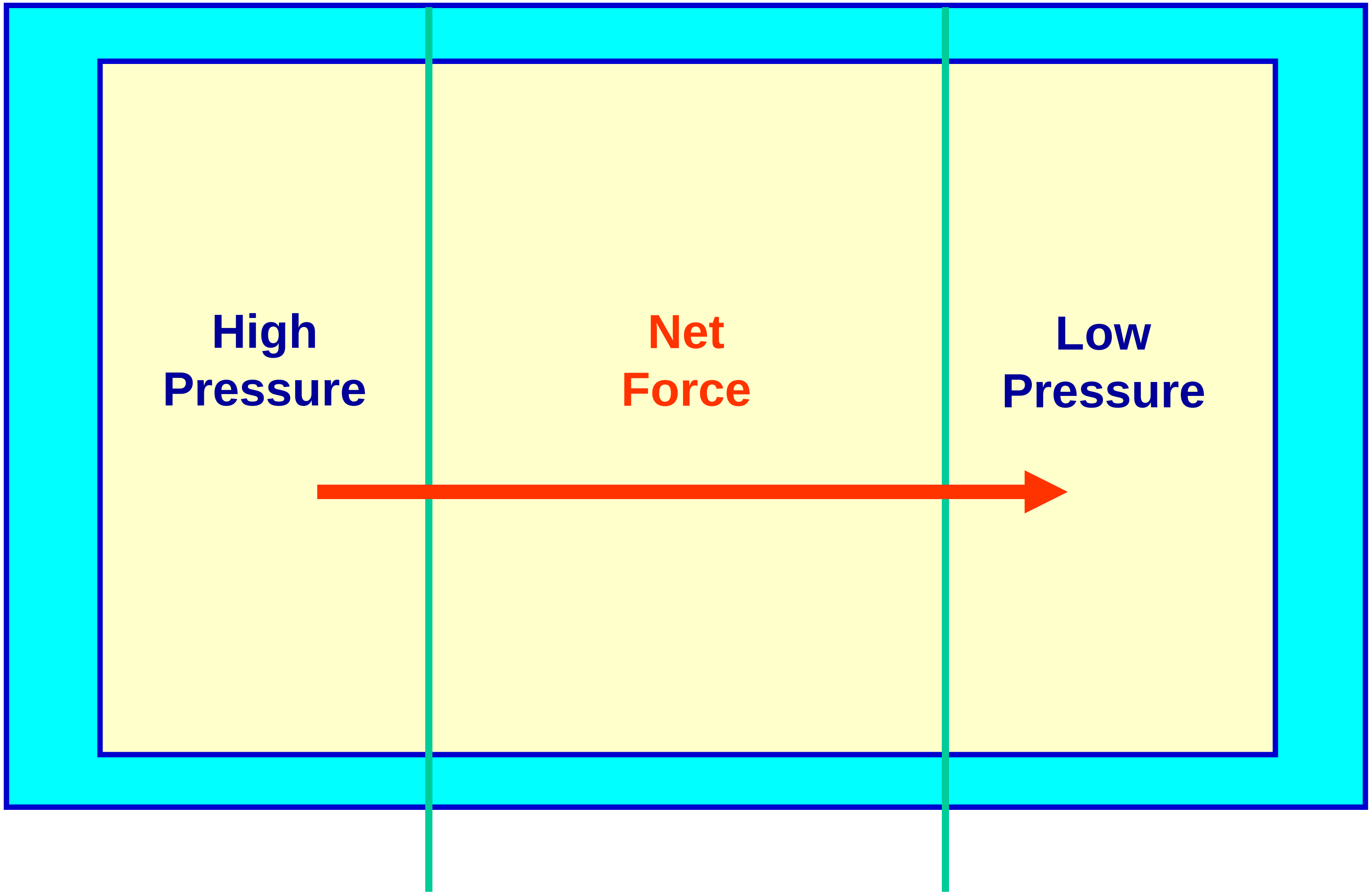
Factors Determining the Wind’s Speed and Direction

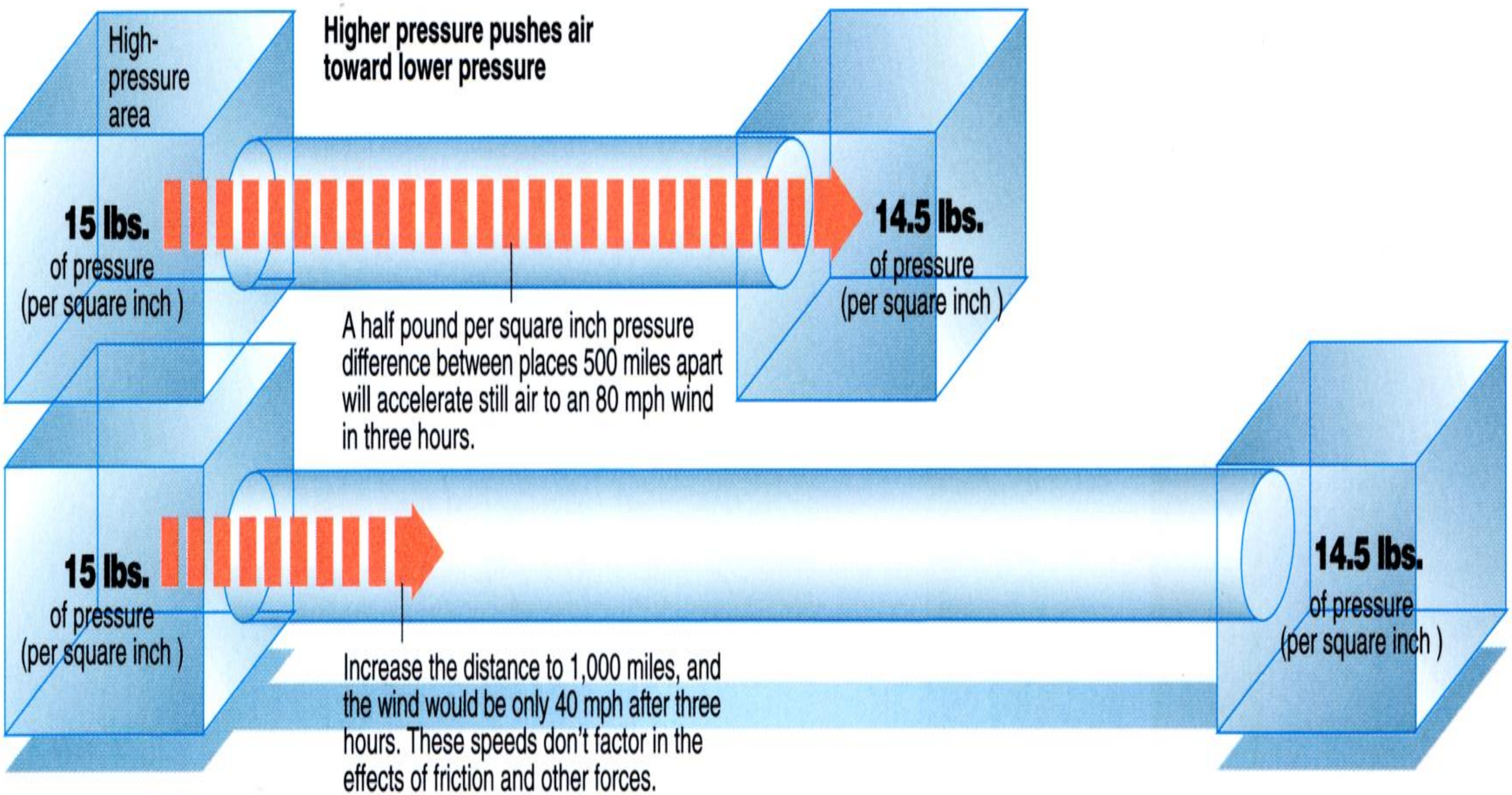
- **Pressure Gradient Force**
  - Generates the wind by causing air to move
  - Movement from high to low pressure areas
- **Friction**
  - Slows the wind
  - Effect is greatest close to earth (less than 3000ft).
- **Coriolis Effect**
  - Causes the wind to curve

Pressure Differences Cause Wind



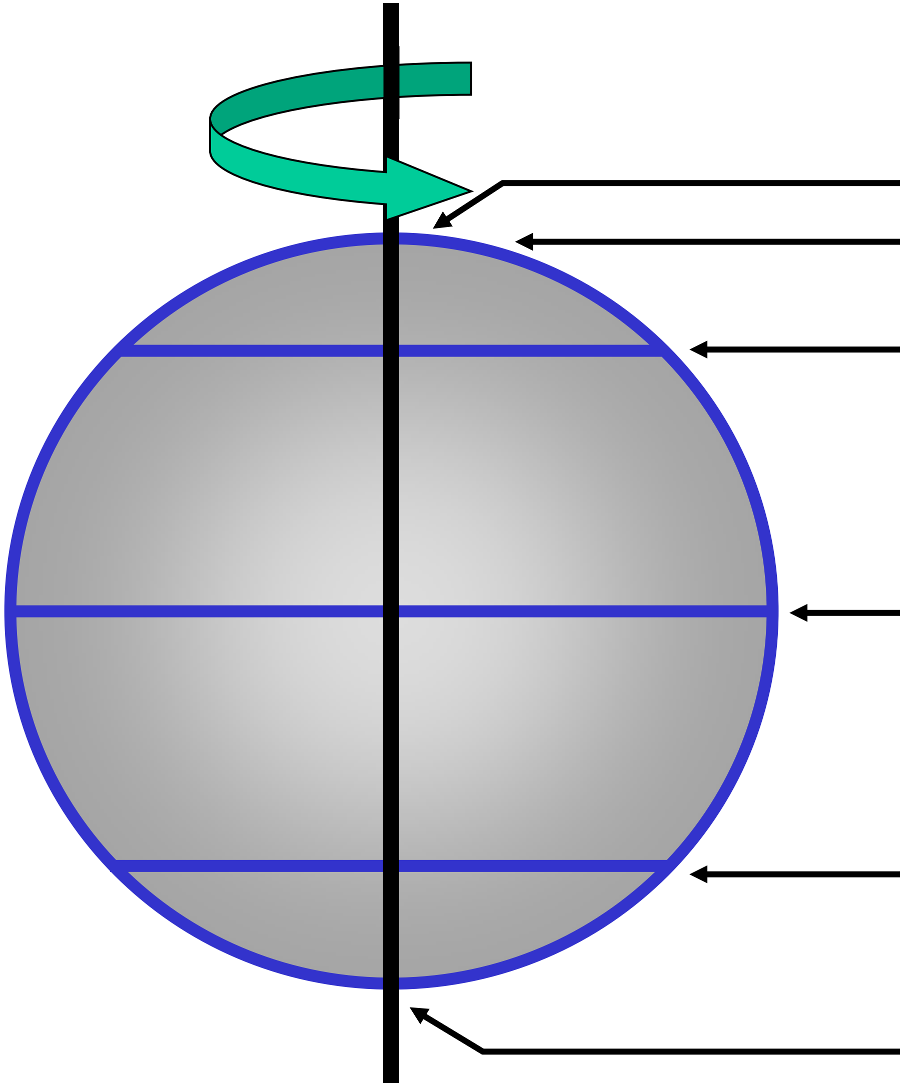
Pressure Gradient Force

greater pressure gradient greater wind speed



Speed of Earth's Rotation

rotation of Earth is counter-clockwise



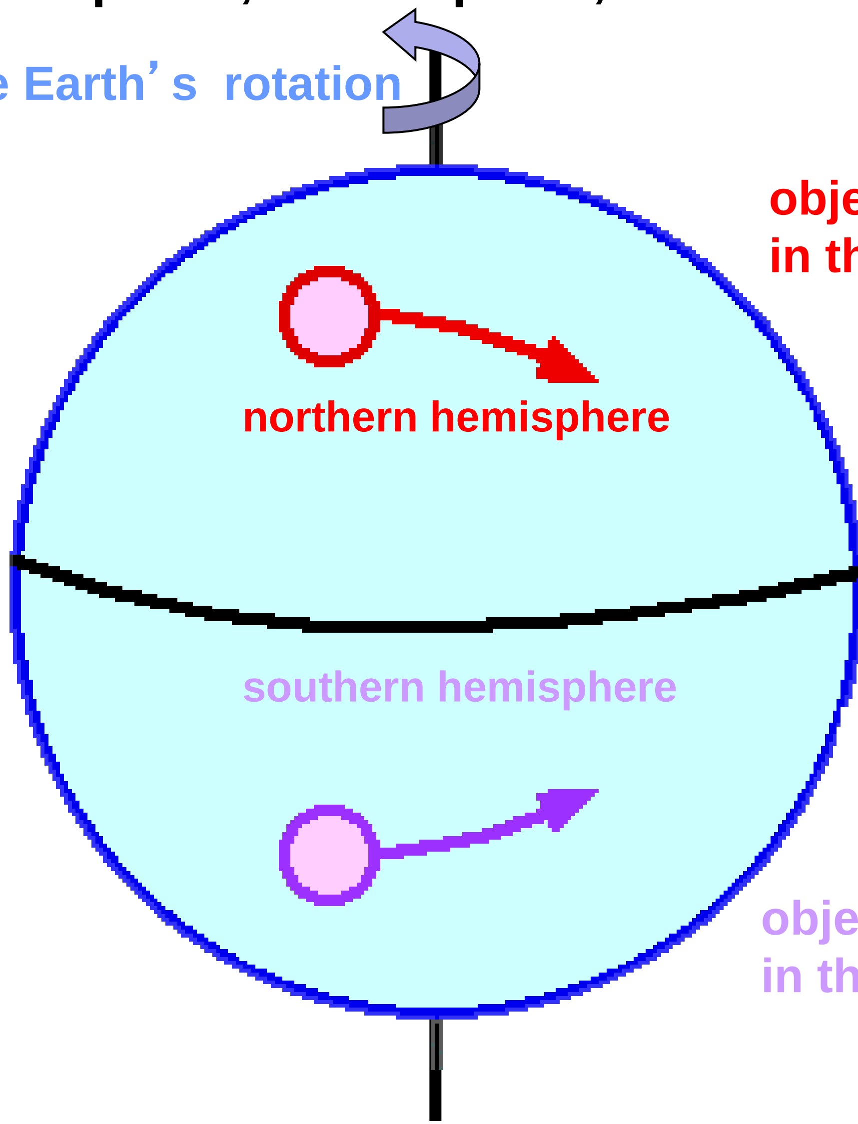
Coriolis Effect

cause wind to curve

effect zero at Equator, max at poles; more with strong winds

Due to the Earth's rotation

objects deflect to the right
in the northern hemisphere

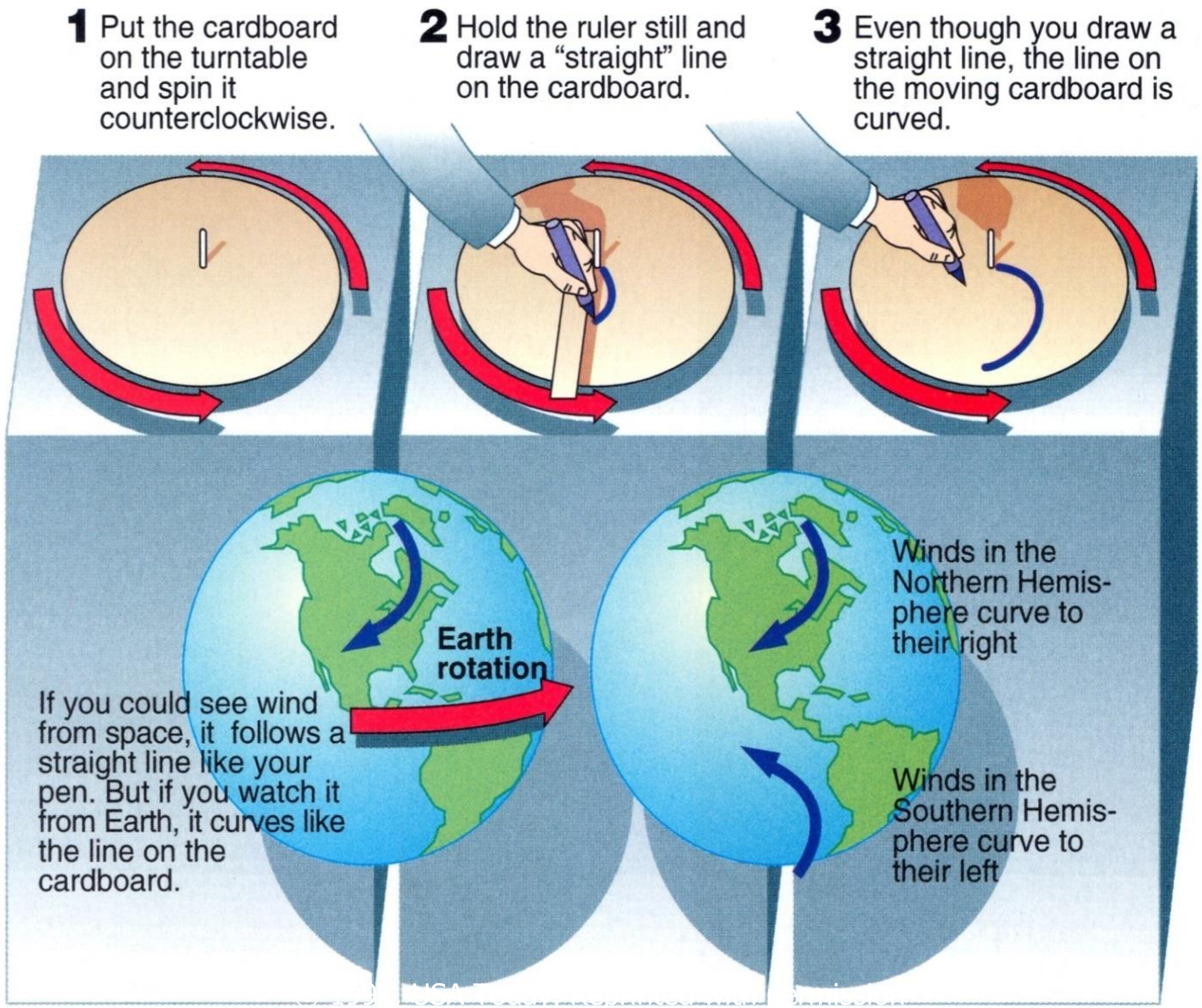


objects deflect to the left
in the southern hemisphere

Coriolis Effect

imagine yourself on a merry-go-round throwing a ball across to a companion ball travels in a straight line from perspective of merry go round, but curved path when seen from above

Concept of Conservation of Angular Momentum

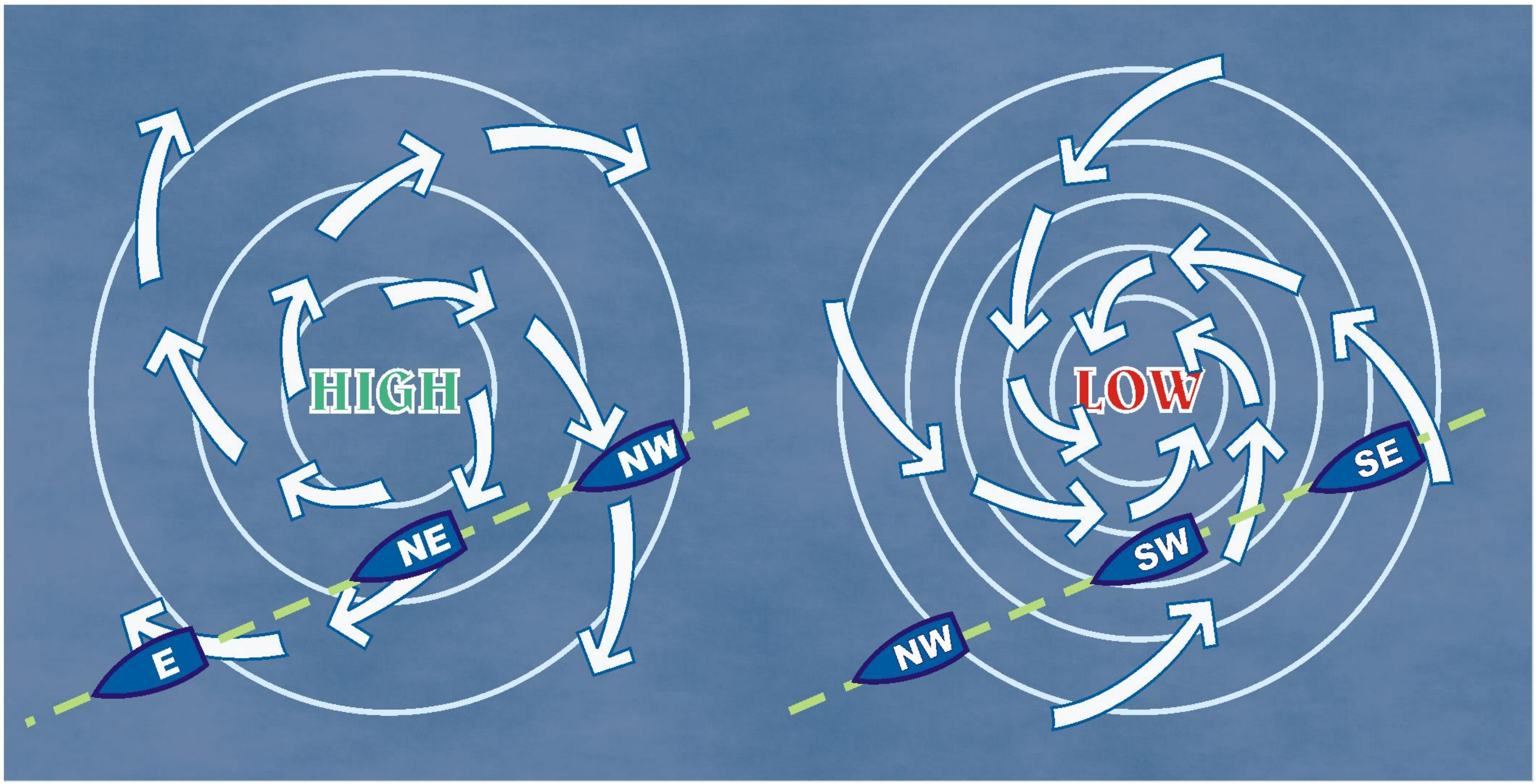


A Video Demonstrating Coriolis Effect

- http://youtu.be/i2mec3vgeaI
- 3:05 mins.

Surface High & Low

winds spiral outward and clockwise in a high
winds spiral inward and counterclockwise in a low



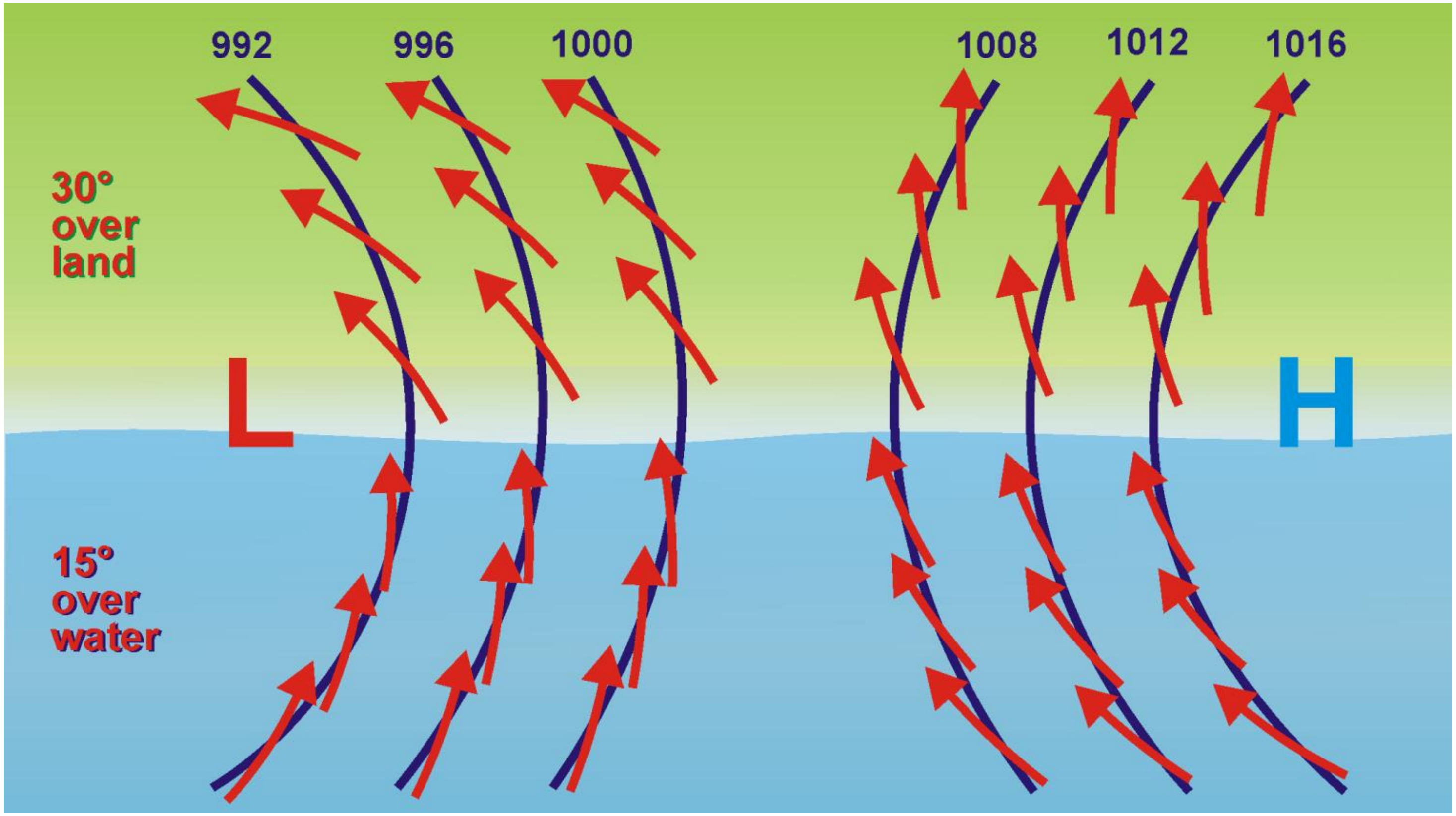
HIGH - winds spiral outward clockwise*
weakest near center

LOW - winds spiral inward counterclockwise*
strongest near center

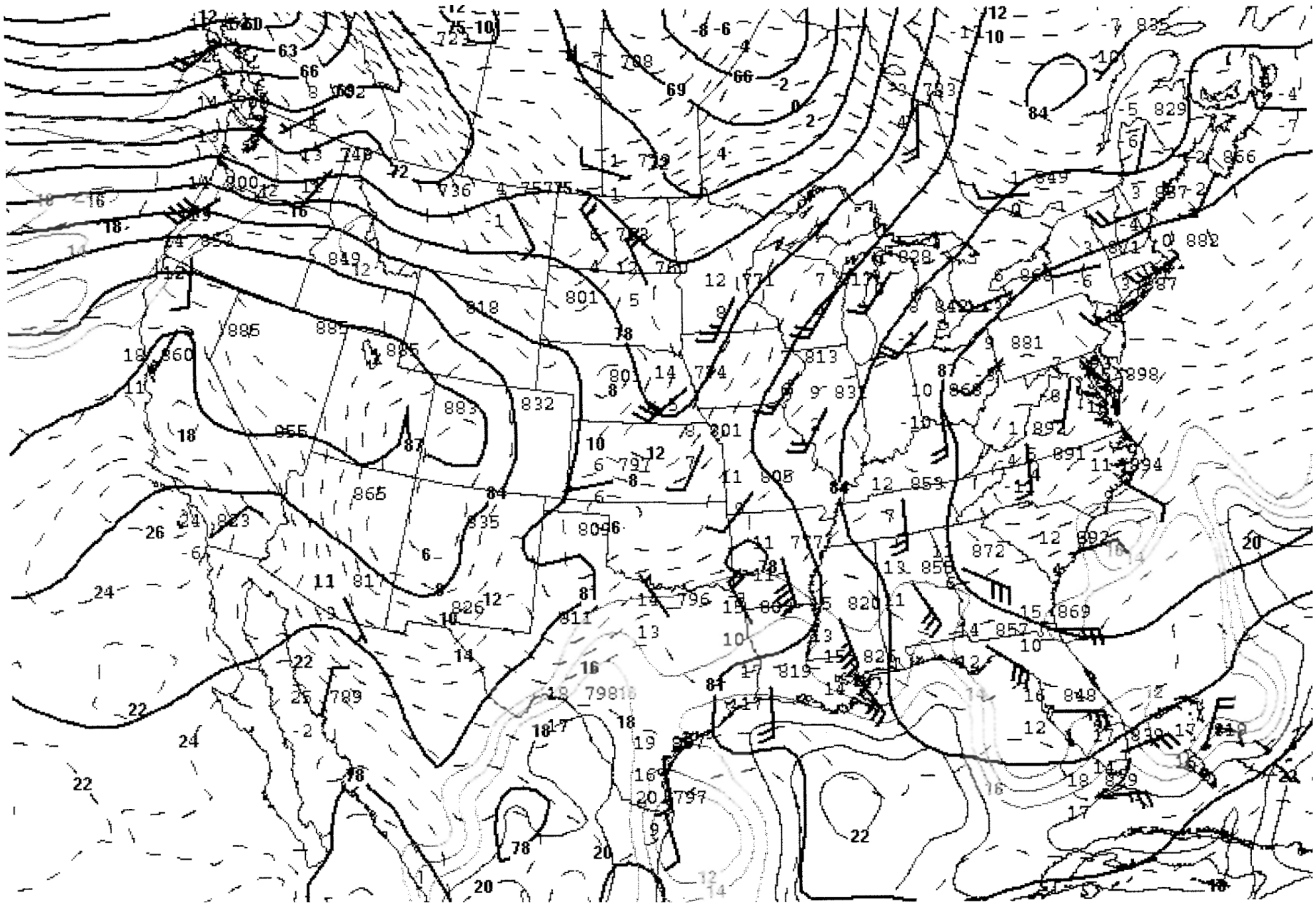
* reversed in Southern Hemisphere

Surface Cross-isobar Flow

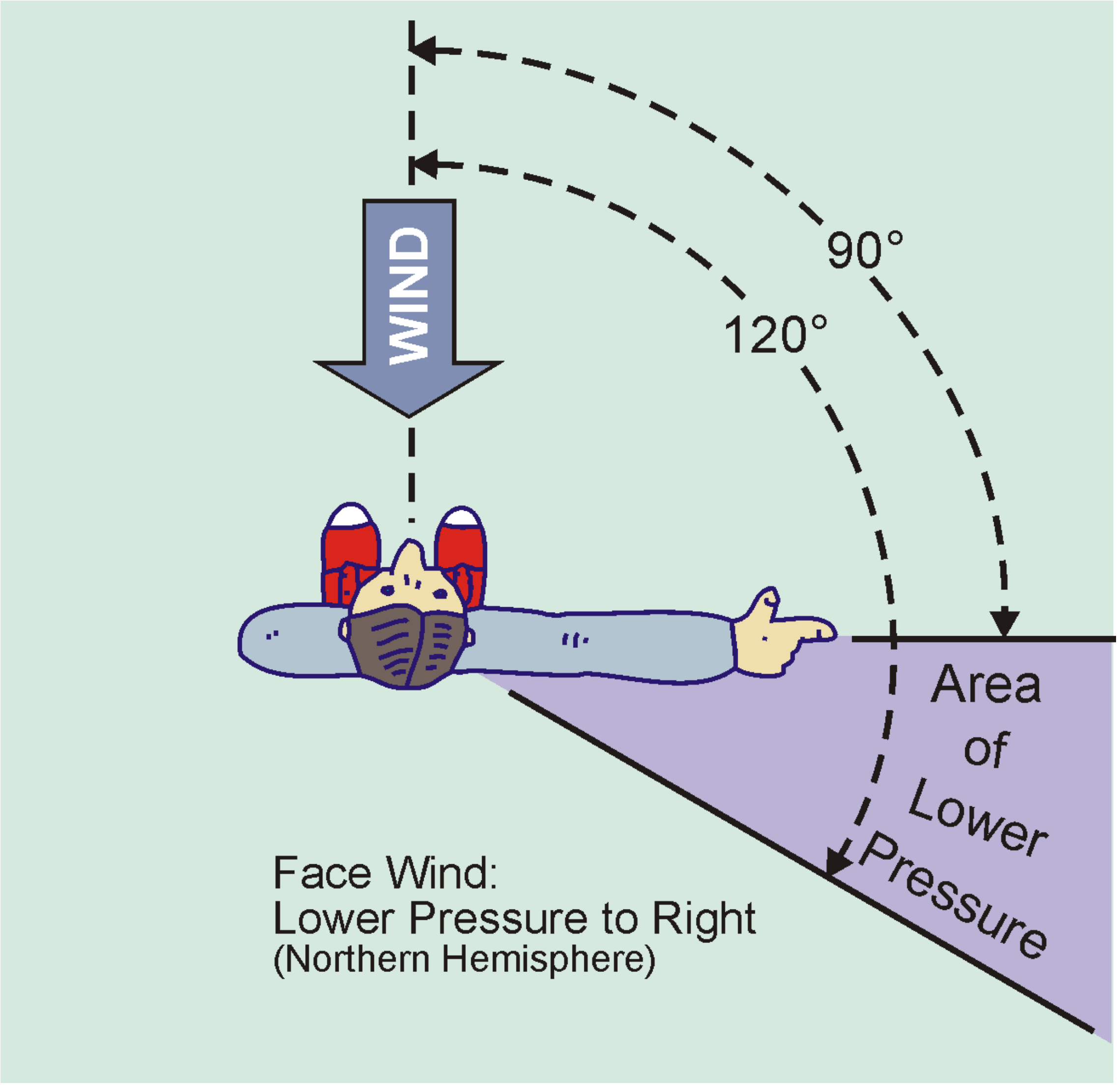
there is more friction over land than water



Low-Level Chart



Buys Ballot’s Law



PUTTING TEMP. PRESSURE, VOLUME TOGETHER: IDEAL GAS LAW

Weather

- **Ideal Gas Law   PV= n RT   or to simplify PV ~ nT**

- An ideal gas is defined as one in which all collisions between atoms or molecules are perfectly elastic and in which there are no intermolecular attractive forces. One can visualize it as a collection of perfectly hard spheres which collide but which otherwise do not interact with each other. In such a gas, all the **internal energy is in the form of kinetic energy and any change in internal energy is accompanied** by a change in temperature.
- An ideal gas can be characterized by three state variables:
  - absolute pressure (P), volume (V), and absolute temperature (T).
- n = number of moles which is a measure of the number of molecules.
- R = universal gas constant = 8.3145 J/mol K

- NOTE: This is optional material and will not be covered on exam, but helpful to know for those who want to learn more. See reference to www.hyperphysics.com
- I have included in your references a simplified discussion of this taken from a Introductory Meteorology Textbook: Essentials of Meteorology 8th Ed Ahrens and Henson. " The Atmosphere Obeys the Gas Law"

The Atmosphere Obeys the Ideal Gas Law: PV=nRT

Weather

- The Ideal Gas Law we know to be: **Pressure x Volume ~ T (can ignore R, a constant)**
- We can restate the Ideal Gas Law as :

- Density, which is Mass per Volume D = M / V (Note: n = # molecules a proxy for mass)

- Thus, we have **Pressure = Temperature x Density**

We know that **cold air is denser than warm air when the pressure is constant.** Thus a **cold air mass tends to sink while a warm air mass rises**. Per the equation above, if the temperature is lower, the density must be higher for a given pressure.(same altitude). But also in the case of Global Circulation, in a **HIGH PRESSURE ZONE, at constant temperature, the density of the air must be greater. There are more "air molecules" within a given volume of that portion of the atmosphere.**

- Please review article provided in email "The Atmosphere Obeys the Ideal Gas Law"
- **CREDITS TO: *ESSENTIALS OF METEOROLOGY: AN INVITATION to the ATMOSPHERE* by Ahrens and Henson, 8th Ed. P.150**

Chapter 2
Summary

- Winds are named for the direction from which they blow.
- The Northeast Trade Winds blow from the northeast between the Horse Latitudes and the ITCZ (Doldrums).
- The Prevailing Westerlies blow generally west to east between the Horse Latitudes and the Subpolar Low.
- The average atmospheric pressure at sea level is 14.7 psi, 29.92 inHg, and 1013.2 mb.
- The Pressure Gradient Force, Friction and the Coriolis Effect together determine the wind's speed and direction.
- Close isobar spacing indicates a steep pressure gradient and high wind speed.
- In the Northern Hemisphere the Coriolis Effect deflects wind to the right causing cyclonic rotation (counterclockwise) around lows and anticyclonic rotation (clockwise) around highs.

Chapter 2
Summary- cont.

- The Coriolis Effect increases with latitude and higher wind speed.
- Surface winds flow around highs and lows somewhat crosswise to the isobars at about 15 degrees over water and about 30 degrees over land.
- Winds aloft have a different flow than surface winds mainly because of a greater Pressure Gradient Force and the absence of surface friction.
- Buys Ballot's Law is a way of determining the direction to a low.
- Winds veer clockwise. Winds back counterclockwise.

FUTURE LLI WEATHER COURSES

- Spring 2020 LLI Feb. 20, 2020
  - Water, Humidity, Fog, Atmospheric Stability, Clouds, Precipitation
- Future Classes to cover these topics
  - Thunderstorms, Tornadoes, Lightning, Optical Effects
  - Mid-latitude weather and storms
  - Tropical Weather and Storms, Hurricanes
  - Weather forecasting processes and resources

QUESTIONS?