UNIT 13: WEATHER AND CLIMATE

After Unit 13 you should be able to:

- *Be able to use Selected Properties of Earth's Atmosphere, Planetary Wind and Moisture Belts in the Troposphere, Temperature, Pressure, Key to Weather Map Symbols, Average Chemical Composition of Earth's Crust, Hydrosphere, and Troposphere, and Surface Ocean Currents charts from the ESRT.*
- *Be familiar with the function of the ozone layer*
- *Understand the transferences of energy: conduction, convection, radiation*
- *Understand the Greenhouse Effect, identify greenhouse gases, and understand factors that impact climate such as ocean currents, latitude, and altitude*
- *Understand the impact volcanic eruptions can have on short term climate*
- *Understand how air pressure is measured, the key differences between high and low pressure, and the factors that impact air pressure*
- *Understand how air pressure plays a role in weather prediction and wind as well as tools used to measure wind speed and direction*

After Unit 13 you should be able to (continued):

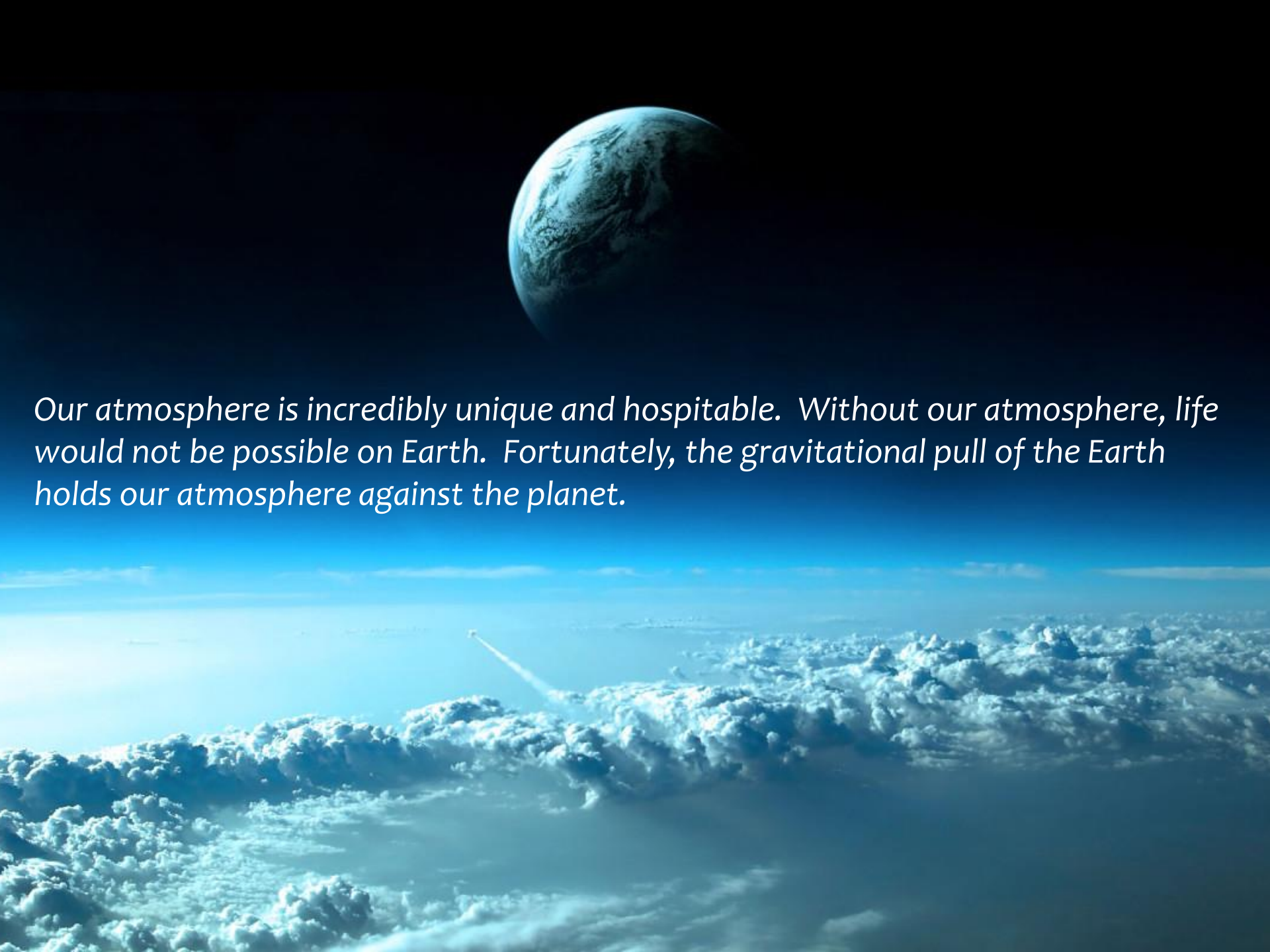
- *Understand and decode air mass symbols and fronts and understand what changes occur as they pass a weather station*
- *Be able to accurately draw isobars and calculate gradient for pressure, temperature, etc.*
- *Understand the role prevailing winds play in weather prediction*
- *Be able to plan and execute safety precautions in the event of a significant weather event such as a hurricane, lake effect snowstorm, and tornado*
- *Be able to fully encode and decode a weather station with symbolic representations*

Unit 13 vocabulary you should be able to use and understand:

- *Atmosphere*
- *Altitude*
- *Troposphere*
- *Stratosphere*
- *Mesosphere*
- *Thermosphere*
- *Ozone layer*
- *Radiation*
- *Convection*
- *Conduction*
- *Density*
- *Greenhouse effect*
- *Infrared radiation*
- *Greenhouse gases*
- *Water vapor*
- *Carbon dioxide*
- *Nitrogen Dioxide*
- *Methane*
- *Transparency*
- *Local*
- *Regional*
- *Latitude*
- *Insolation*
- *Angle of incidence*
- *Barometric pressure*
- *Air pressure*
- *Barometer*
- *Atmospheres*
- *Millibars*
- *Inches of mercury*
- *Isobars*
- *Gradient*
- *High pressure*
- *Low pressure*
- *Clockwise*
- *Counterclockwise*
- *Coriolis effect*
- *Cold front*
- *Warm front*
- *Stationary front*
- *Occluded front*
- *Wind*
- *Wind vane*
- *Anemometer*
- *Thermometer*
- *Cyclone*
- *Anticyclone*
- *Prevailing winds*
- *Jet stream*
- *Air masses*
- *Continental air mass*
- *Maritime air mass*
- *Arctic air mass*
- *Polar air mass*
- *Tropical air mass*
- *Atom*
- *Molecule*

Unit 13 vocabulary you should be able to use and understand:

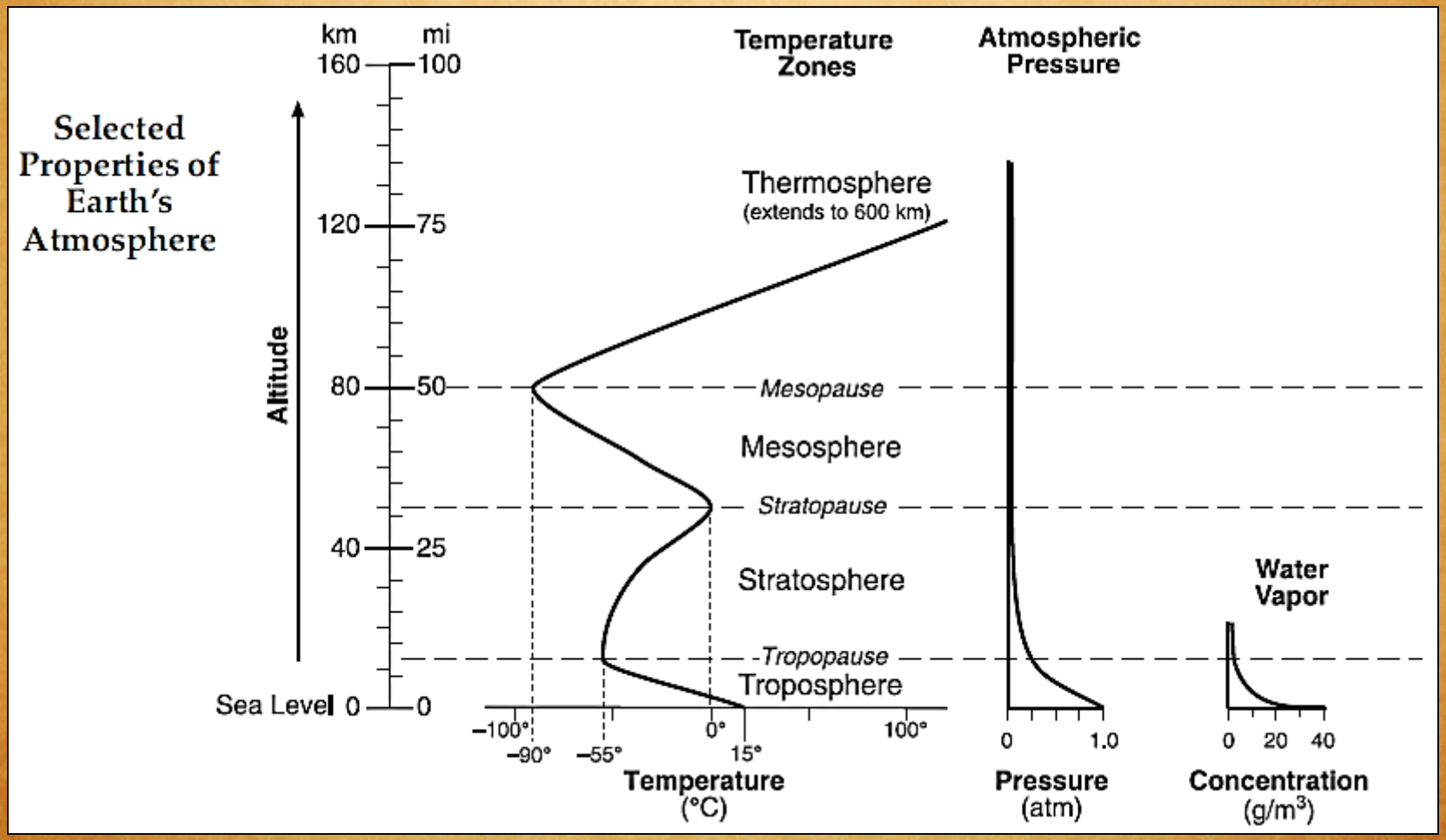
- *Hurricane*
- *Tornado*
- *Weather station model*
- *Cloud cover*
- *Visibility*
- *Temperature*
- *Dewpoint*
- *Feather*
- *Knots*
- *Barometric trend*
- *Precipitation*
- *Encode*
- *Decode*



Our atmosphere is incredibly unique and hospitable. Without our atmosphere, life would not be possible on Earth. Fortunately, the gravitational pull of the Earth holds our atmosphere against the planet.

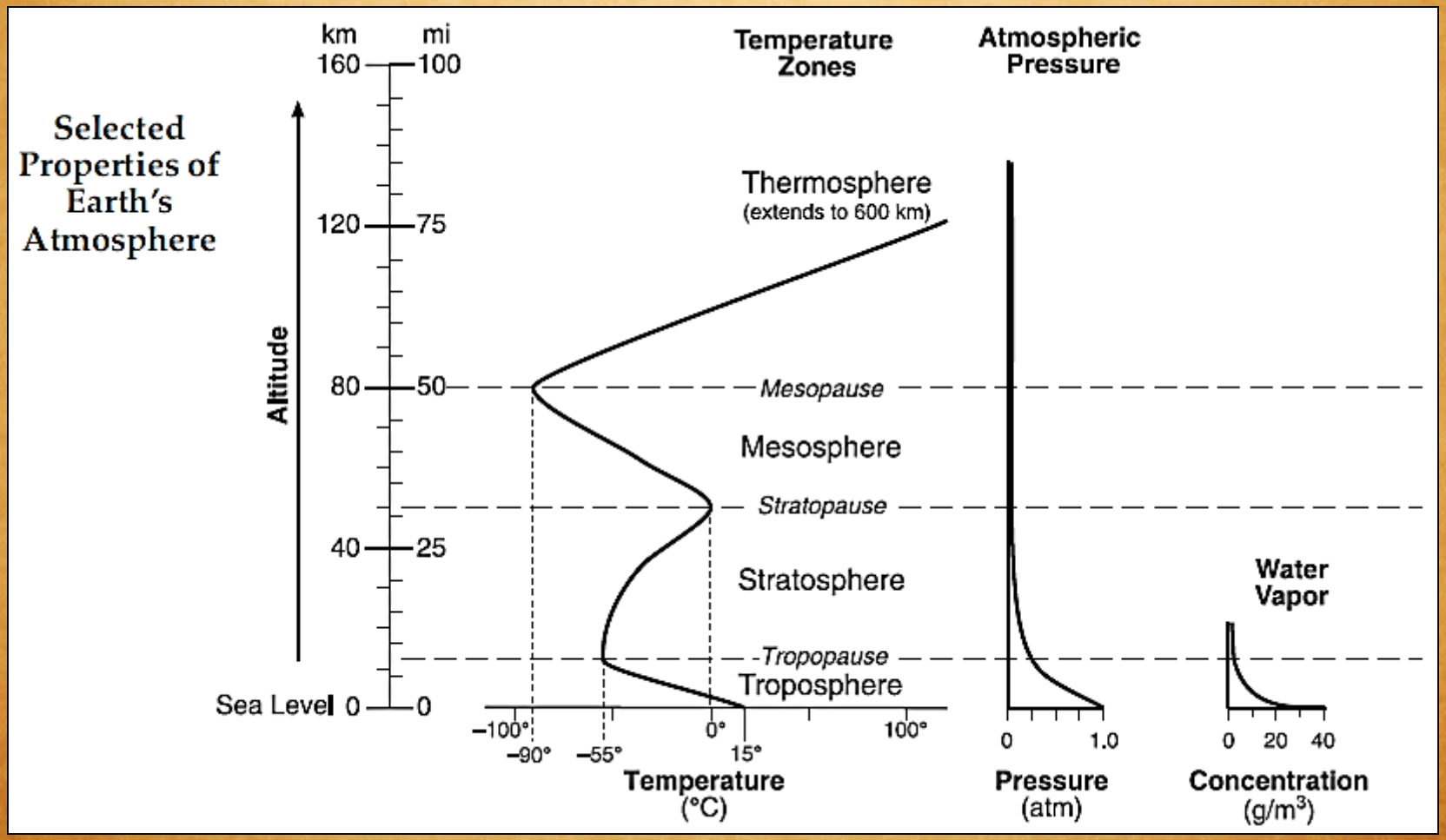
Layers of the Atmosphere

- *Our atmosphere contains several distinct layers*



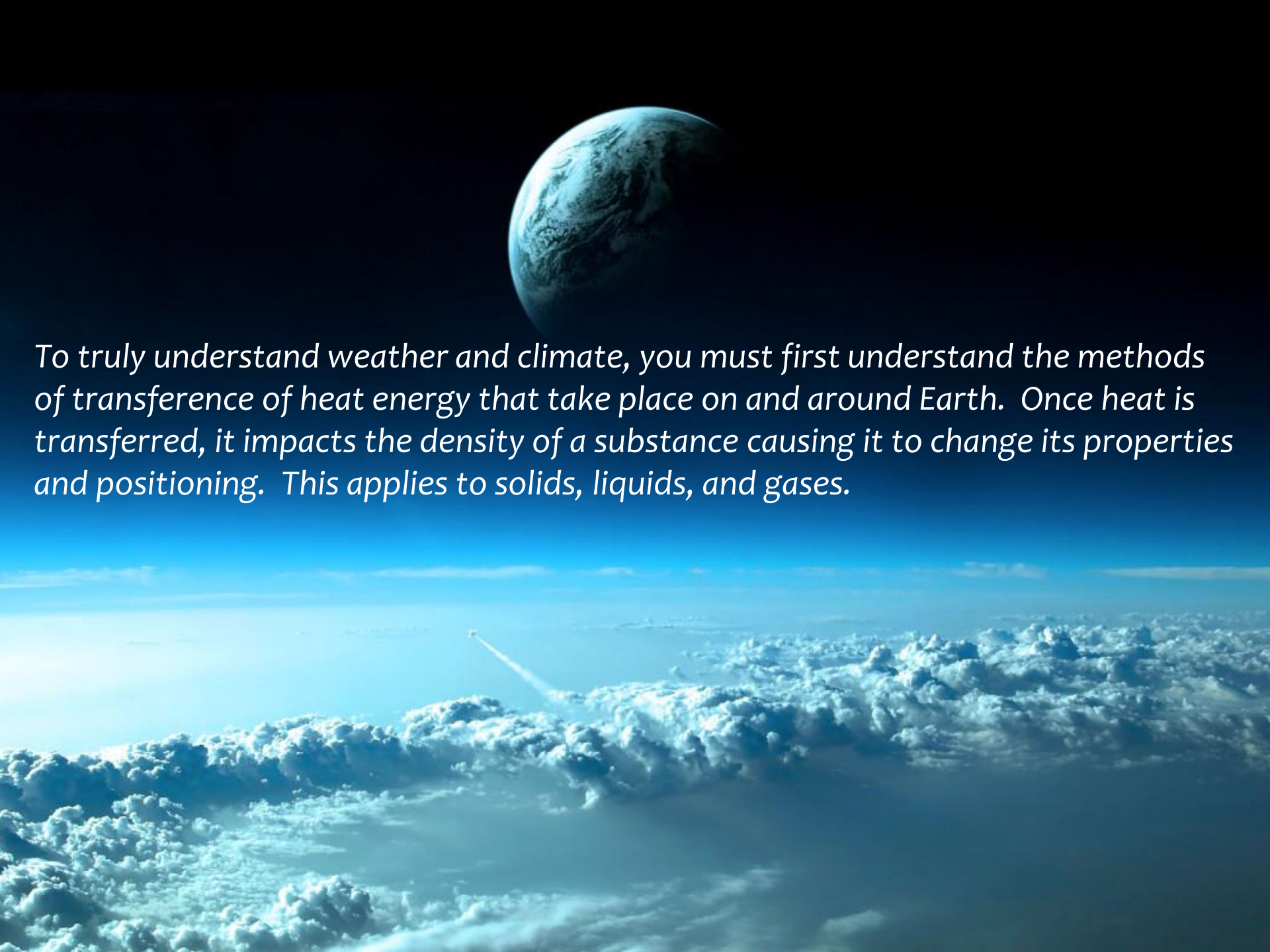
Characteristics of the Atmosphere

- *The layers of the atmosphere are defined by* **changes in temperature**

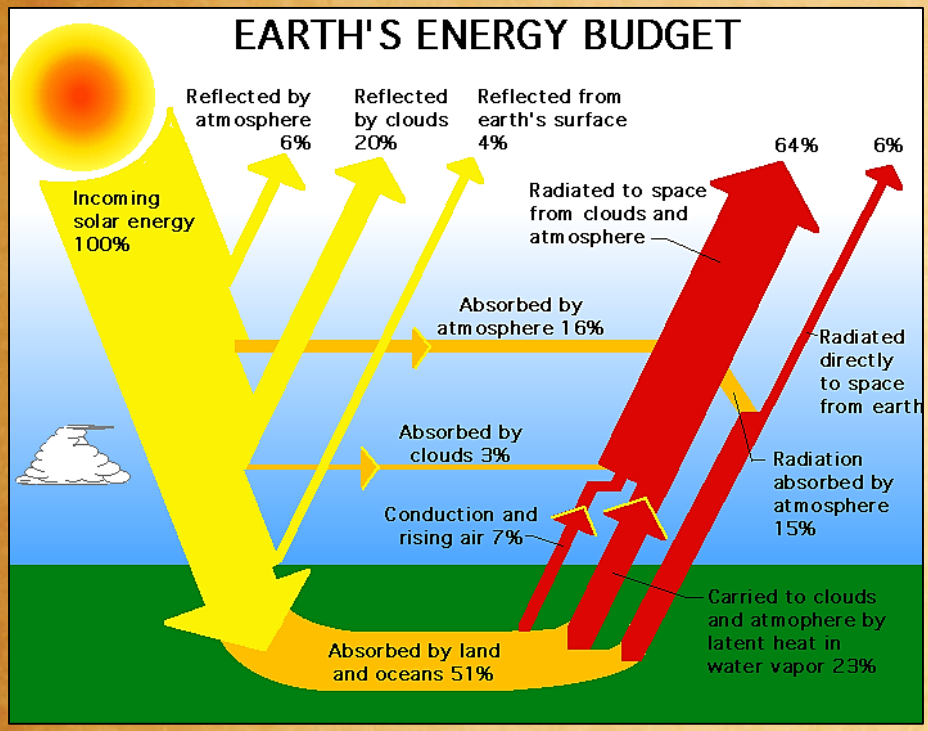


Unique Layer: The Ozone Layer

- *The ozone layer is located in the* **stratosphere**
- *Ozone (O_3) protects organisms on Earth's surface from the majority of the Sun's ultraviolet (***UV***) radiation*



To truly understand weather and climate, you must first understand the methods of transference of heat energy that take place on and around Earth. Once heat is transferred, it impacts the density of a substance causing it to change its properties and positioning. This applies to solids, liquids, and gases.

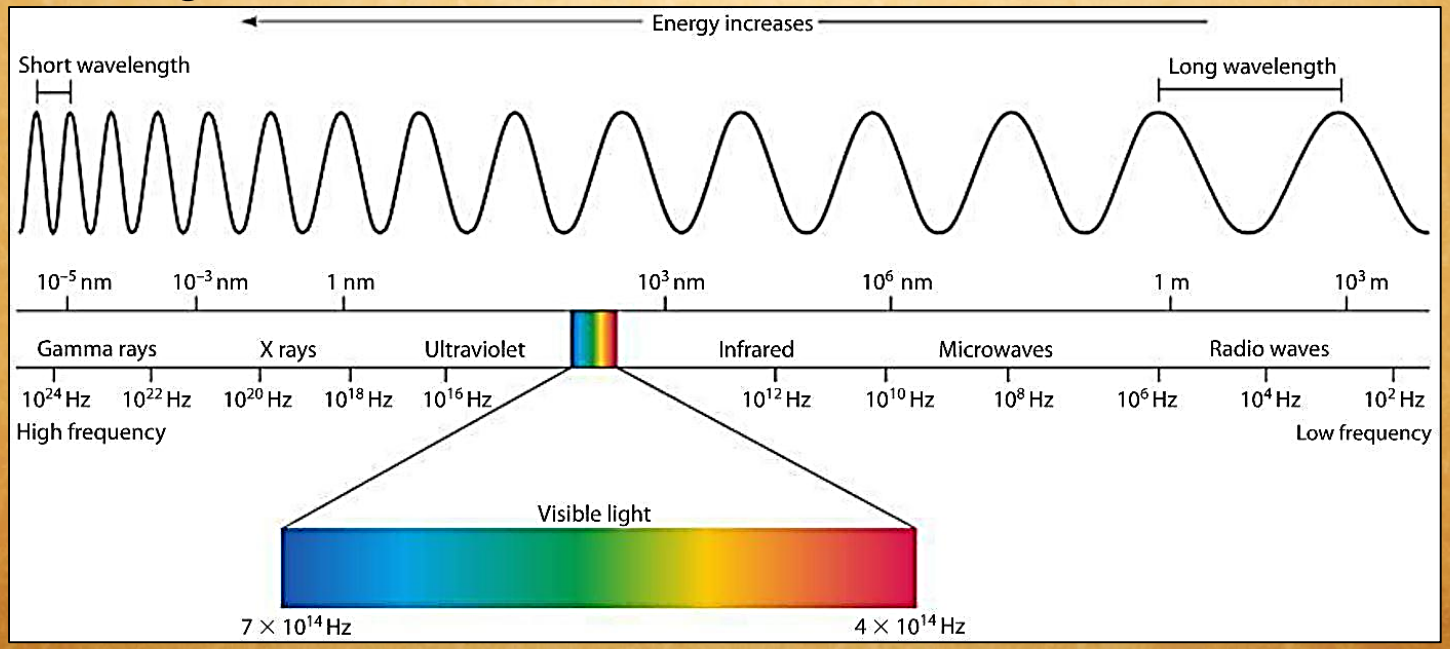


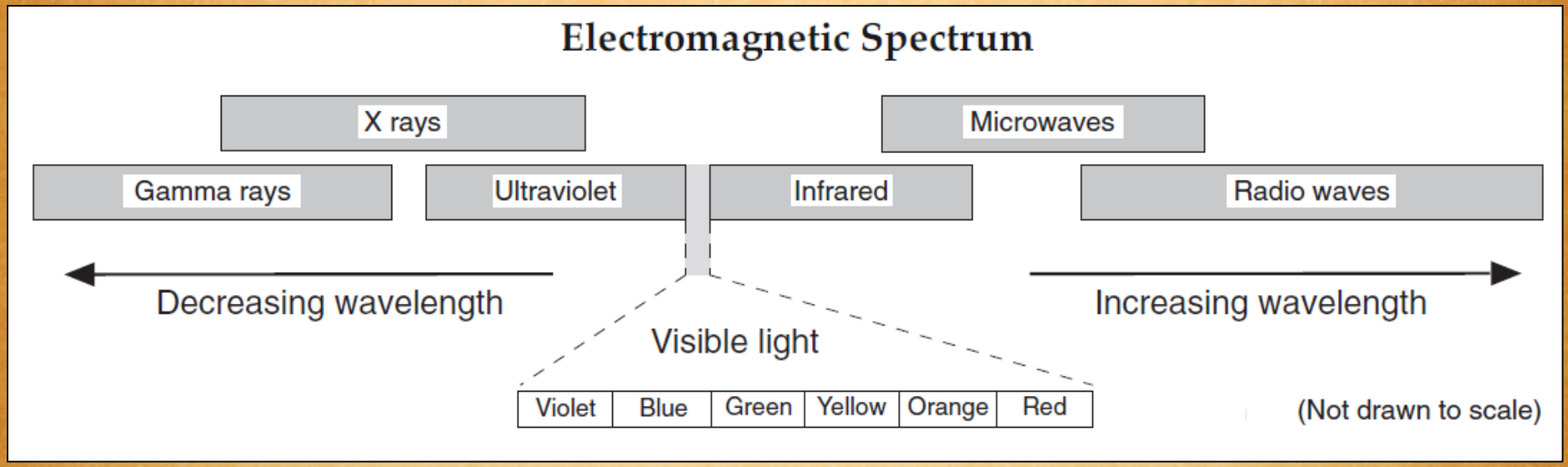
Method #1: Radiation

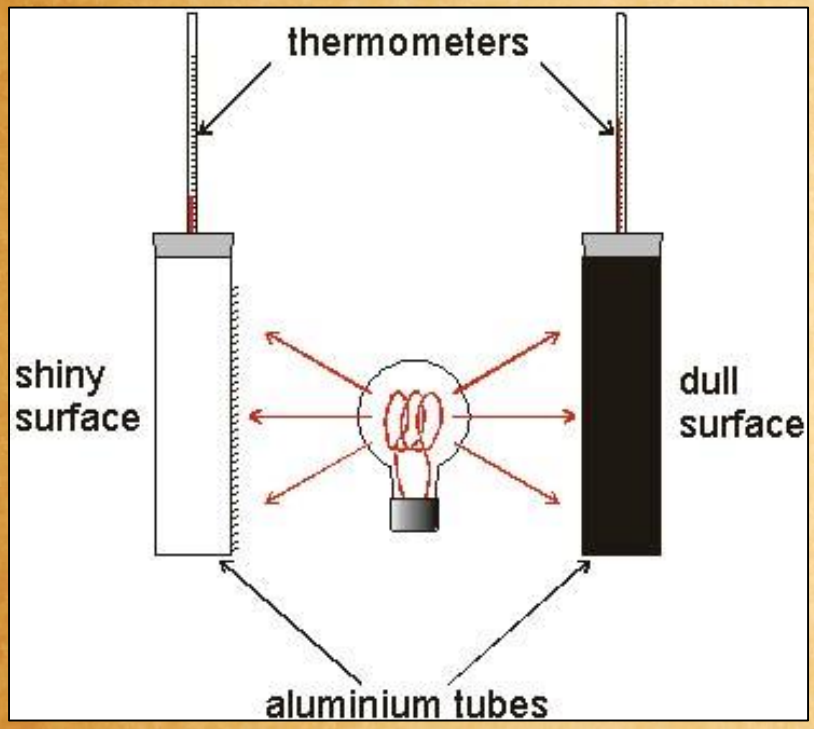
- *Radiation is the transference of energy in* **waves** *through the atmosphere or atoms in solids, liquids, and gases*
- *Absorption of these waves by atoms can produce heat*
- *Main sources of radiation:* **the Sun** *and decay of* **radioactive elements** *within the Earth*

Radiation and the Electromagnetic Spectrum

- *Waves of radiation are defined by the* **electromagnetic spectrum**
- **Shorter wavelengths have greater energy**, *longer wavelengths have less energy*
- *Longer wave radiation, like that of radio waves is harmless, whereas shorter waves such as ultraviolet can be harmful with prolonged exposure.*
- *The wavelengths and types of radiation can be found in the reference tables*



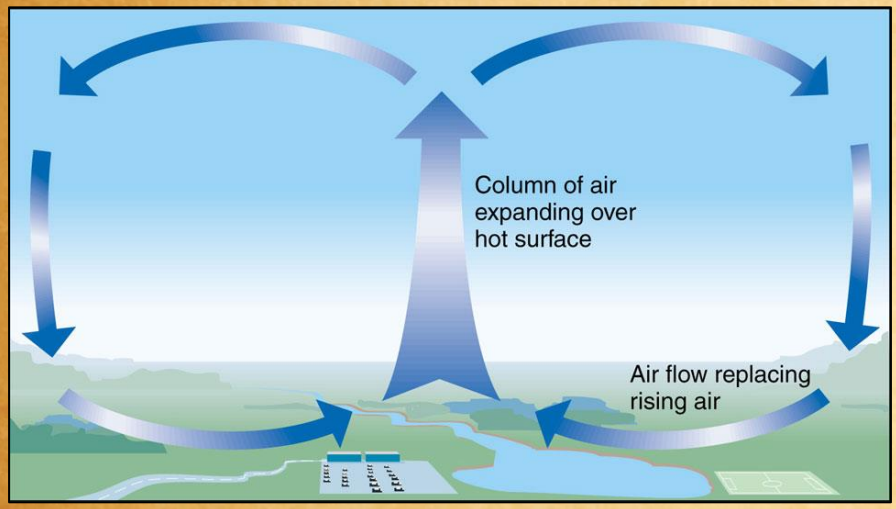

Electromagnetic Spectrum
X rays
Microwaves
Gamma rays
Ultraviolet
Infrared
Radio waves
Decreasing wavelength
Increasing wavelength
Visible light
Violet
Blue
Green
Yellow
Orange
Red
(Not drawn to scale)



Absorbers, Radiators, and Reflectors

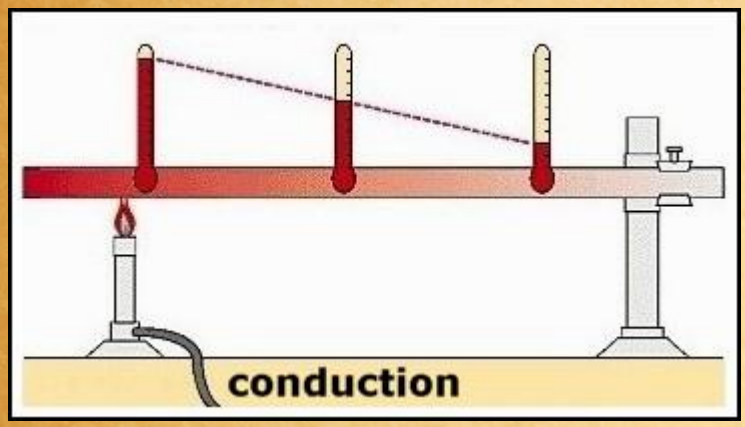
All objects (bodies) emit radiation. Certain characteristics can make some bodies better radiators or reflectors.

- **Surfaces that absorb the most energy from the Sun are dark in color, dull, and rough in texture**
- **These surfaces radiate energy easily as well** *(such as infrared)*
- *Smooth or shiny and light colored surfaces reflect radiation more easily and are poor radiators/absorbers.*



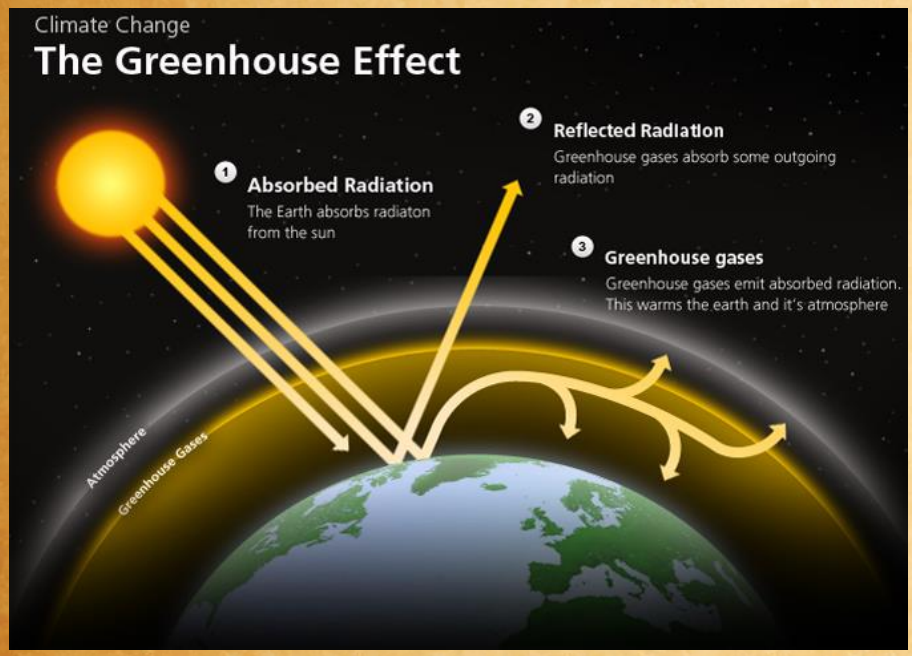
Method #2: Convection

- *Warmer, less dense substances* **rise** *and transfer their heat energy upward*
- *Commonly found:* **atmosphere** *(rising warm air, cloud formation as it cools);* **asthenosphere** *(mantle convection)*



Method #3: Conduction

- *Transfer of energy through* **atoms in contact with each other**
- *Example: metamorphism of rocks in contact with magma; as distance from magma increases, the grade of metamorphism decreases*

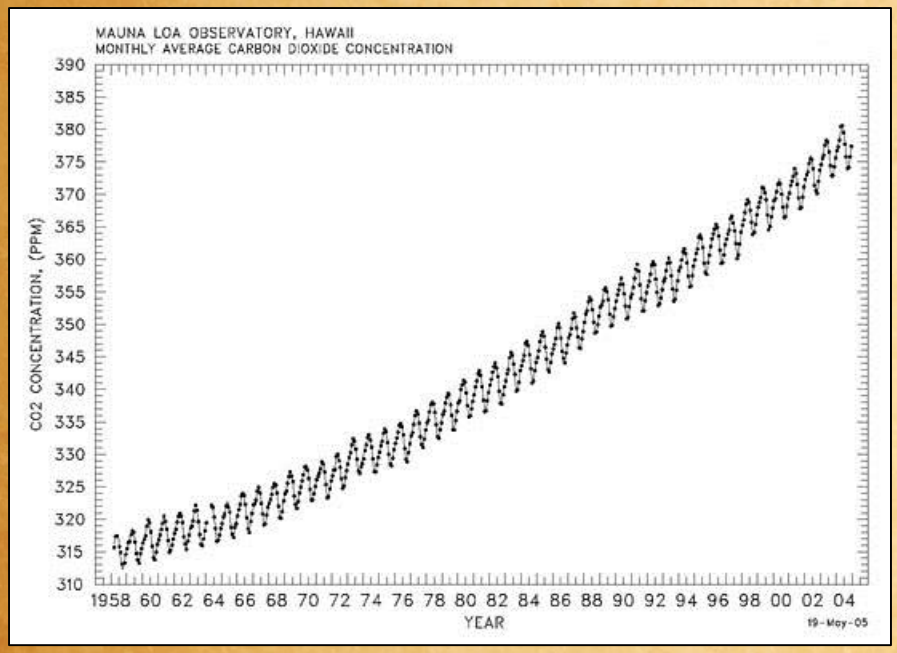


The Greenhouse Effect: Creating a Hospitable Earth

- **Atmospheric gases insulate the Earth** *in a phenomenon known as the greenhouse effect*
- *The sun warms the surface of the Earth as its rays strike the ground and oceans*
- **Infrared radiation bounces back** *into the atmosphere where it* **is absorbed and reemitted by gases** *that are present*

What are considered greenhouse gases?

- *Greenhouse gases positively influence climate on Earth (increase temperature)*
- *The #1 greenhouse gas is* **water vapor**
- *Others include:*
  - **Carbon dioxide (CO_2)**
  - **Methane (CH_4)**
  - **Nitrogen Dioxide (NO_2)**



Concerns with Climate Change

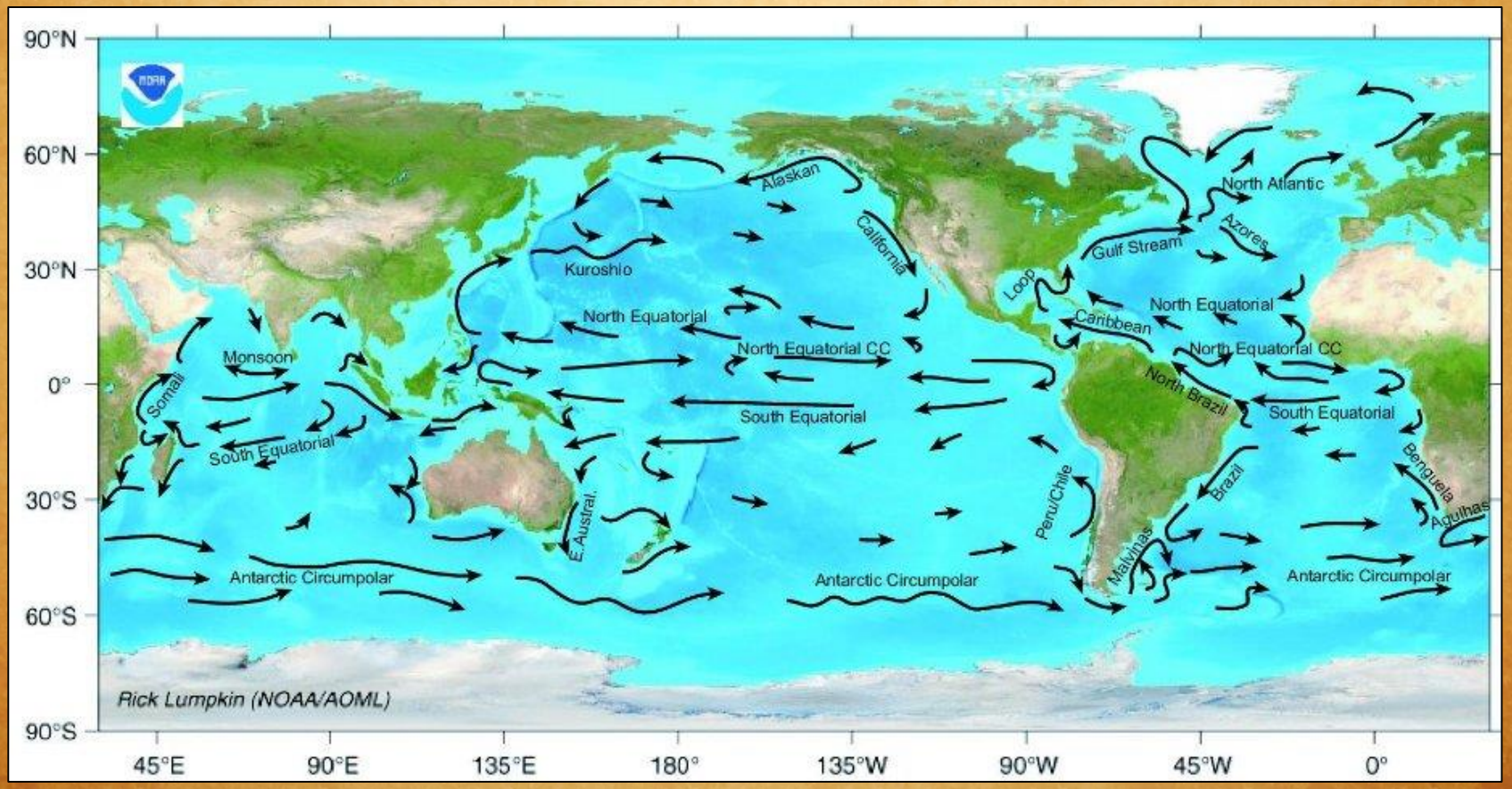
- *Humans are introducing* **carbon dioxide into the atmosphere** *at an incredible rate*
- *Concern has arisen because we have found a correlation between atmospheric CO_2 concentrations and a possible increasing average global temperature*

Other Influences on Worldwide Climate

- *Volcanic eruptions cool worldwide climate as* **particulates** *and sulfur dioxide are released into the atmosphere,* **reducing transparency**

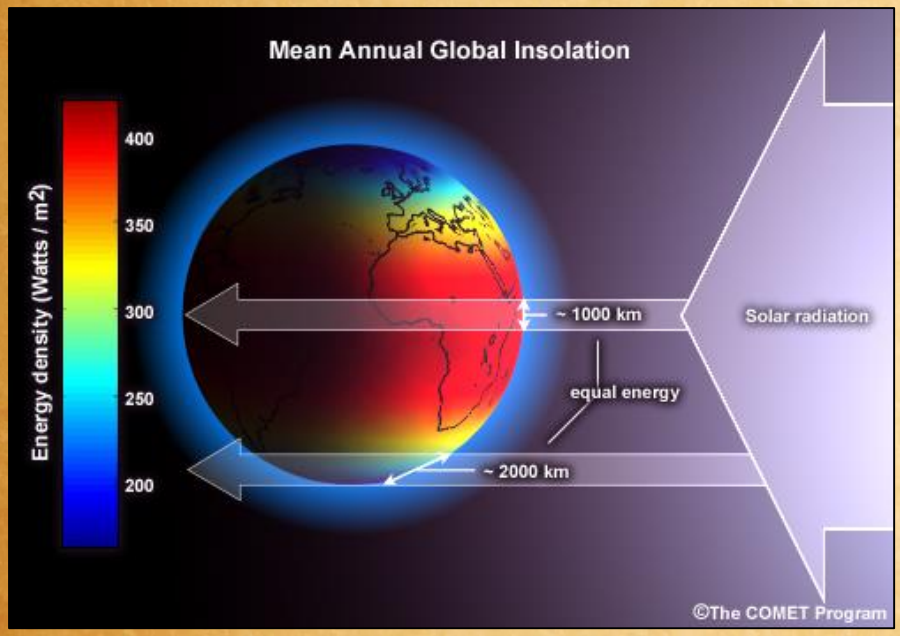
Regional Climate Factors

- *Ocean currents* **increase humidity** *in an area and* **moderate climate** (**warmer or cooler** *based on the type of* **current**)



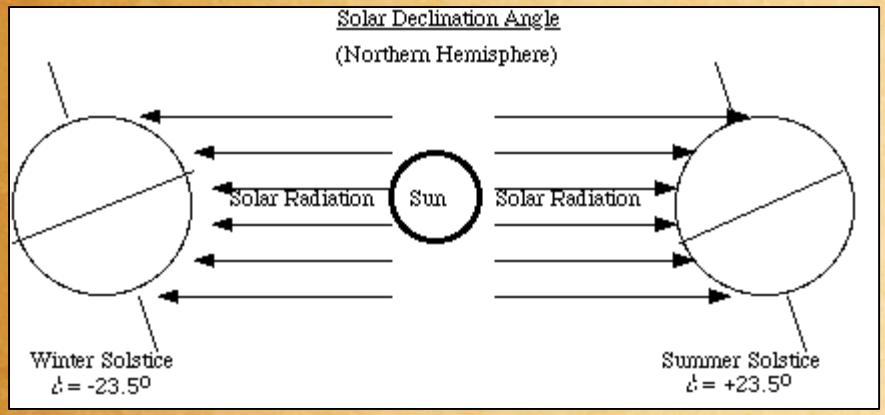
Elevation / Altitude

- *Cities located* **higher** *above sea level experience* **cooler climates**, *low elevations experience warmer climates*



Latitude

- *Latitude has the most significant impact on climate*
- *Recall that the Sun is directly overhead latitudes between 23.5° North and 23.5° South depending on the time of year*
- **The more direct the rays (lower latitudes), the warmer the climate (also more evaporation)**



Angle of Incoming Solar Radiation (Insolation)

- **The more direct the rays (higher angle of incidence), the warmer the climate (also more evaporation)**
- *The rays are more direct during the summer for the Northern Hemisphere*

While climate is the long-term description of temperature and humidity trends in an area, weather is the short-term description of these factors in an area. There are many variables to consider when generating a forecast.

Average Chemical Composition of Earth's Crust, Hydrosphere, and Troposphere

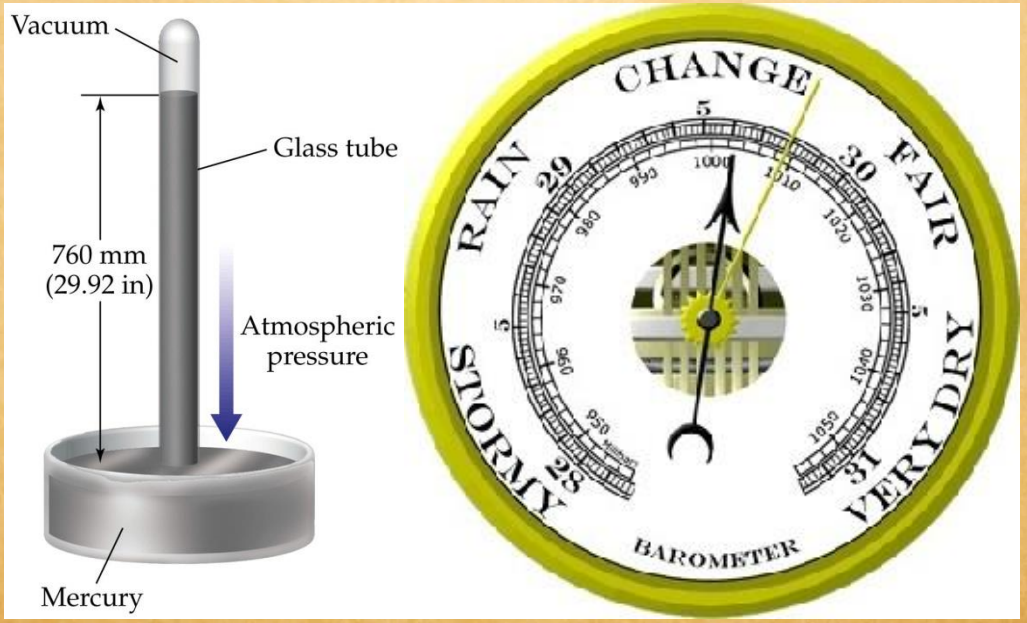
ELEMENT (symbol)	CRUST		HYDROSPHERE	TROPOSPHERE
	Percent by mass	Percent by volume	Percent by volume	Percent by volume
Oxygen (O)	46.10	94.04	33.0	21.0
Silicon (Si)	28.20	0.88		
Aluminum (Al)	8.23	0.48		
Iron (Fe)	5.63	0.49		
Calcium (Ca)	4.15	1.18		
Sodium (Na)	2.36	1.11		
Magnesium (Mg)	2.33	0.33		
Potassium (K)	2.09	1.42		
Nitrogen (N)				78.0
Hydrogen (H)			66.0	
Other	0.91	0.07	1.0	1.0

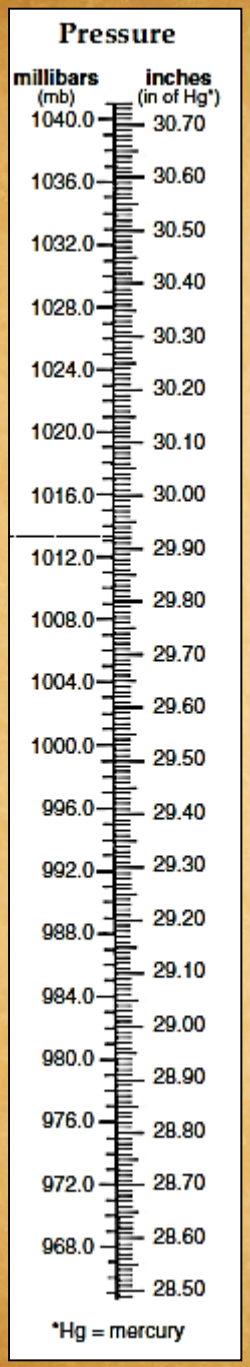
Introducing Air Pressure

- *Air is a mixture of gases, primarily* **nitrogen and oxygen**
- *These gases have mass, and this mass creates* **pressure** *on the surface of the Earth*
- *This pressure is called* **air pressure**

Measuring Air Pressure

- *Air pressure (more appropriately barometric pressure) is measured using a* **barometer**



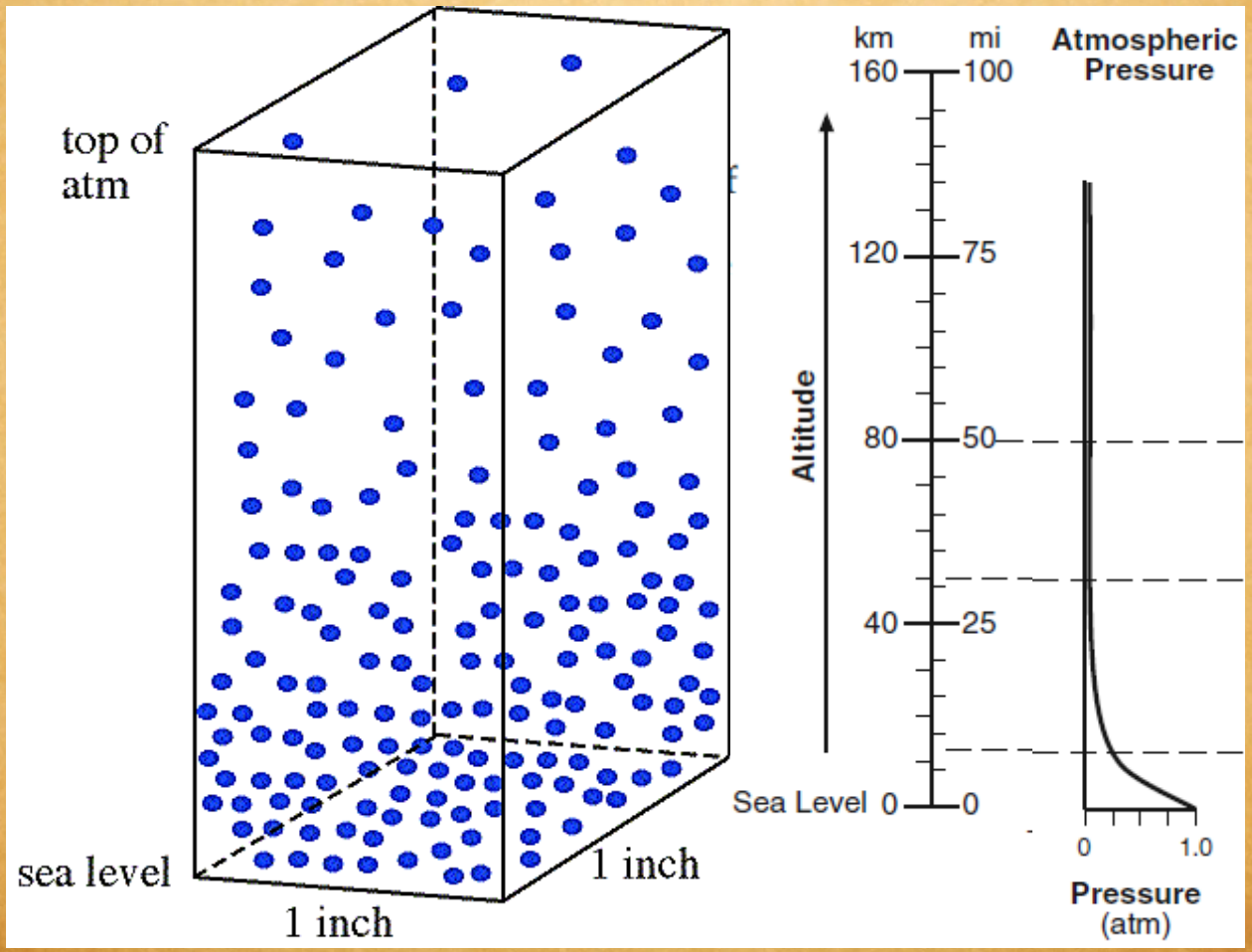


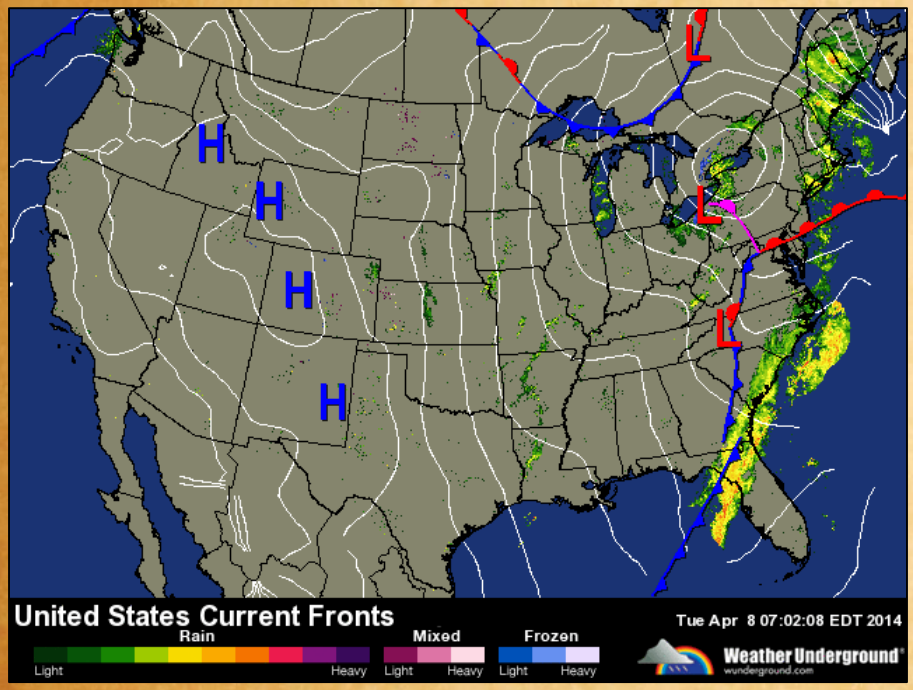
Barometric Pressure Conversions

- *Barometric pressure can be measured using the following units:* **atmospheres, millibars, and inches of mercury**
- *Unfortunately, the units are not uniform or equal, so a conversion chart must be used (ESRT)*

Pressure Trends in the Atmosphere

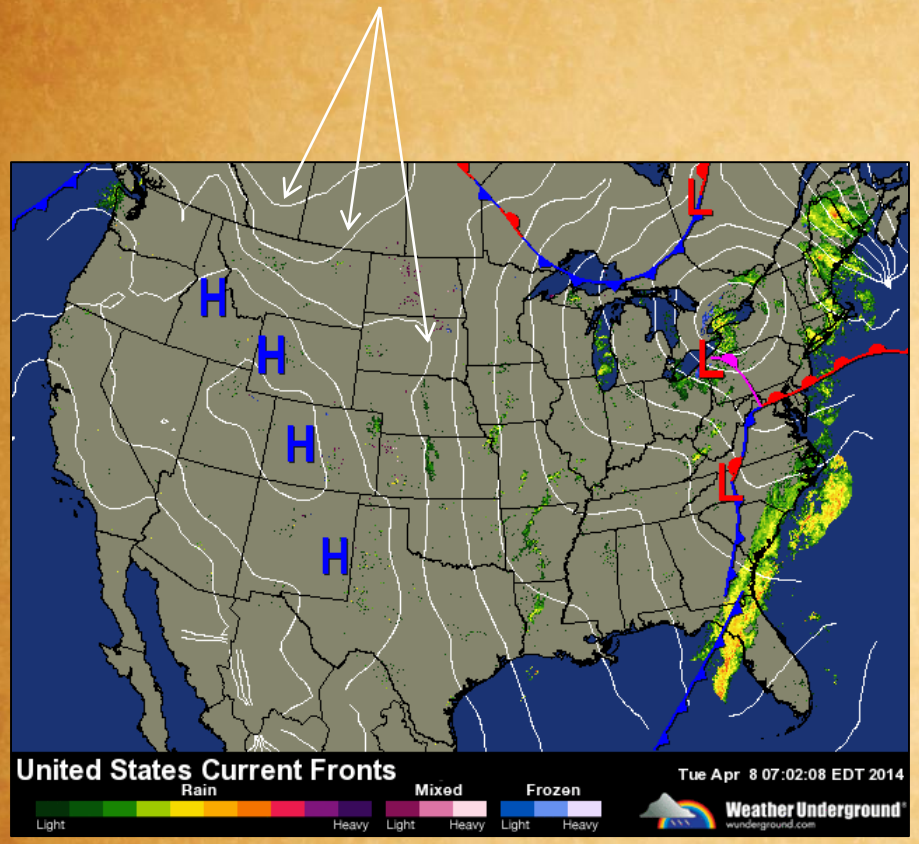
- **As altitude increases, pressure decreases** *(fewer air molecules pressing down)*





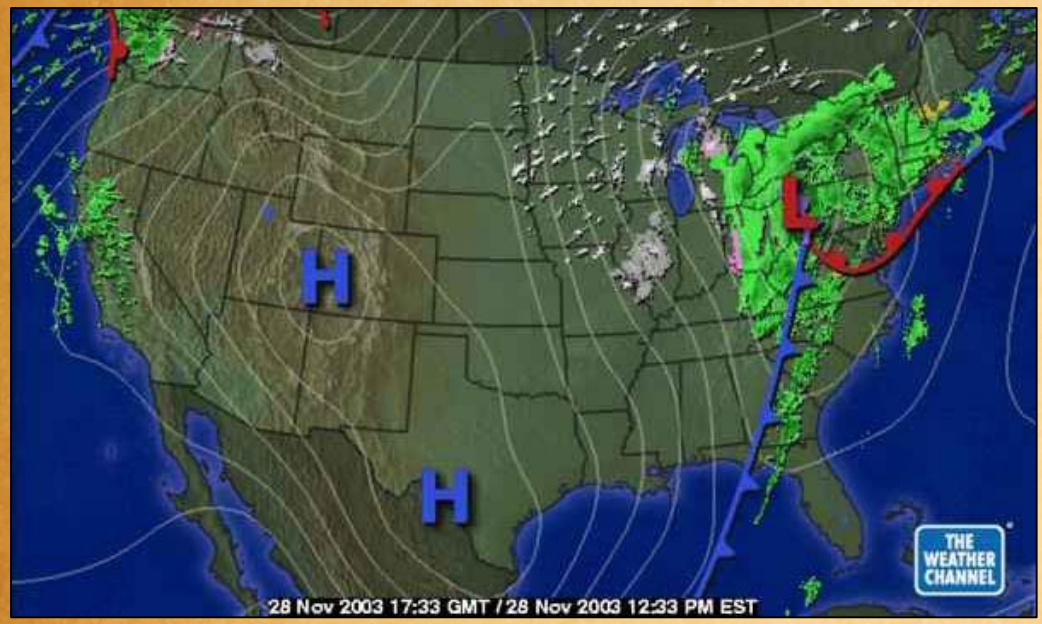
Barometric Pressure in Forecasting

- *Air pressure is the best predictor in the general forecasting of weather*
- *In basic forecasting, you can make some assumptions in your predictions using only barometric pressure*

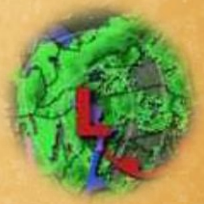


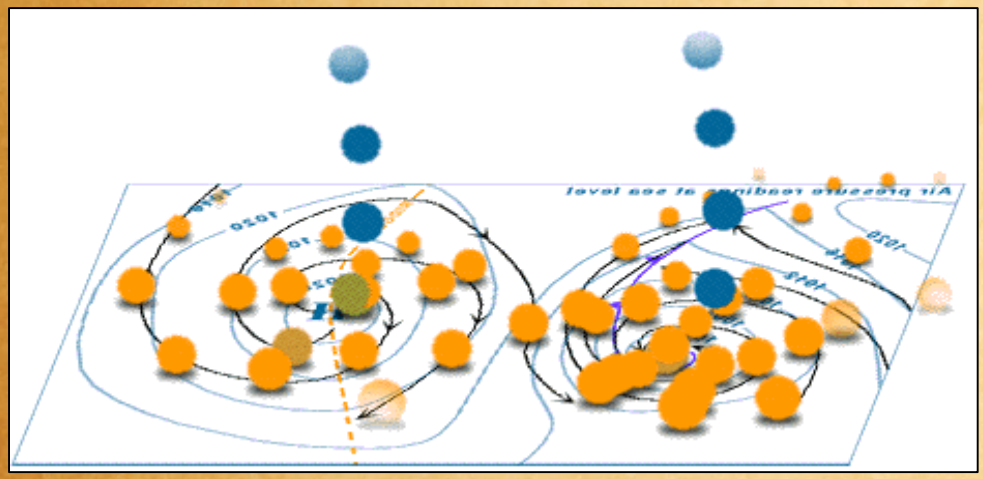
Familiarizing Yourself With Isobars

- *Recall that isolines isolate different measurements*
- *Iso***bars** *are isolines isolating different* **barometric pressures**
- *Drawing isobar rules are the same (if true, go through)*



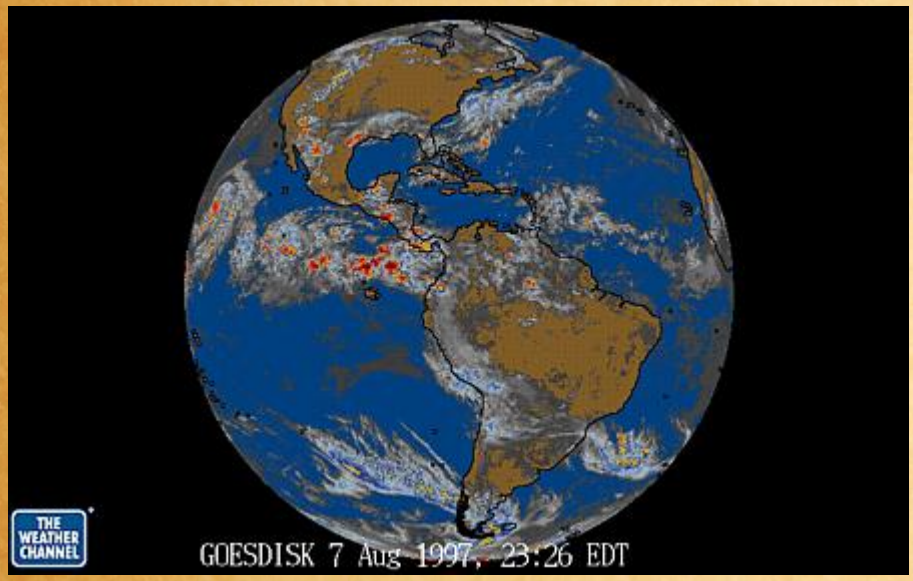
Meteorologists term pressure centers **high or low** *depending on the barometric pressure values associated with that particular system (above 1 atm = high pressure, below 1 atm = low pressure).*





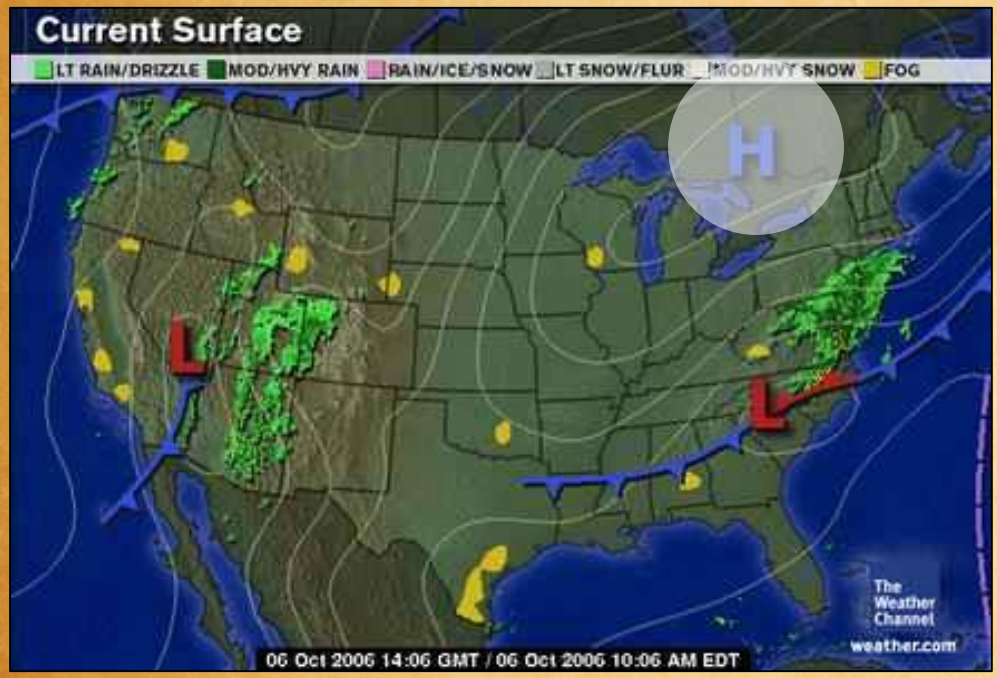
Rotation of Pressure Centers

- *Winds flow:*
  - **Into a Low pressure center**
  - **Out of a High pressure center**
  - **Low pressure rotates counterclockwise**
  - **High pressure rotates clockwise**



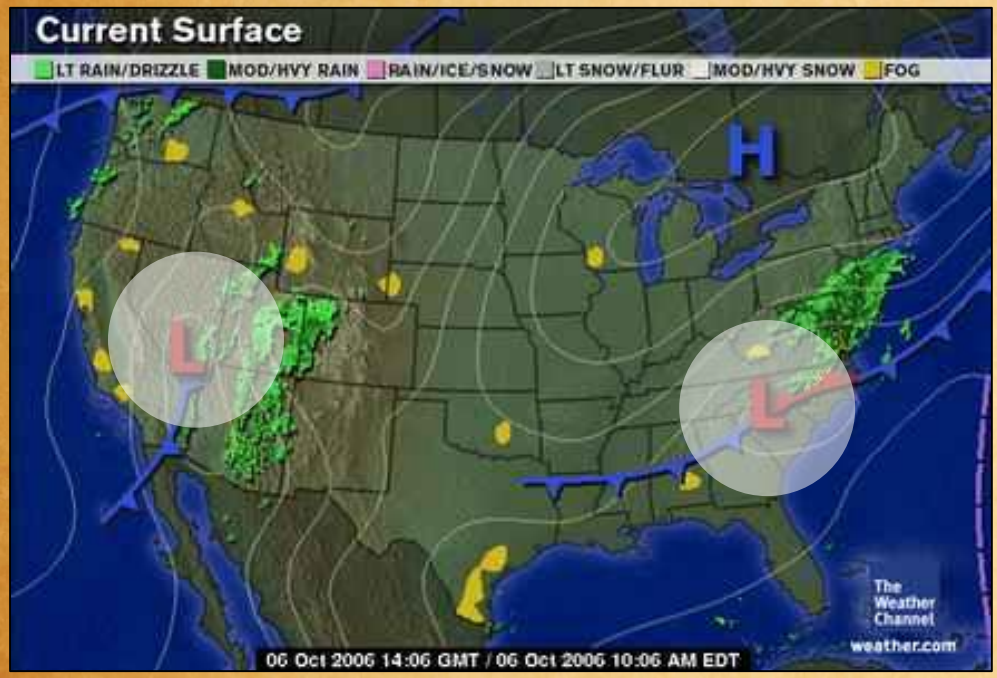
Cause of Rotation

- **Coriolis effect**



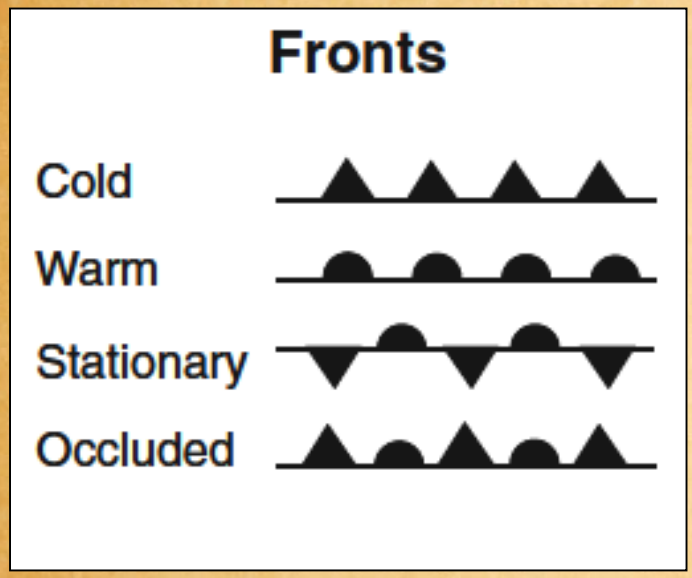
High Pressure Centers (Anticyclones)

- *Associated with* **fair, dry weather**
- *High pressure systems* **lack moisture** *making the* **air more dense, slightly cooler** *at times*
- *Remember:* **High, dry, clear sky**

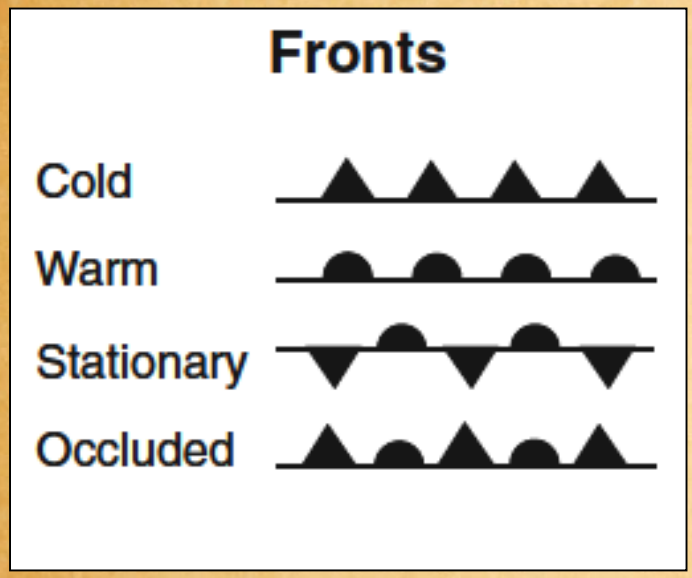


Low Pressure Centers (Cyclones)

- *Changes in temperature, may initially be slightly* **warmer**
- **Moist, less dense air, cloudy, precipitation likely**

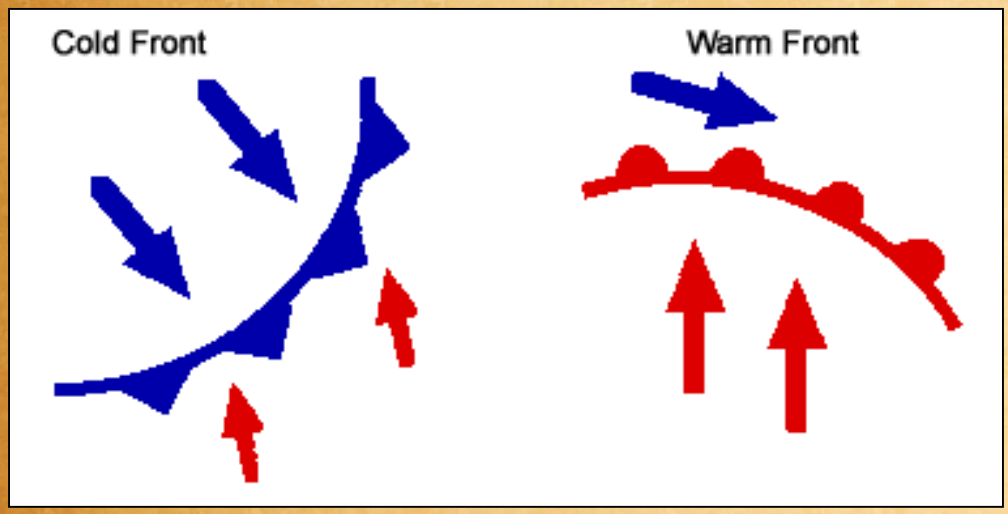


Low pressure centers contain fronts that show the advancing change in air characteristics. Of these the most important are cold and warm fronts.



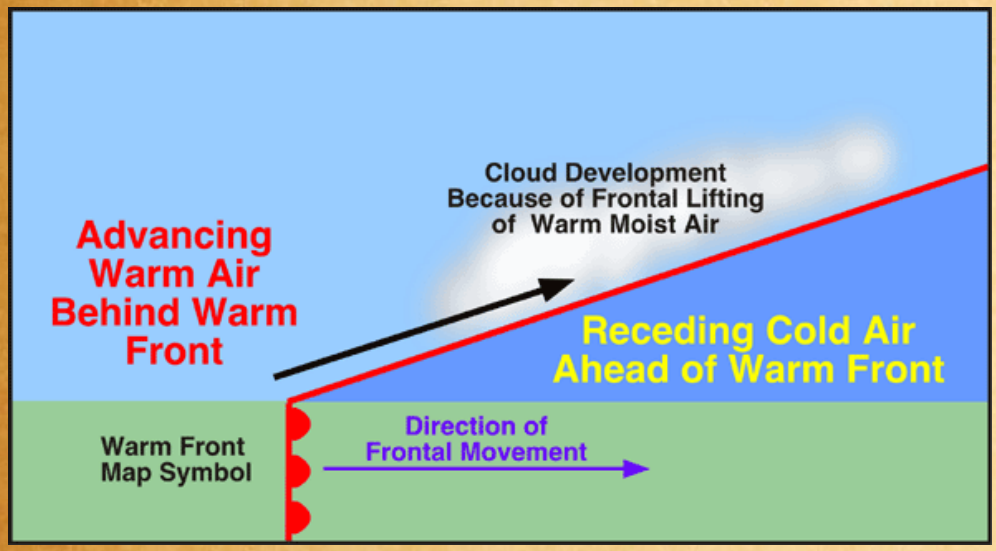
Fronts are defined by the characteristics of the air that follows them.

- **Cold: Cooler air follows**
- **Warm: Warmer air follows**
- **Stationary: Boundary between opposing cold and warm fronts**
- **Occluded: More rapidly moving cold front overtakes the warm front**



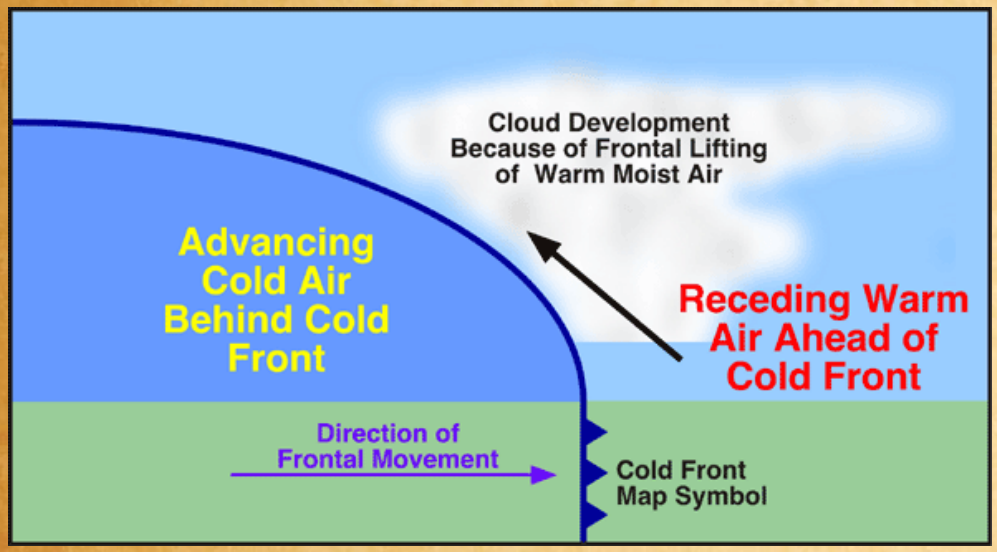
The Most Important Fronts:

- **Warm**
- **Cold**



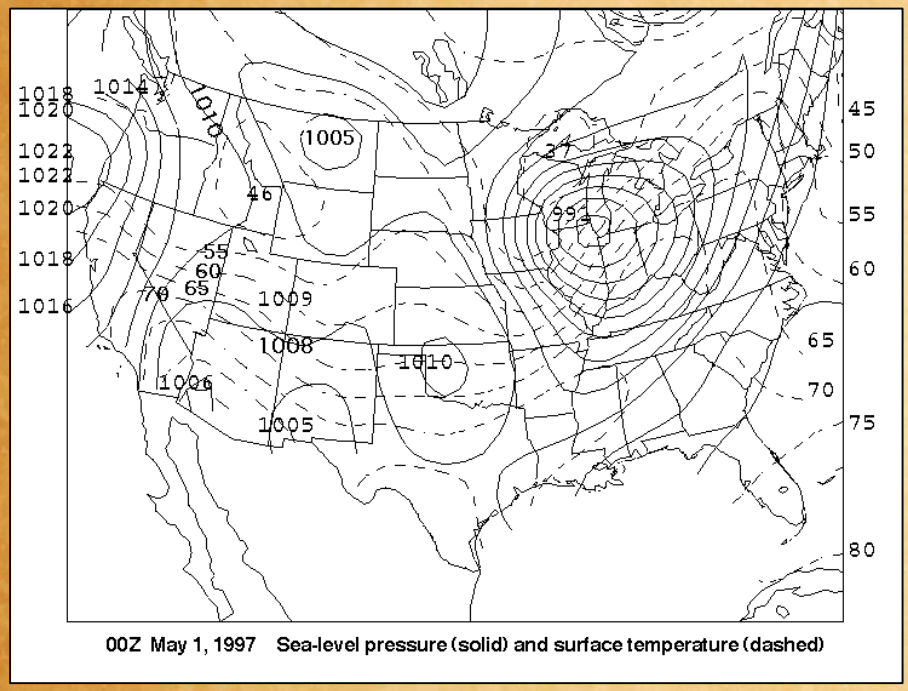
Warm Fronts

- *Frontal boundary followed by* **warm air**
- *Cloud formation and possible light precipitation on the leading edge*



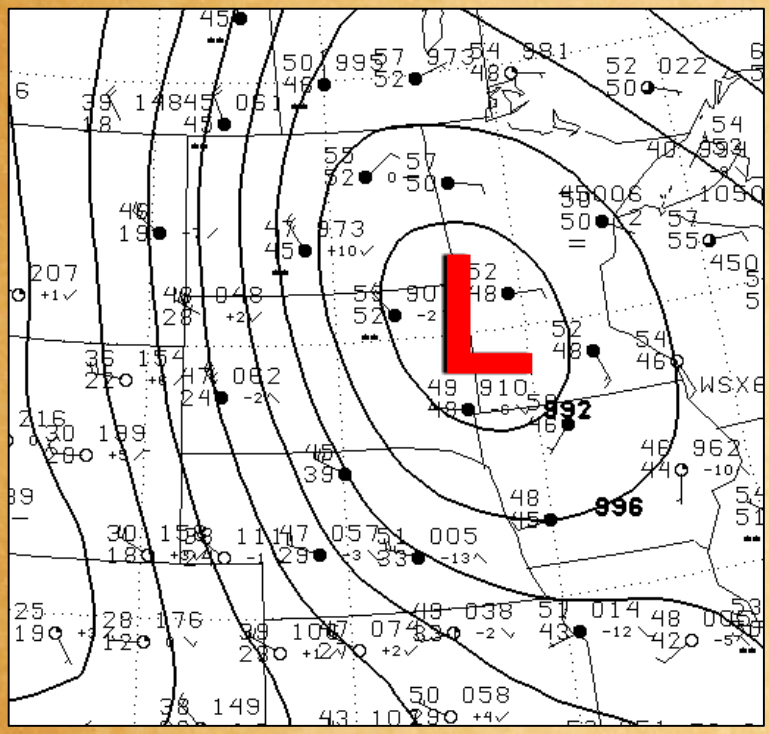
Cold Fronts

- *Leading edge of the cold front brings more* **violent storms** *from rapid rising of air above the approaching* **cool air**



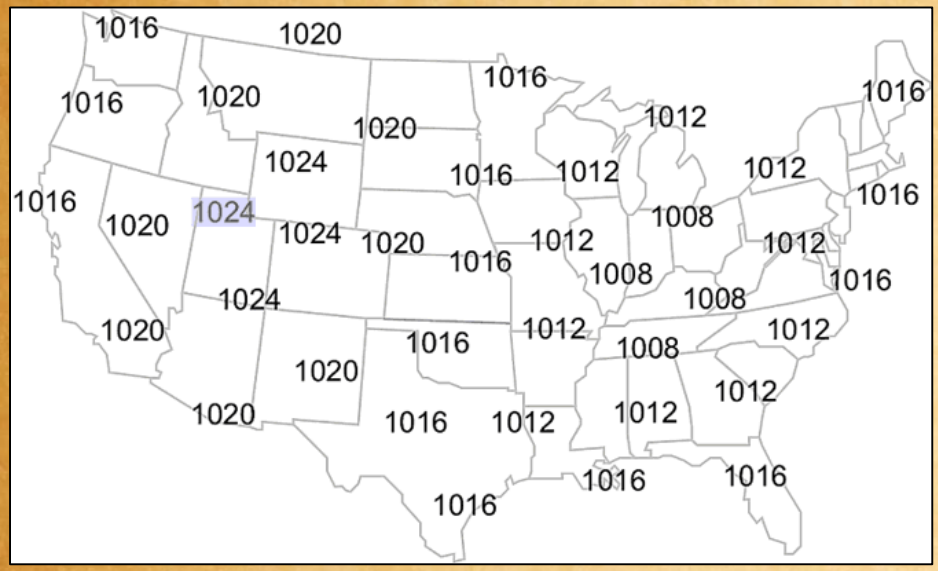
How are areas of Low and High Pressure modeled?

- **Isobar** *maps are created*



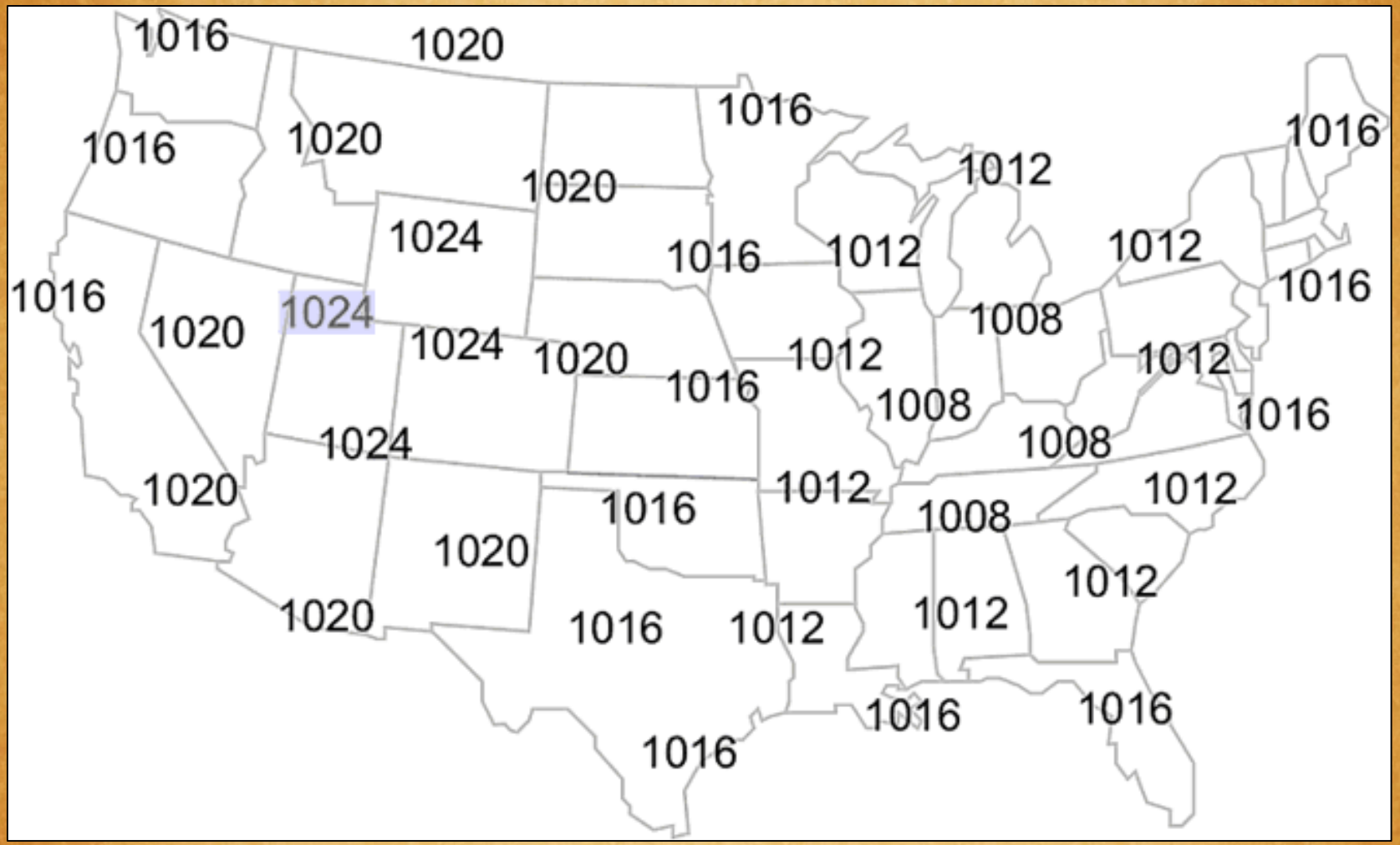
What is an isobar?

- **Isobars isolate pressures that are alike**
- *All values connected by the isobar line will be EXACTLY the same*



Drawing Isobars

- *Isolines rules apply "If true, go through"*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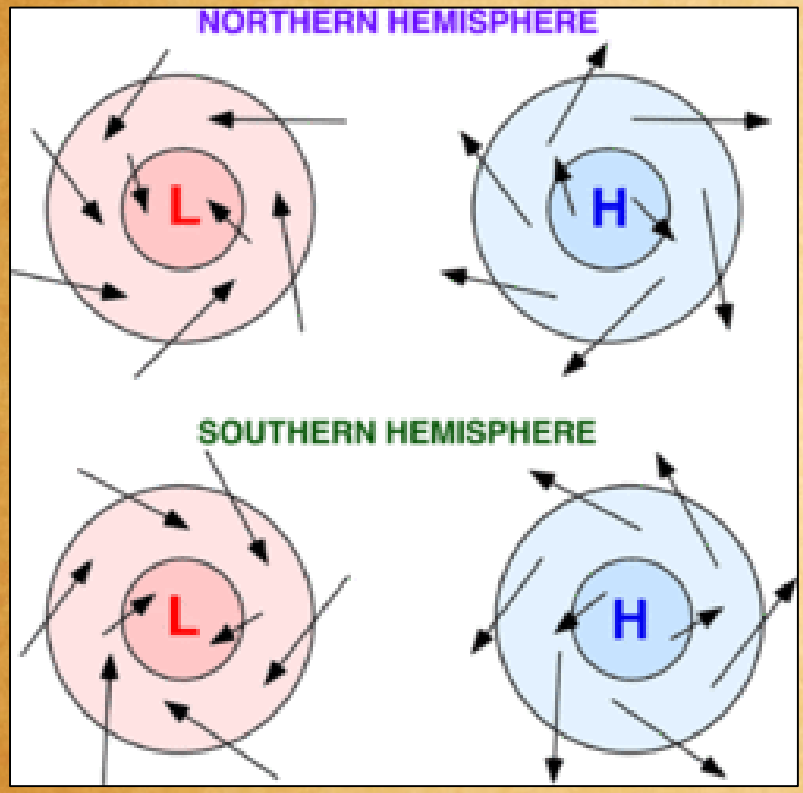
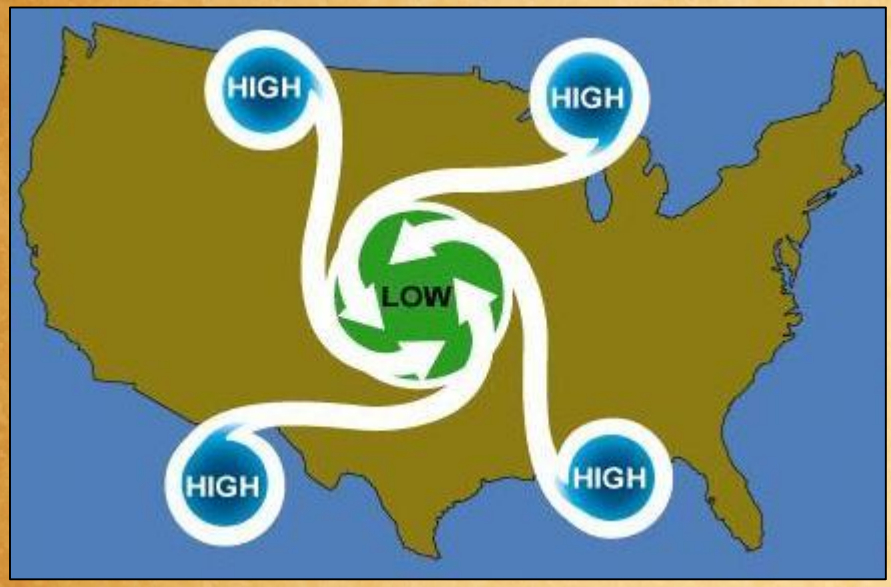


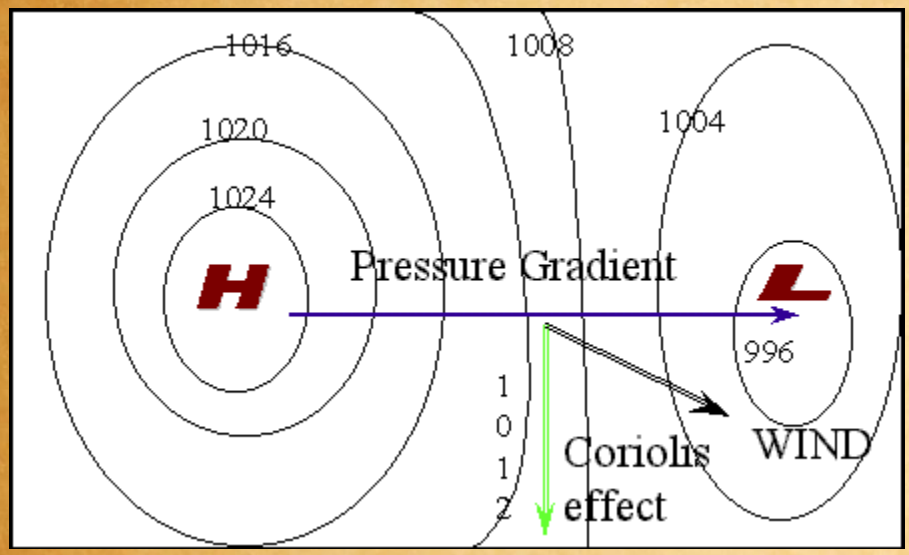
What is the connection between wind and air pressure?

- *Winds circulate in the directions on this diagram*



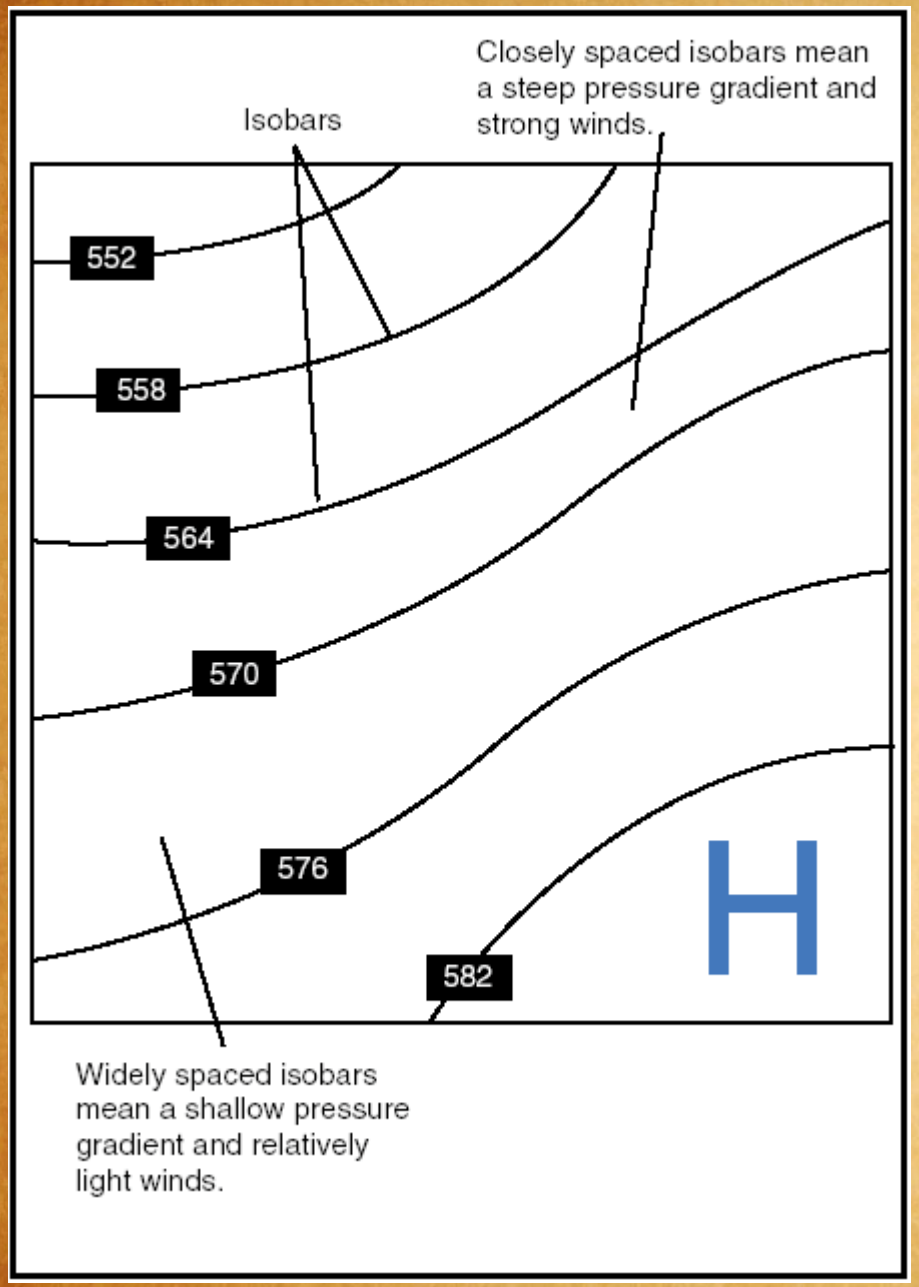
Wind and Air Pressure

- *Winds also flow* **from a High** *pressure system* **into a Low** *pressure system*



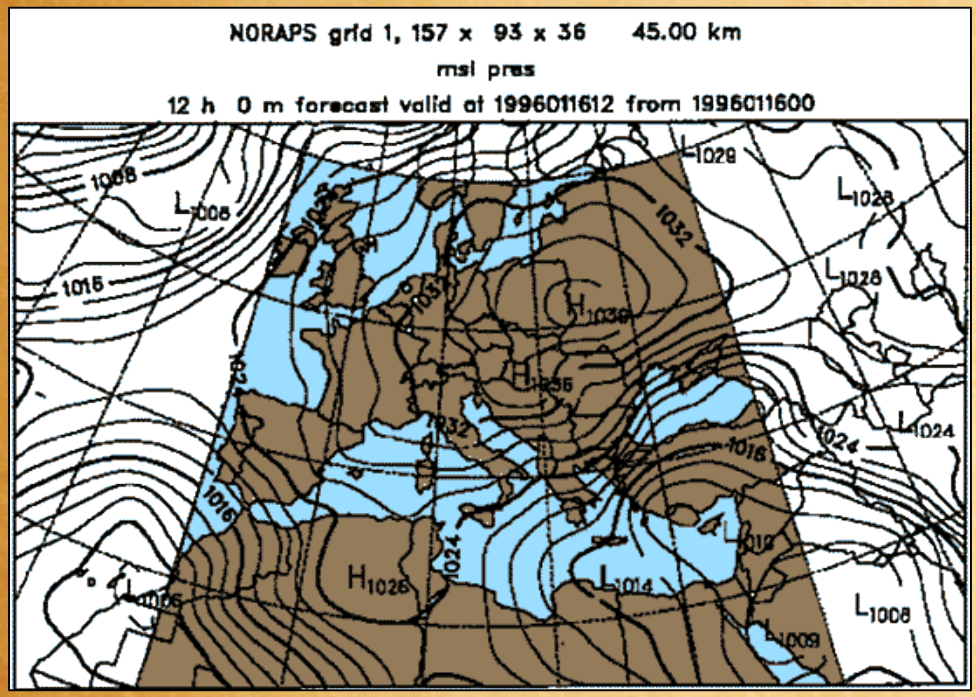
What affects wind speed?

- *The pressure gradient in a weather system*



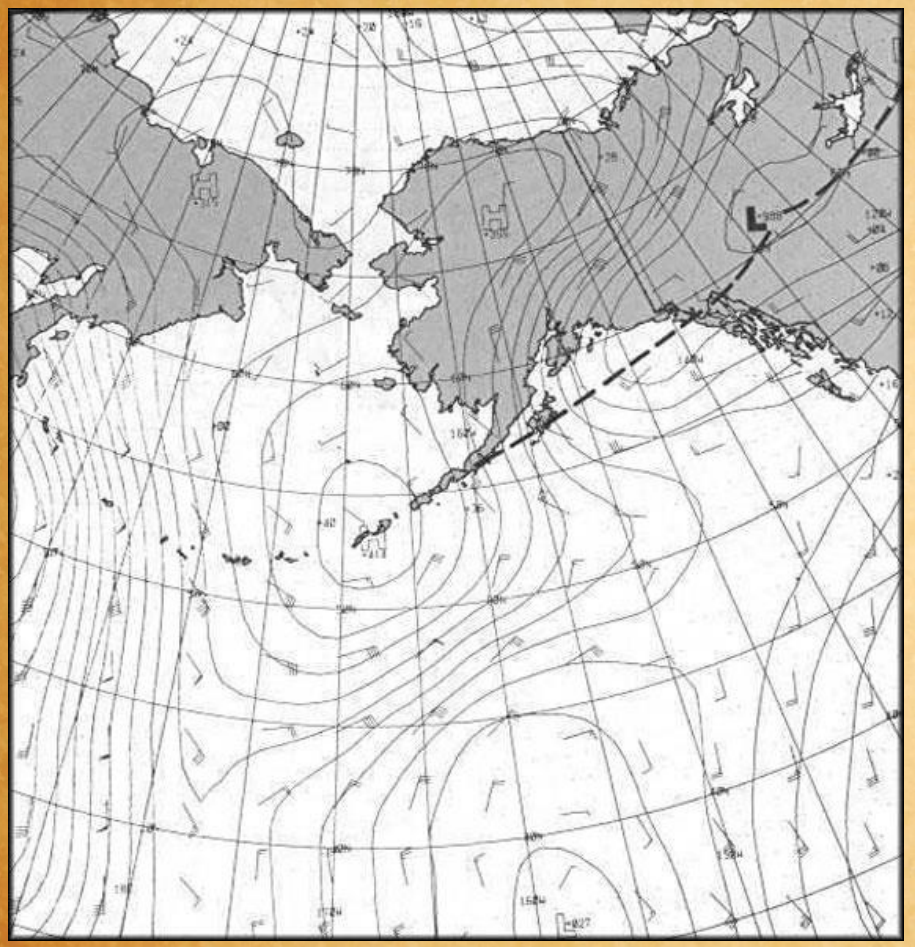
What is a pressure gradient?

- *Recall that the gradient formula and concept applies to many different topics and describes* **how quickly a measurement changes over a distance**
- *A pressure gradient describes how quickly* **pressure changes over a distance**



Pressure Gradient

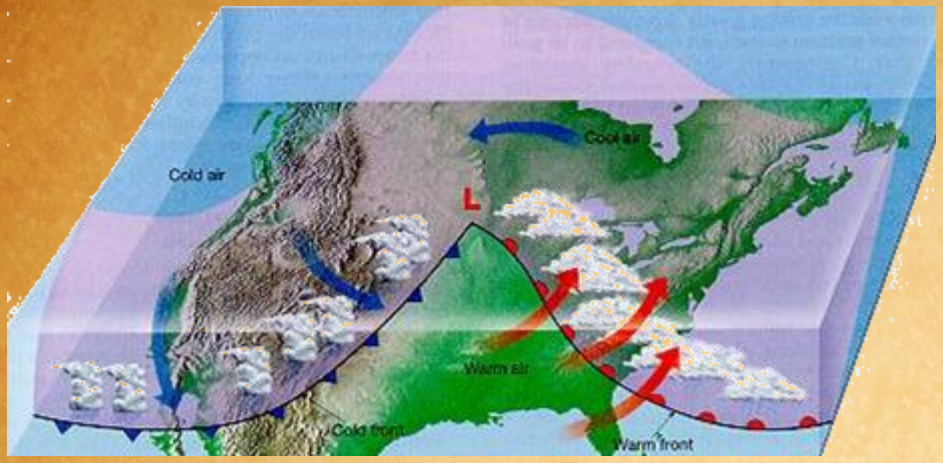
- *Widely spaced isobars mean that winds are relatively weak, while* **close isobars indicate high winds**

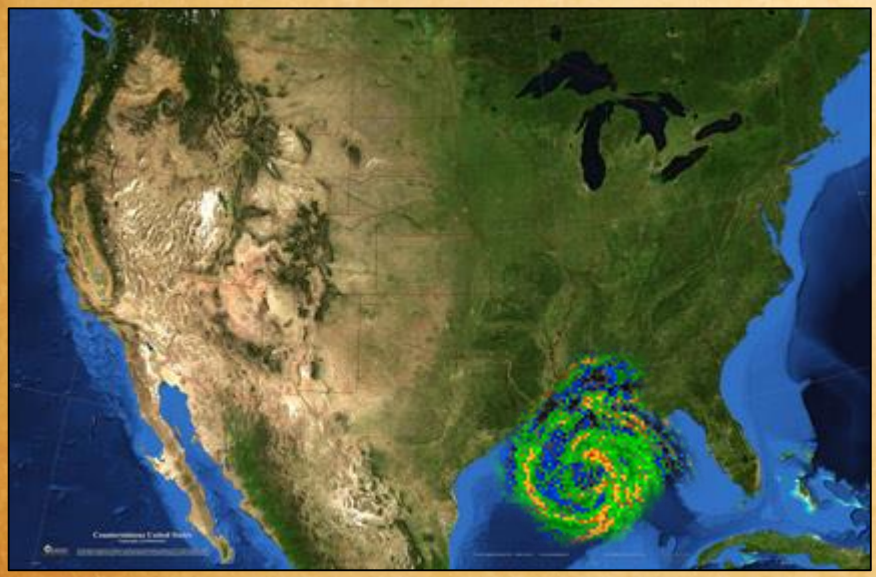


Identify locations with high winds on this map

Instruments Used to Measure Wind

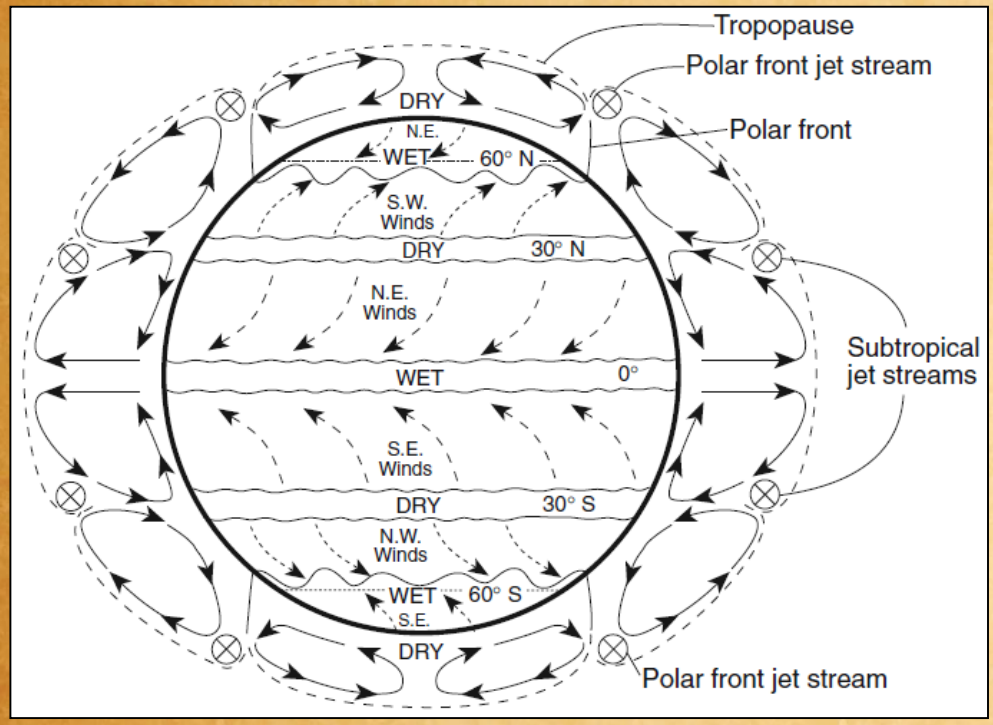
- **Anemometer (speed)**
- **Wind vane (direction)**





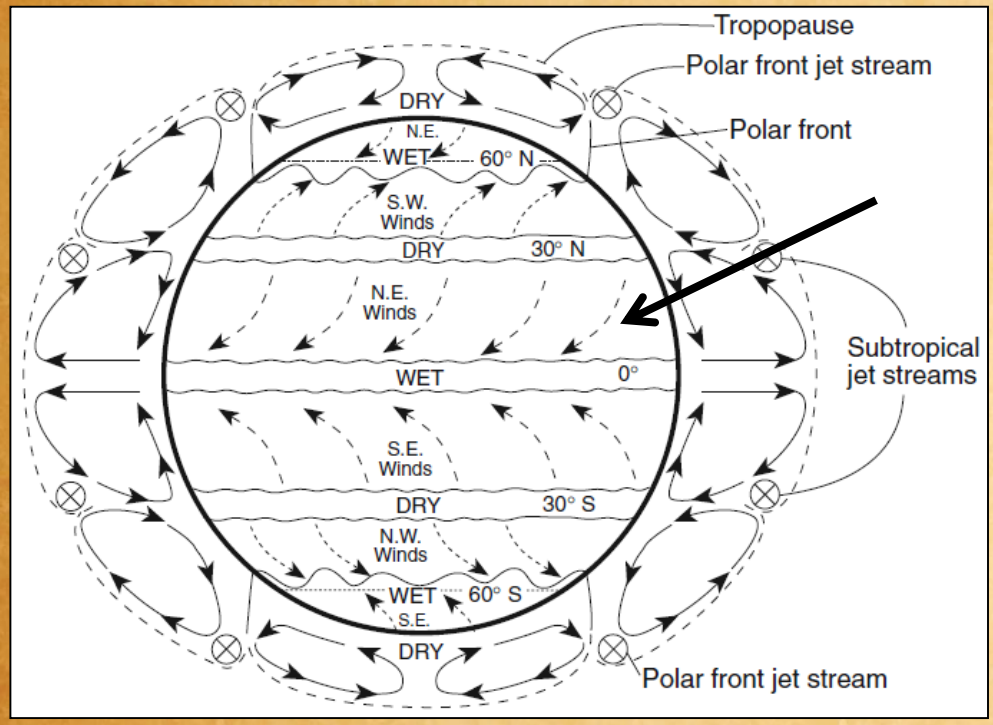
Primary Cause of Wind

- **Uneven heating of the Earth's surface** *causes some air to rise when it is heated while other air cools and sinks (convection)*
- *The* **Coriolis Effect** *causes the East to West, cyclonic and anti-cyclonic motion of wind*



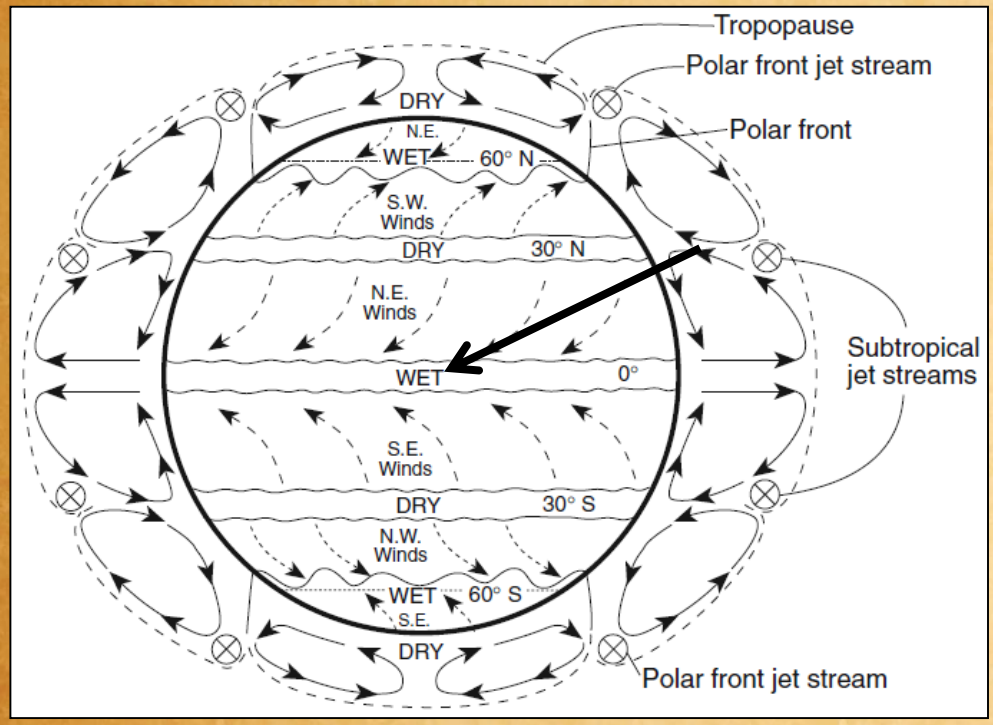
Planetary Winds

- *Planetary winds are dependent on the Coriolis Effect as well as the angle of insolation*



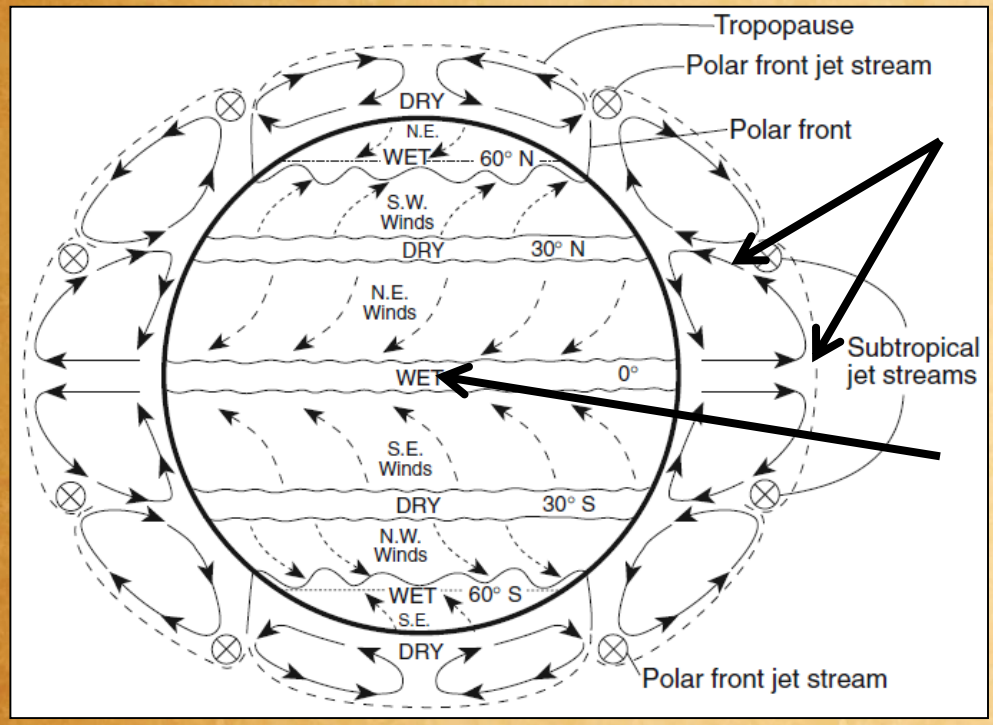
Surface Winds

- *Deflected as a result of the* **Coriolis Effect**



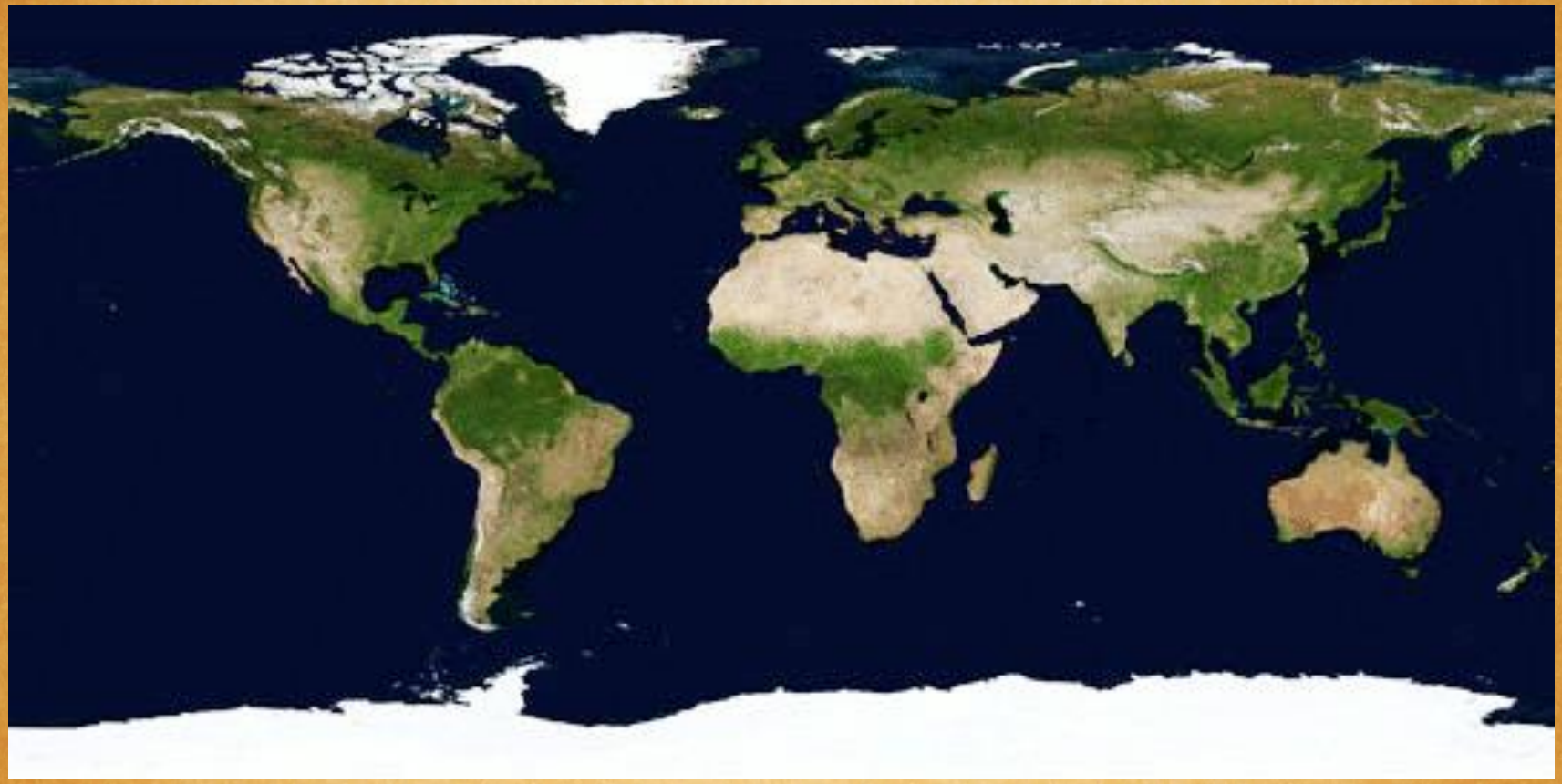
Seasonal Change

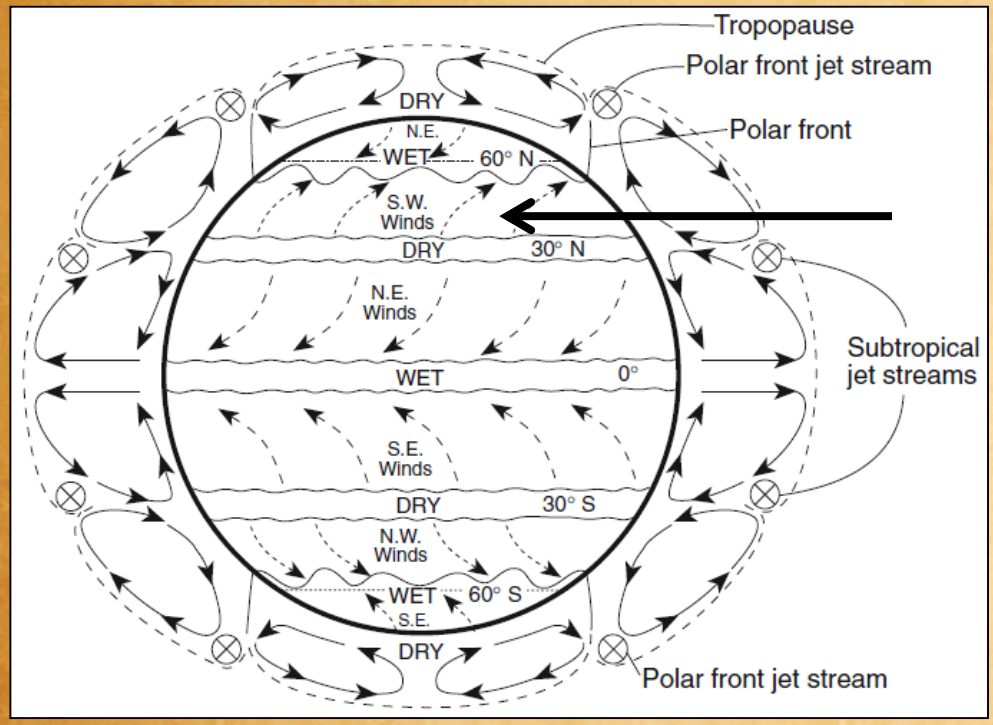
- *Whether or not air is rising and absorbing moisture depends on where the most* **intense rays from the Sun are**
- *This figure is shown at* **equinox,** *where the rays are most intense at the* **equator**



Upper Troposphere

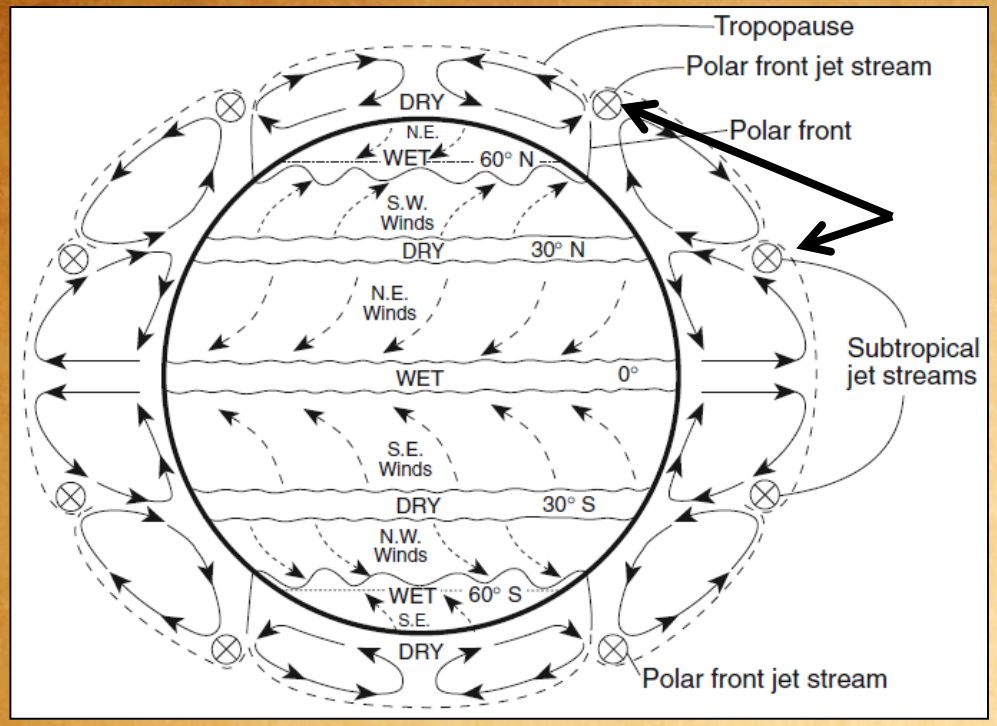
- *Warmer air will rise into the atmosphere, but then will sink farther to the North or South*
- **The moist, warm air at the equator** *is a reason for most* **rainforests** *being found there*
- **Most deserts are at 30 °N and 30 °S**

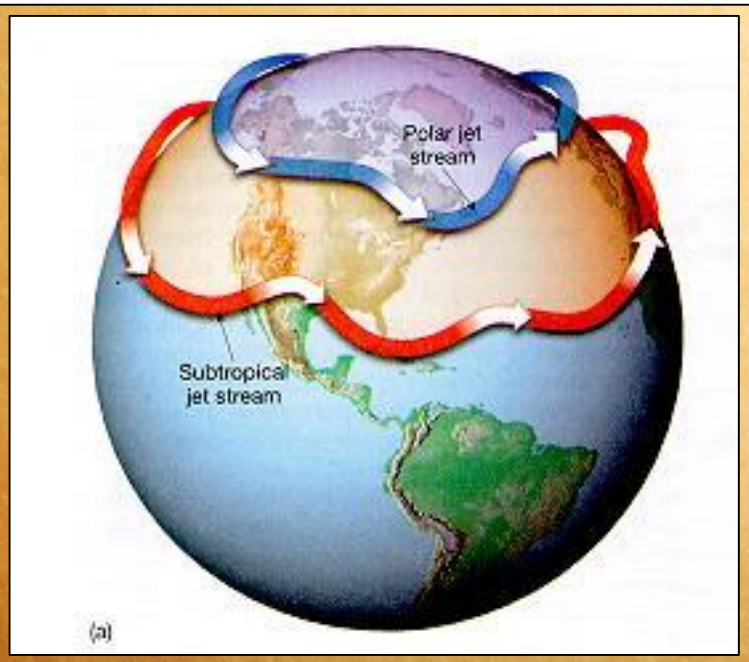




Prevailing Winds In NYS

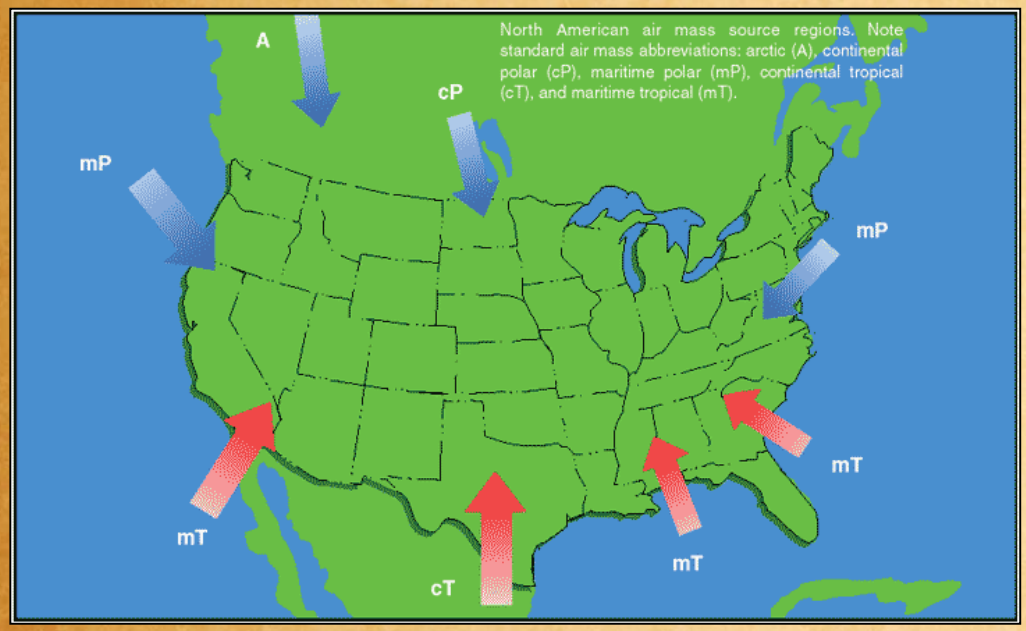
- *Most storm systems traveling to New York arrive from the* **SW**
- *Basic weather prediction point:* **look to the SW** *for our oncoming weather*





Jet Stream

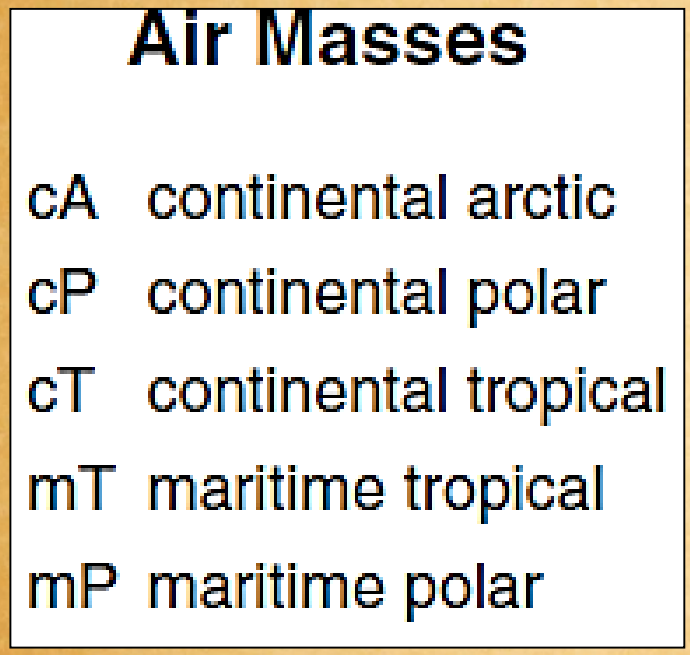
- *The Jet Stream is rapidly moving air aloft that generates* **movement of pressure centers**
- *Jet Streams vary with season based on heating of the Earth's surface; moving generally North or South*



North American air mass source regions. Note standard air mass abbreviations: arctic (A), continental polar (cP), maritime polar (mP), continental tropical (cT), and maritime tropical (mT).

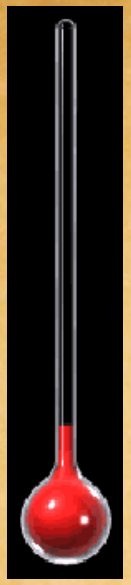
Wind Influences the Formation of Air Masses

- *Air masses are named based on their* **source region**
- *Their source region determines their* **characteristics**



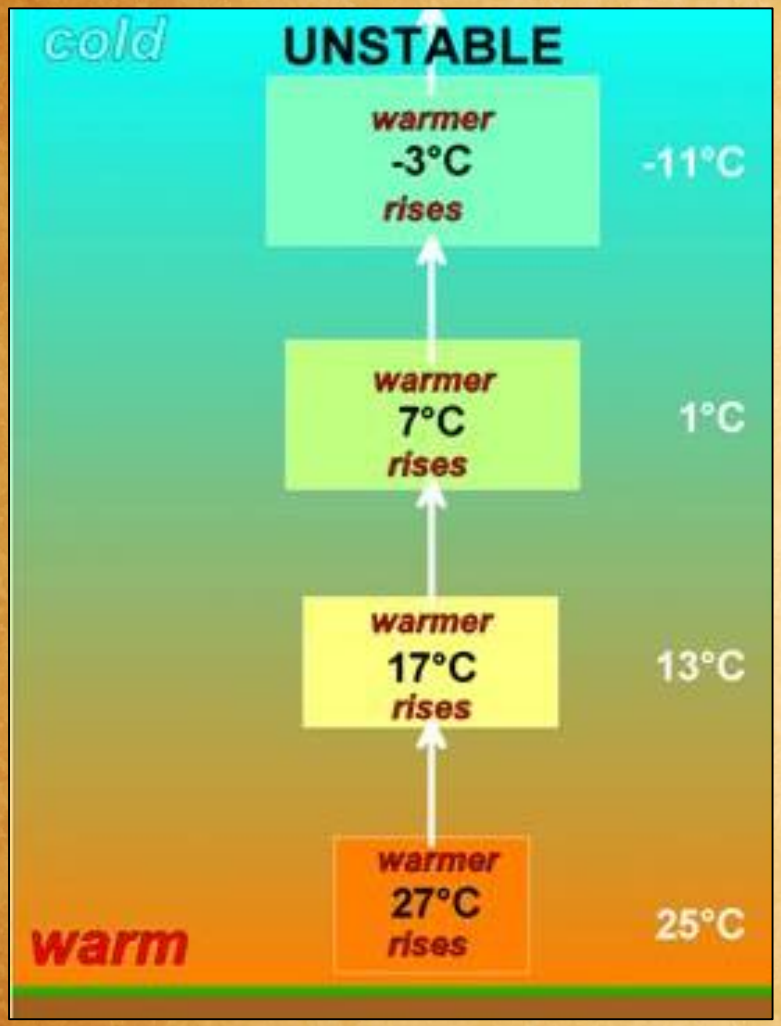
Air Masses

- **c = continental = dry**
- **m = maritime = wet**
- **A = arctic = very cold**
- **P = polar = cool**
- **T = tropical = warm**



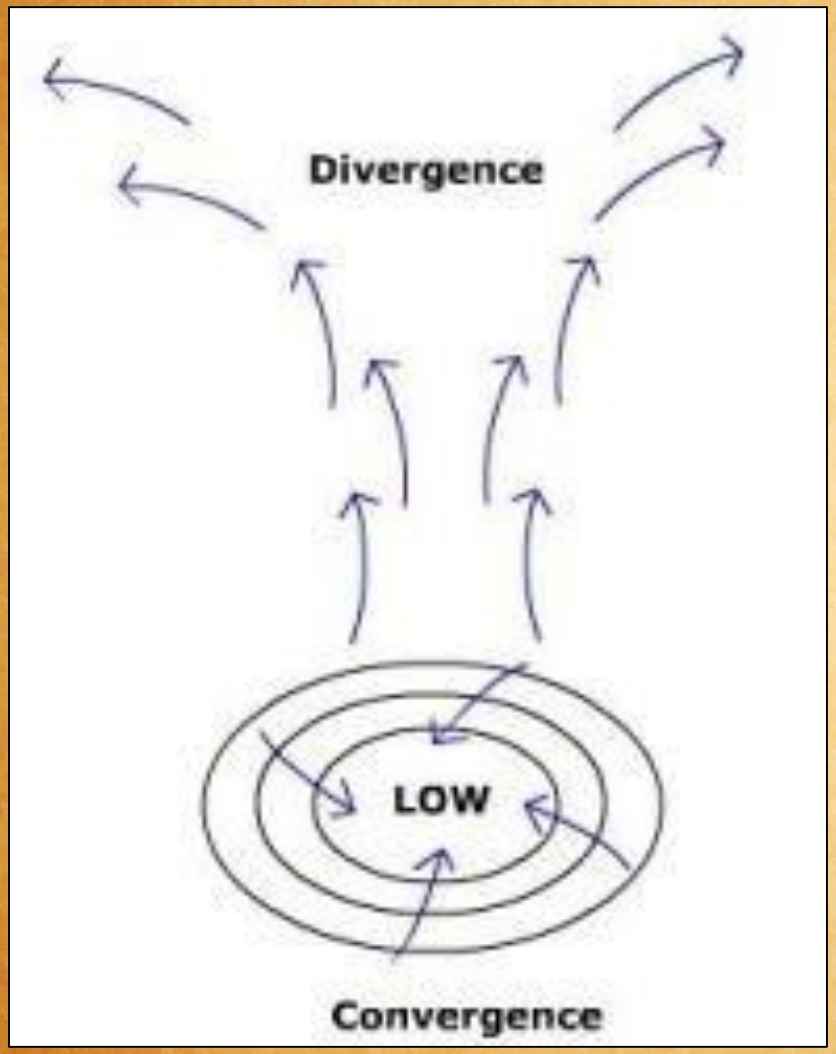
What factors impact air pressure?

- *Temperature*
- *Humidity*

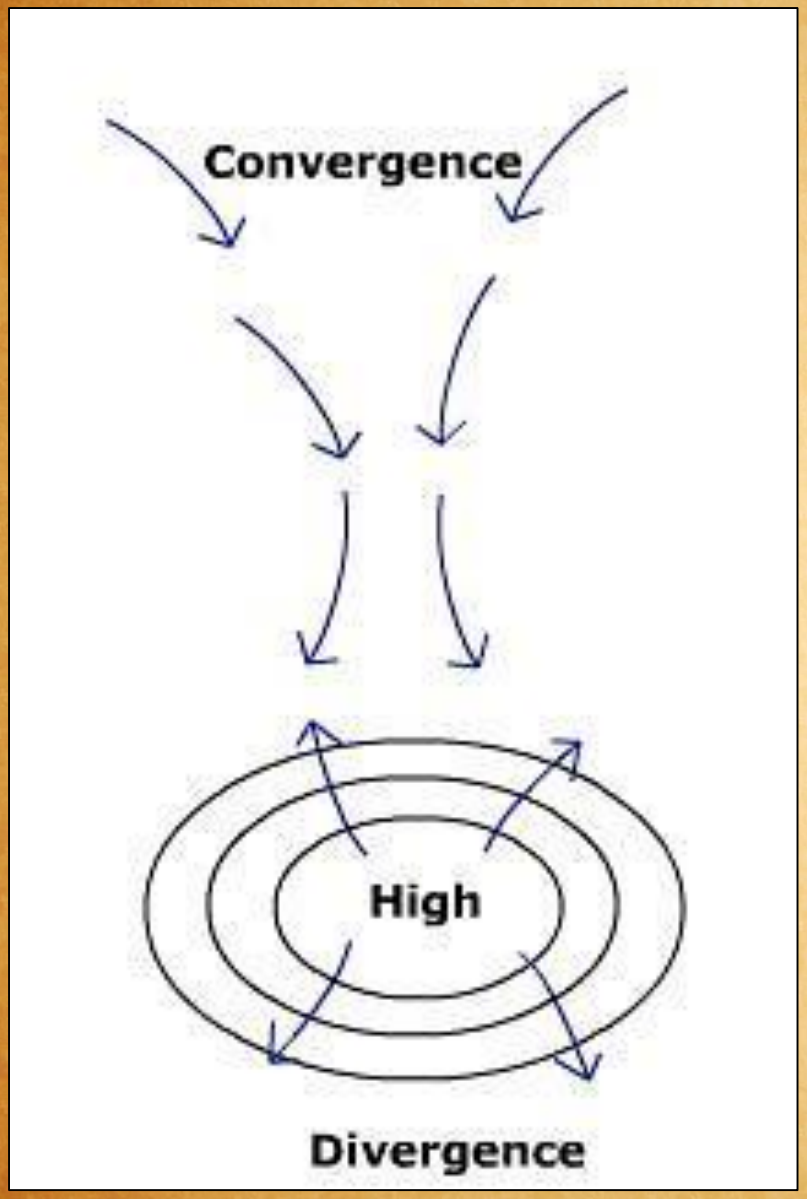


How do warmer temperatures affect air pressure?

- *Rising temperatures cause air to* **expand**
- *Expanding air becomes* **less dense and rises**
- *This air creates an area of* **low pressure**



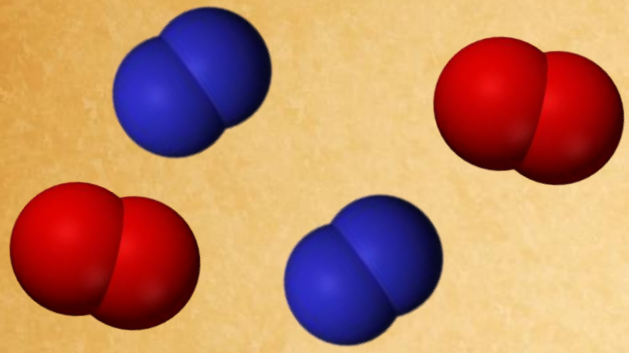
Recall that winds flow into a Low in a counterclockwise fashion, a result of the suction created by the rising warm air



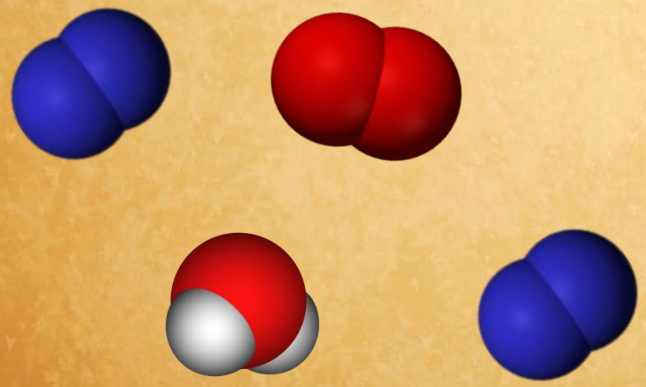
How do colder temperatures affect air pressure?

- *Cooling trends cause air to compress*
- *This compression causes the air to become more dense and sink*
- *This* **sinking air creates pressure on the surface of the Earth**

Dry Air: Mostly N_2 and O_2



Humid Air: N_2, O_2, and H_2O

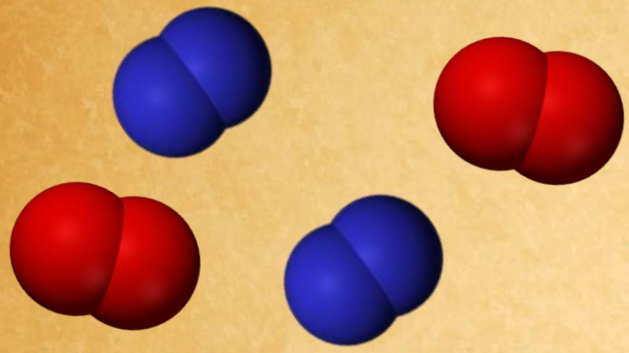


Humidity and Air Pressure

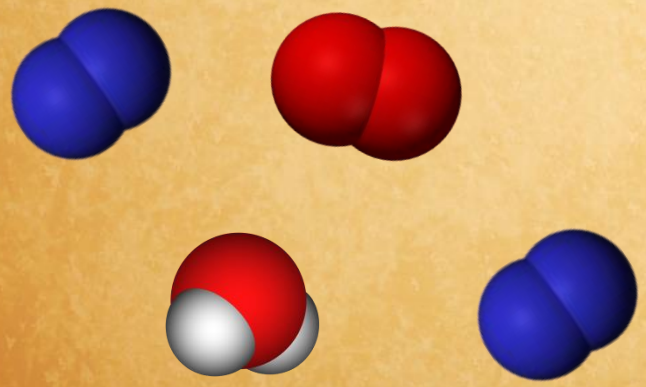
The space in the lower atmosphere can only hold so many molecules

- *Humid air contains different quantities of gas molecules*
- **Dry Air: Mostly N_2 and O_2**
- **Humid Air: N_2, O_2, and H_2O**

Dry Air: Mostly N_2 and O_2



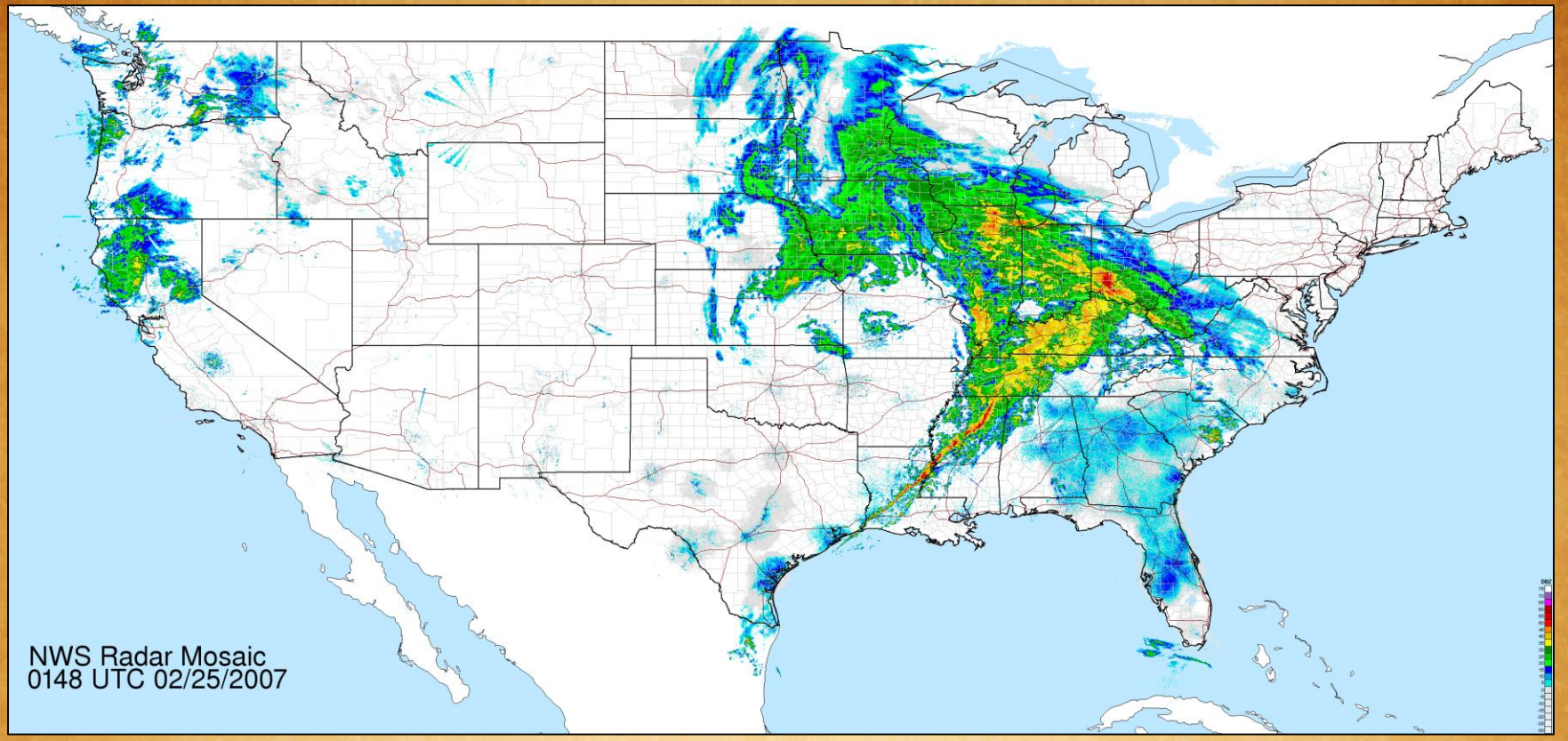
Humid Air: N2, O2, and H_2O



Masses of Molecules

N_2 = 28 g/mol
O_2 = 32 g/mol
H_2O = 18 g/mol

- *When water is present in the atmosphere, its mass is lower*
- *This lower mass results in* **lower pressure**



Humid air is associated with Low Pressure

Dry air is associated with High Pressure

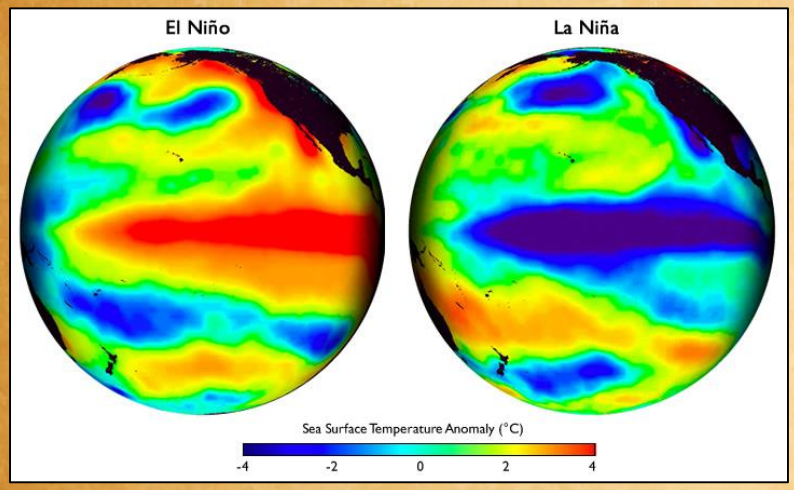
Label the pressure centers based on humidity on the map

Hurricanes and Tornadoes

- *Very destructive; hurricanes more widespread damage (in the Fall) after forming over the Atlantic Ocean, tornadoes isolated and intense (mostly late Spring and Summer)*

- **Seek shelter in strong parts of your home (closets, near plumbing like a bathtub, basement)**

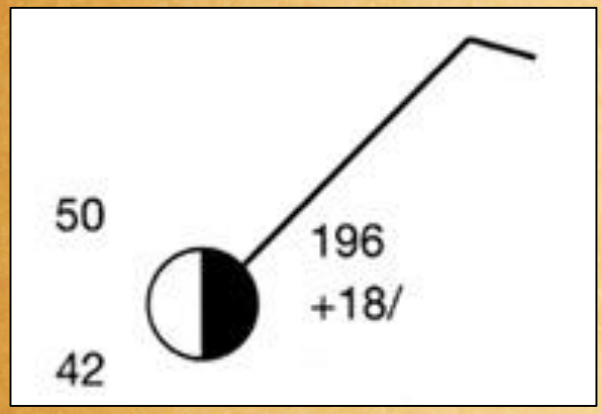
- **Prepare for loss of electricity and lack of potable water**



El Nino and La Nina

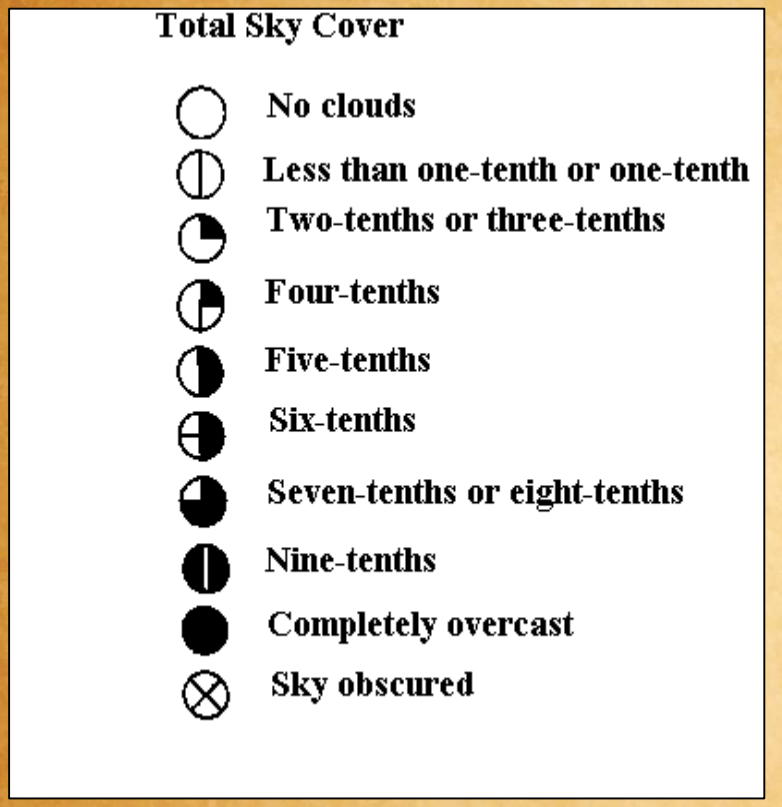
- *During years where an El Nino event occurs, the atmosphere and ocean water in the middle of the Pacific Ocean warms*
- *La Nina events result in cooler water and air temperature in the same regions*

Communication is vitally important in weather prediction and preparation. Local meteorologists are able to communicate conditions in their area through weather station models.



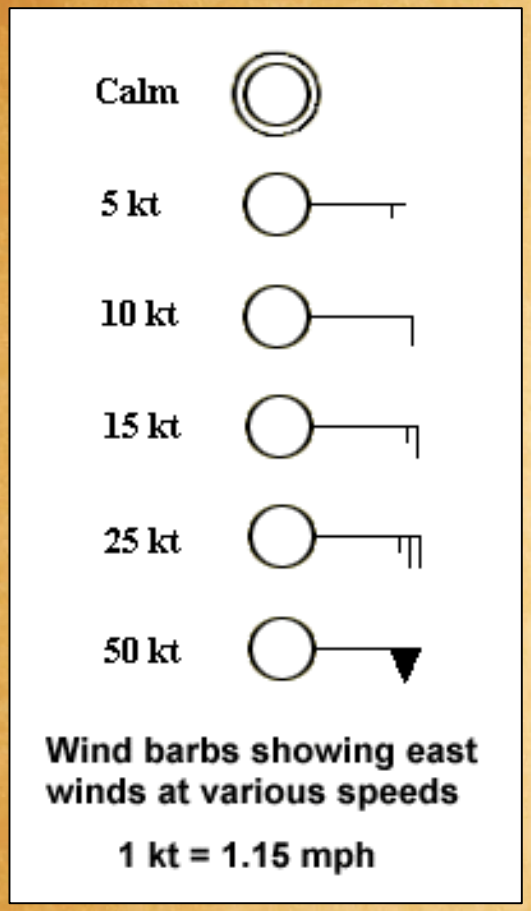
Features

- *Weather stations report a variety of information*



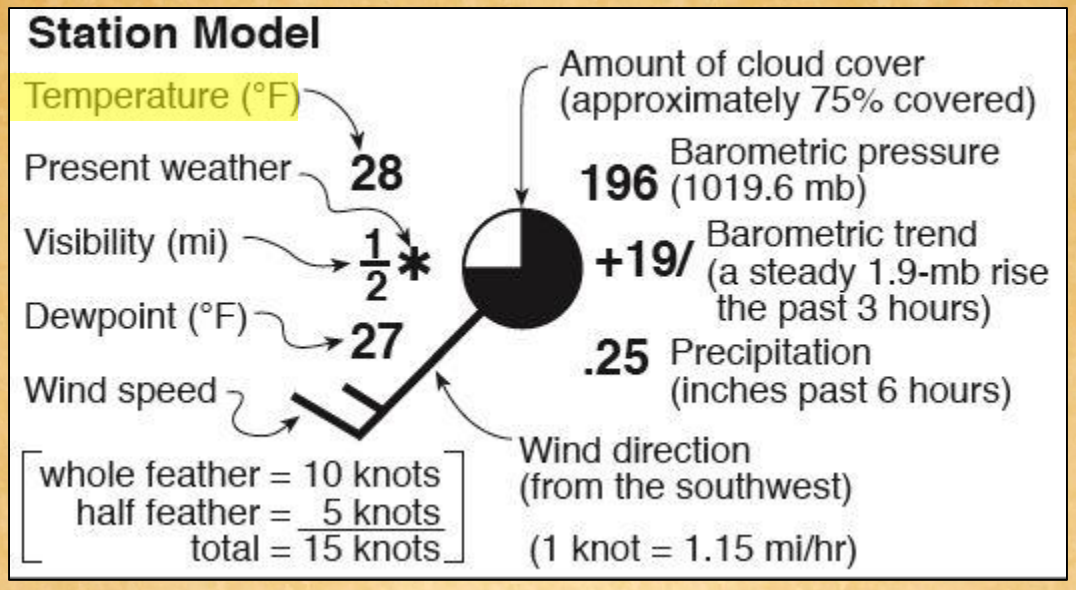
Cloud Cover

- *How much of the sky is covered by clouds?*
- **Shade that amount in the circle at the center of the model**



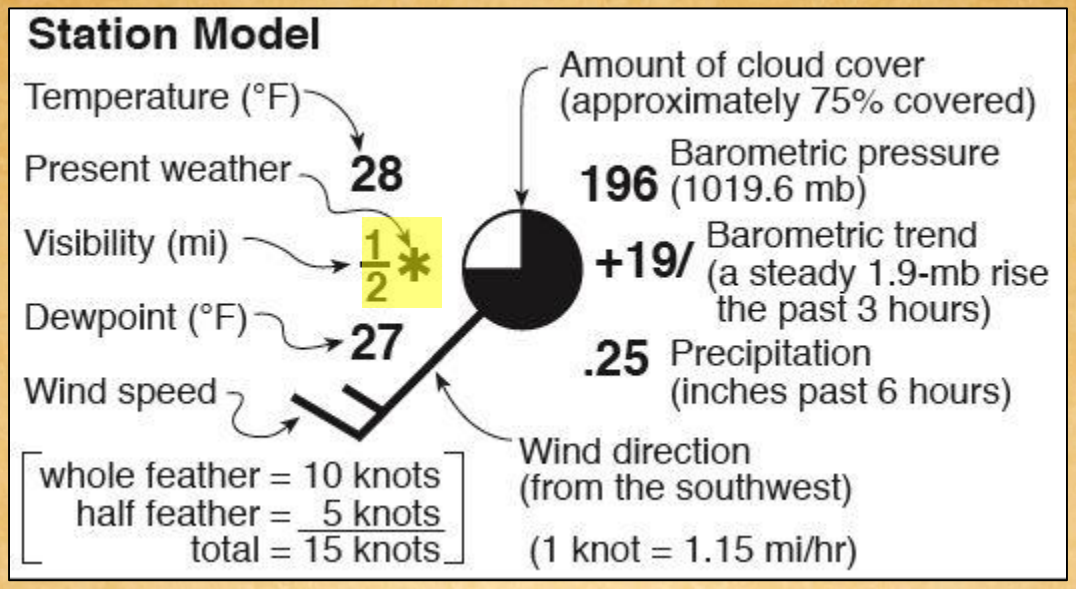
Wind Speed

- *Measured in knots*
- *Points in the direction the wind is coming from*
- *1 knot = 1.15 mi/hr*
- **Long Feather = 10 knots**
- **Short Feather = 5 knots**
- **Add feathers for total speed**



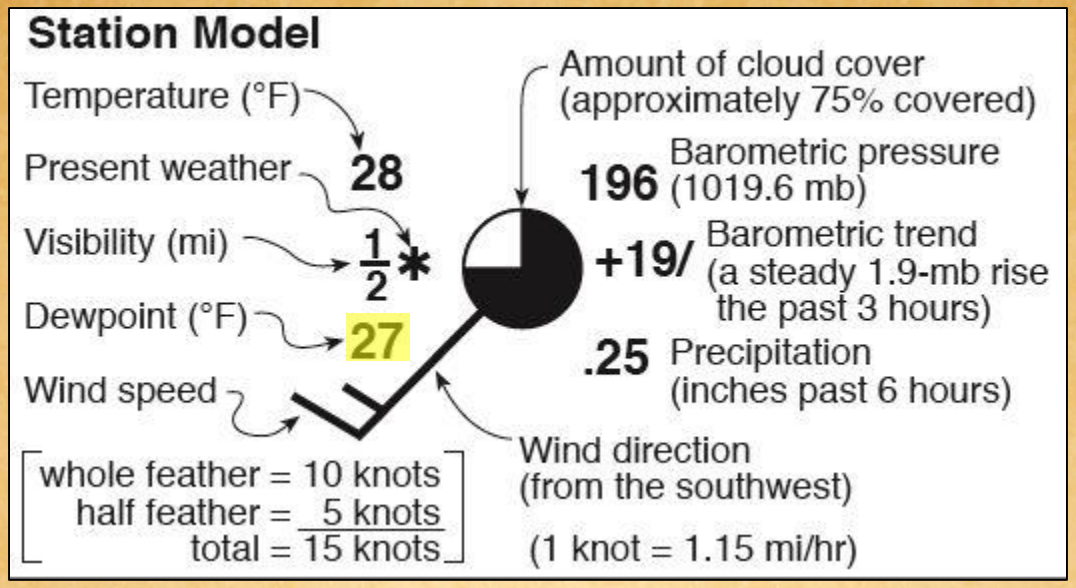
Temperature

- **In degrees Fahrenheit, no degree symbol**



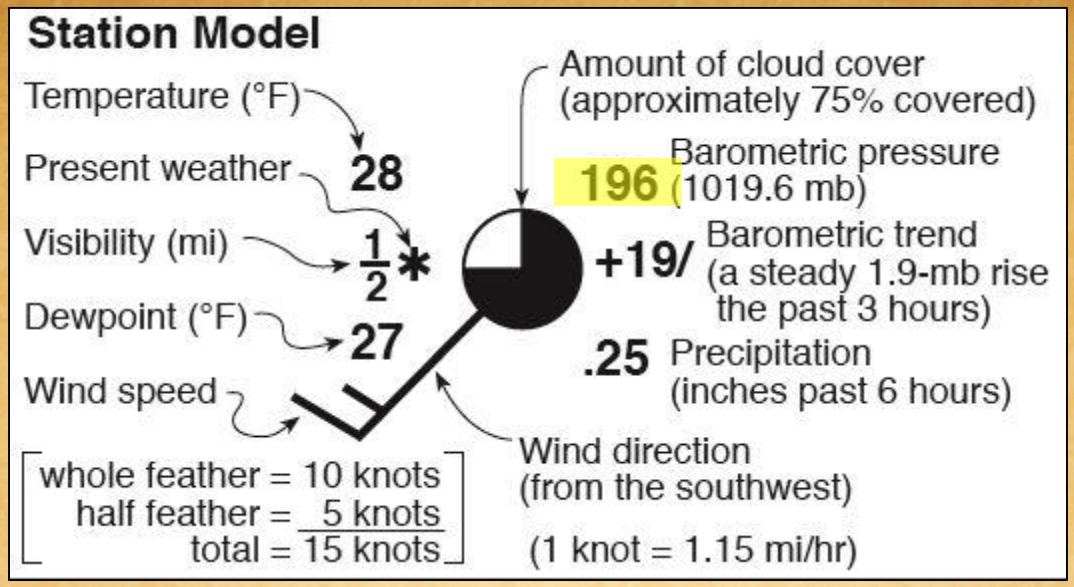
Precipitation and Visibility

- **Use your ESRT symbol bank (present weather), visibility in miles**



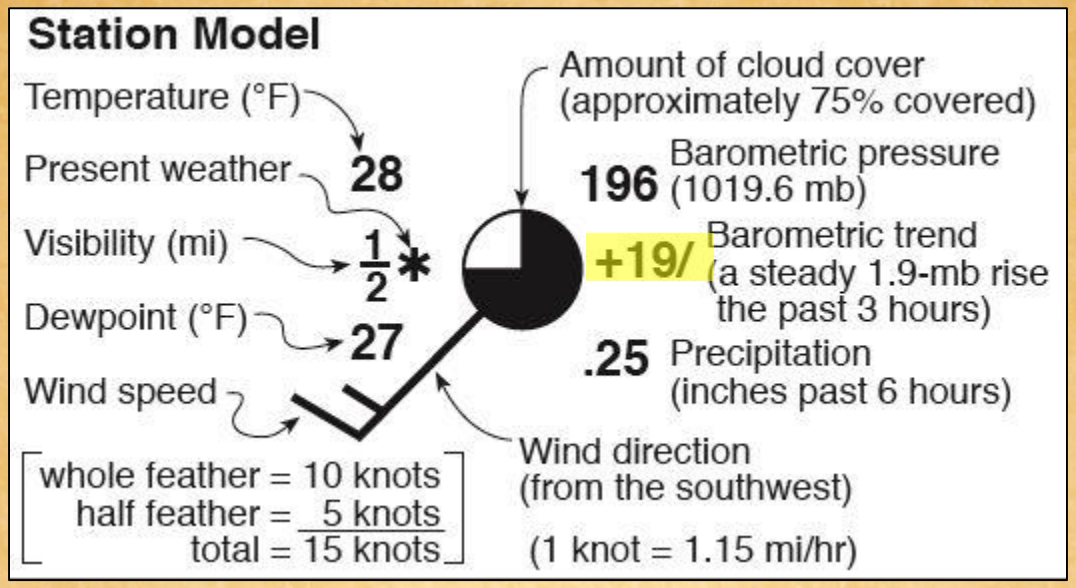
Dewpoint

- **In degrees Fahrenheit**, *temperature at which condensation will take place*
- *If this is close to the air temperature it is possible that precipitation is going to take place (high humidity)*



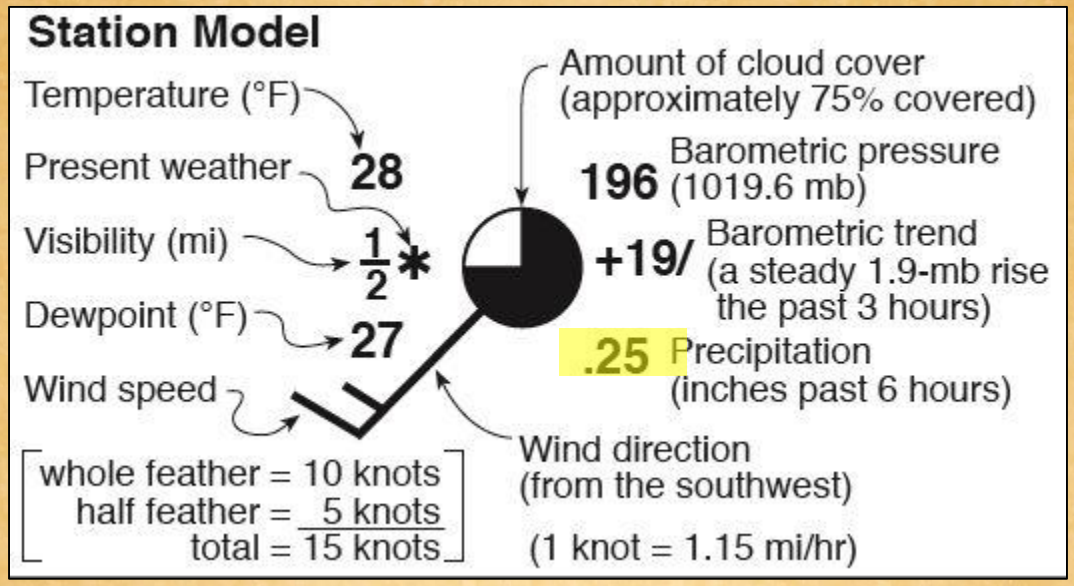
Barometric Pressure

- *You need to convert units before plotting on the weather station model*
- **If above 1000 mb, remove the preceding "10"**
- **If below 1000 subtract the first "9"**
- **No decimals on the diagram!**
- *Reading the model: if <500 add a "10" and a decimal before the last number, if >500 add a "9" and a decimal before the last number*



Barometric Pressure Trend

- *Remove decimal, add rising symbol (/) or falling (\)*



Recent Precipitation

- **In decimal form**