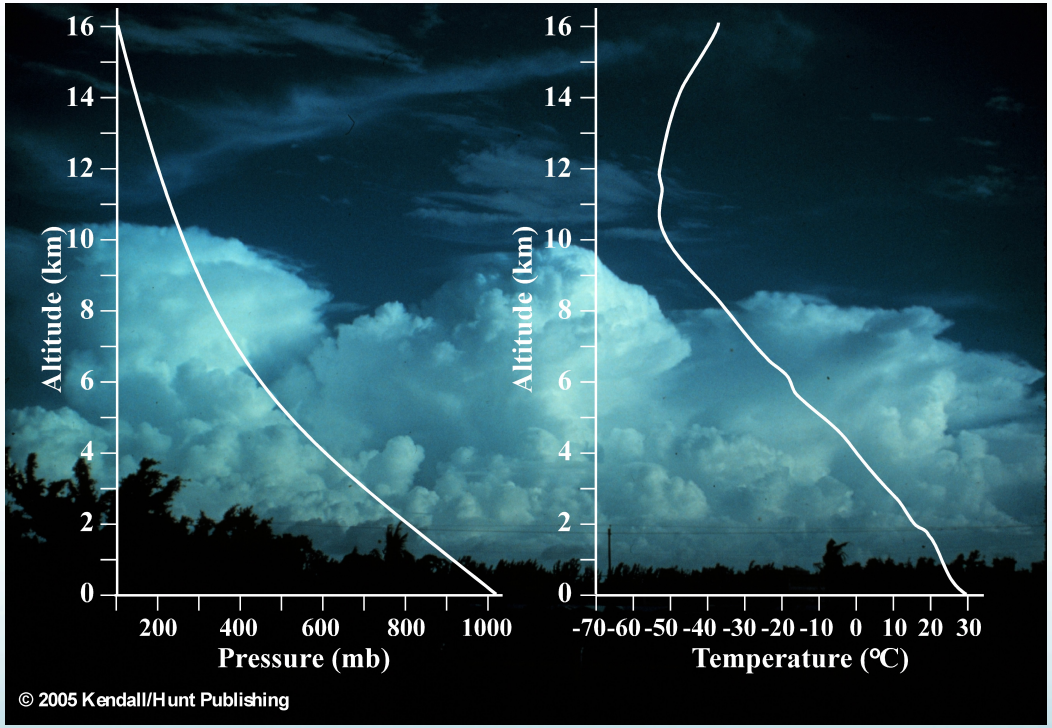
Chapter 1
Properties of the Atmosphere



Composition of the atmosphere

- What is the atmosphere?
  - Thin layer of air above the surface of the Earth
  - Atmosphere ~200km, Radius of earth 6378 km
  - Weather occurs in lowest 12 km
- What is the atmosphere made of?
  - Nitrogen 78%
  - Oxygen 21%
  - Other gases (carbon dioxide, ozone, etc) <1%
  - Water (vapor, liquid, solid)
  - Aerosols

Clicker question

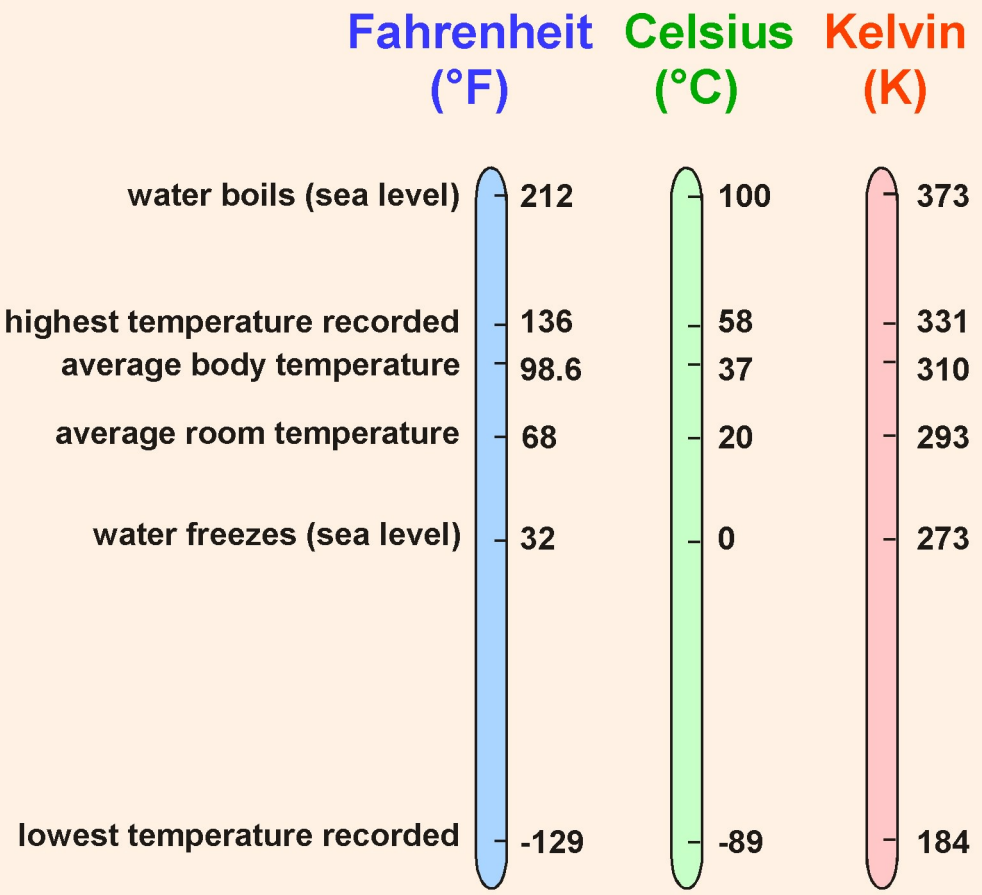
- What component of the atmosphere is most important to weather?
  A. Nitrogen
  B. Oxygen
  C. Carbon dioxide
  D. Ozone
  E. Water

Temperature

- What is temperature?
  - A measure of the average speed of molecules that move in a substance
  - Air temperature is the speed of air molecules
- What happens when two objects of different temperature are brought into contact with each other?
  - Transfer of energy (temperature) from warmer (faster) to colder (slower) object
- How do we measure temperature?
  - Thermometers, thermistors

Temperature scales

°C	°F
-40	-40
-35	-31
-30	-22
-25	-13
-20	-4
-15	5
-10	14
-5	23
0	32
5	41
10	50
15	59
20	68
25	77
30	86
35	95



Temperature Conversions

$°C = (°F - 32)/1.8$

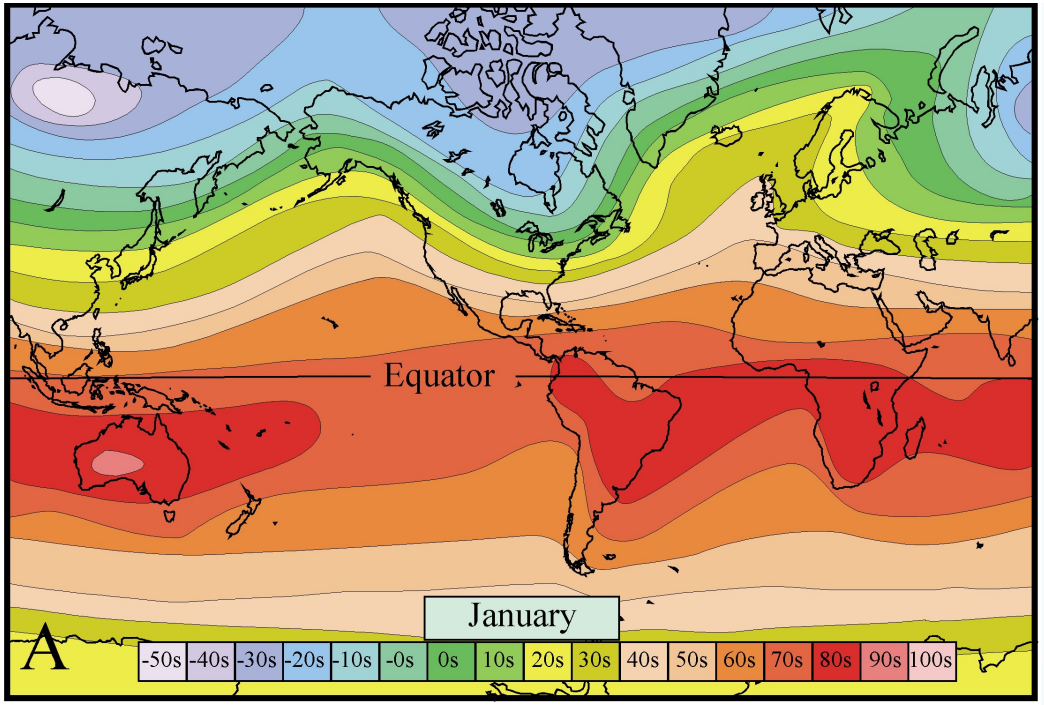
$K = °C + 273.15$

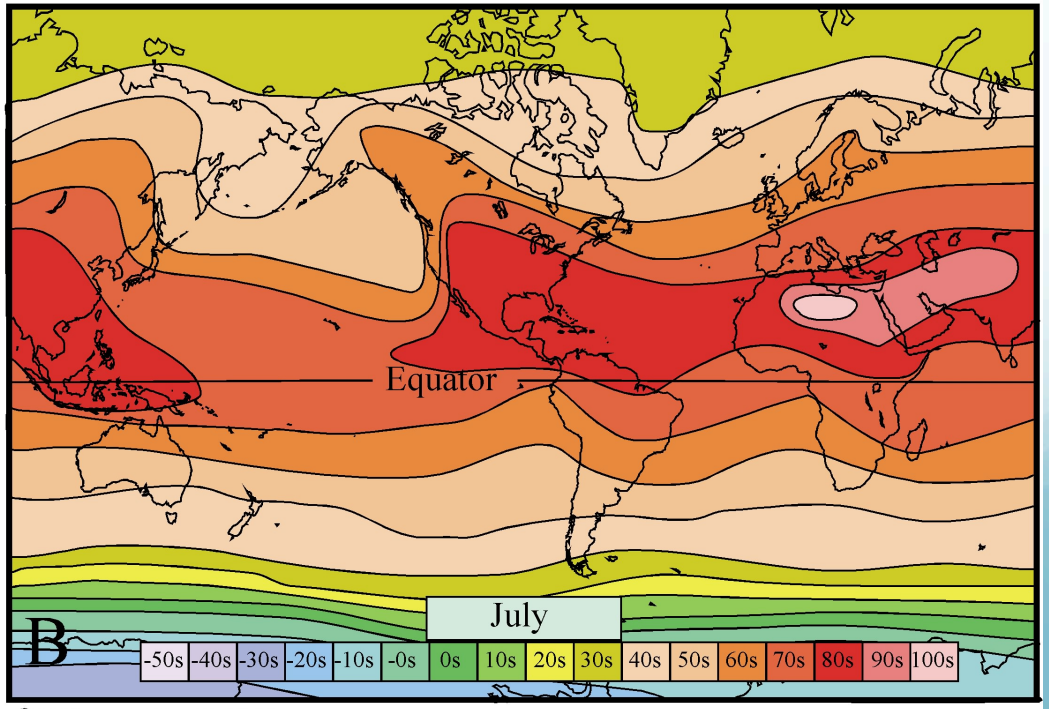
Global temperature

How does temperature vary during the year and across the Earth?

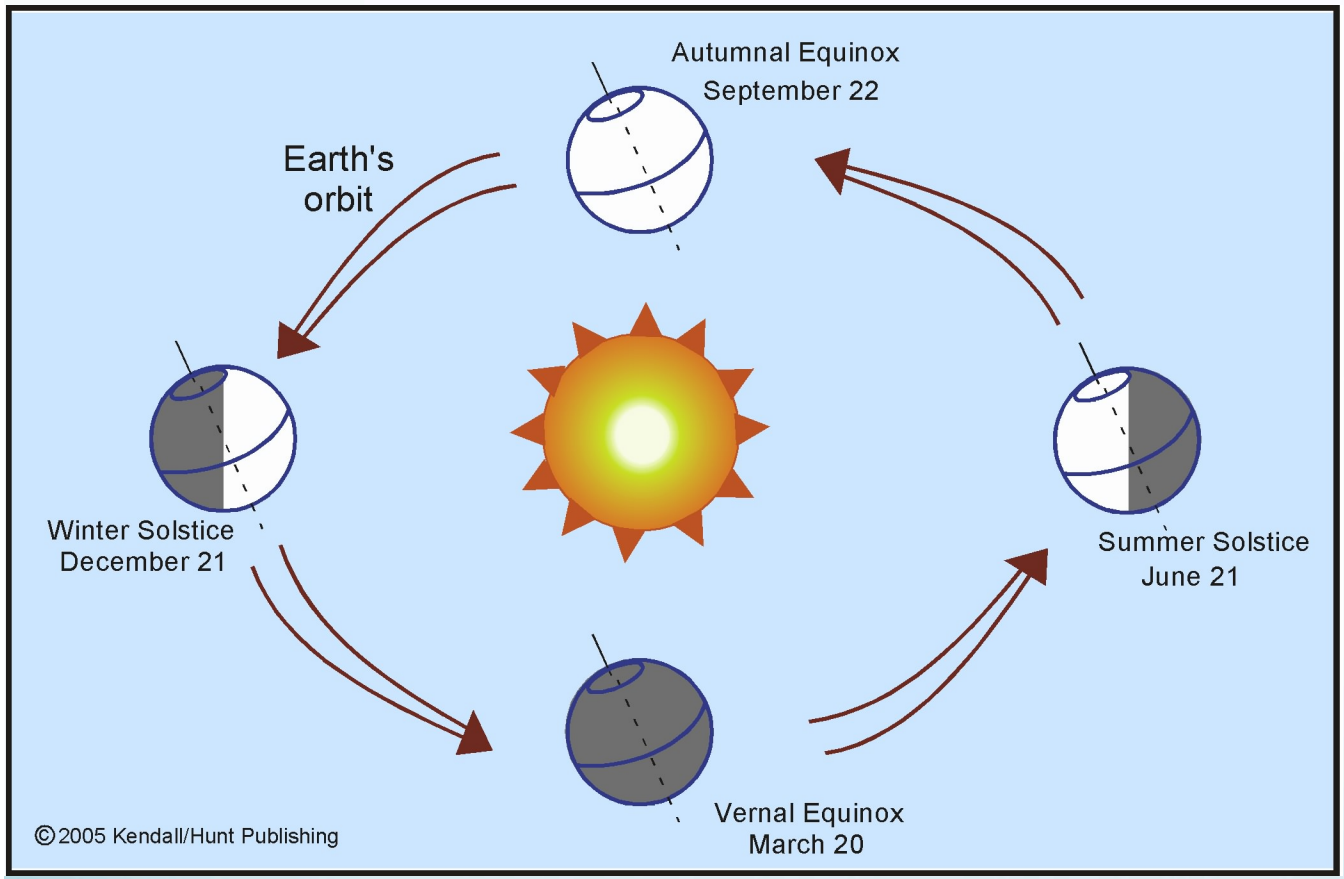
Why does the temperature change during the year?

Why is this change larger in middle and high latitudes than in the tropics?



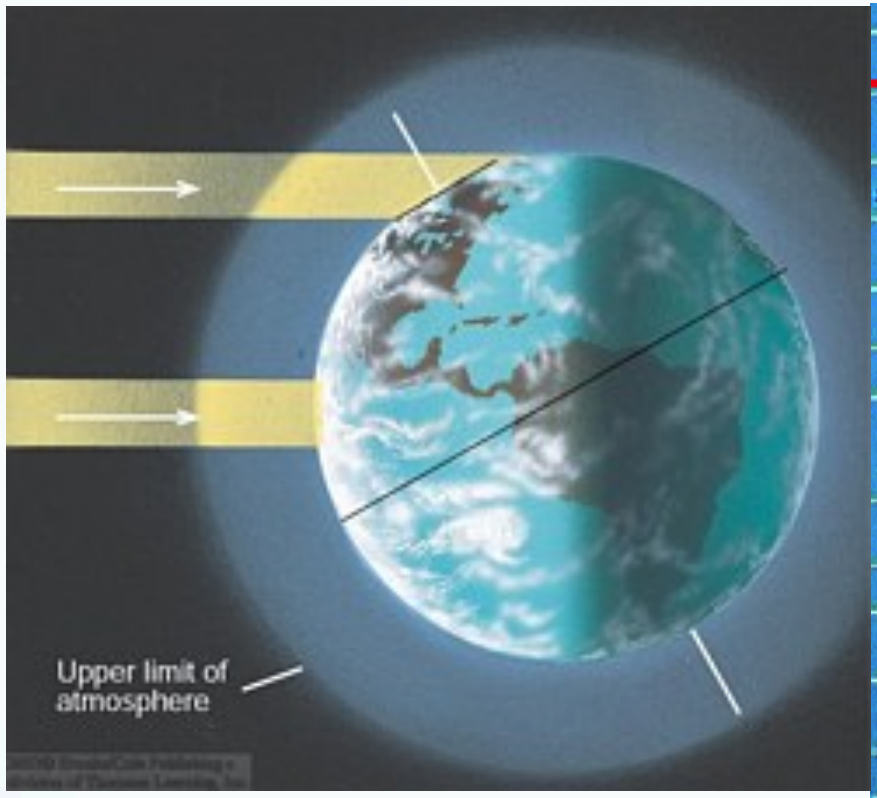


Seasons



How do seasons vary from the equator to the poles?

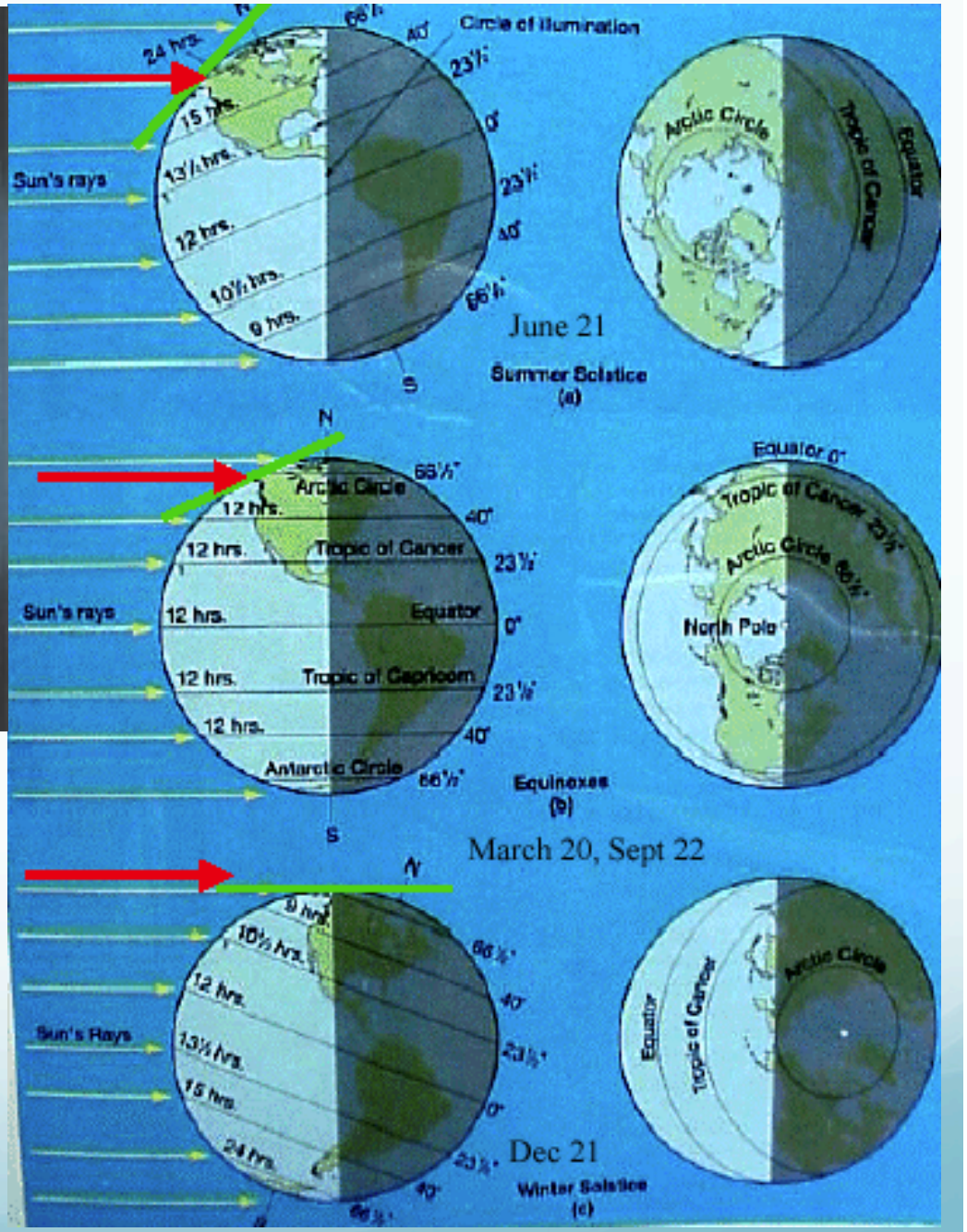
It's all about the tilt of the earth!



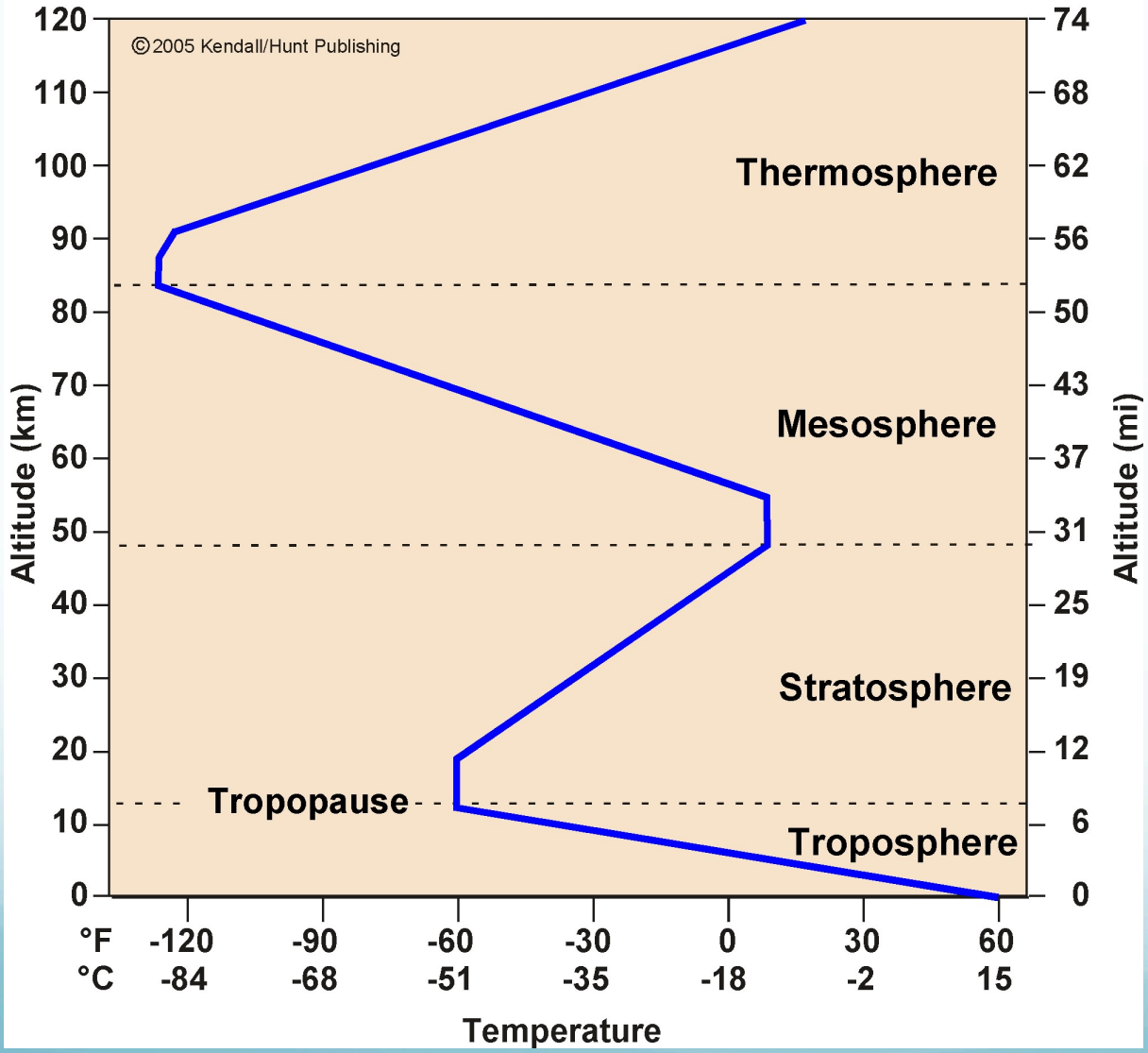
1. Length of daylight

2. Amount of atmosphere for sun's rays to pass through

3. Area illuminated by sun



Vertical structure of the atmosphere



Temperature increase

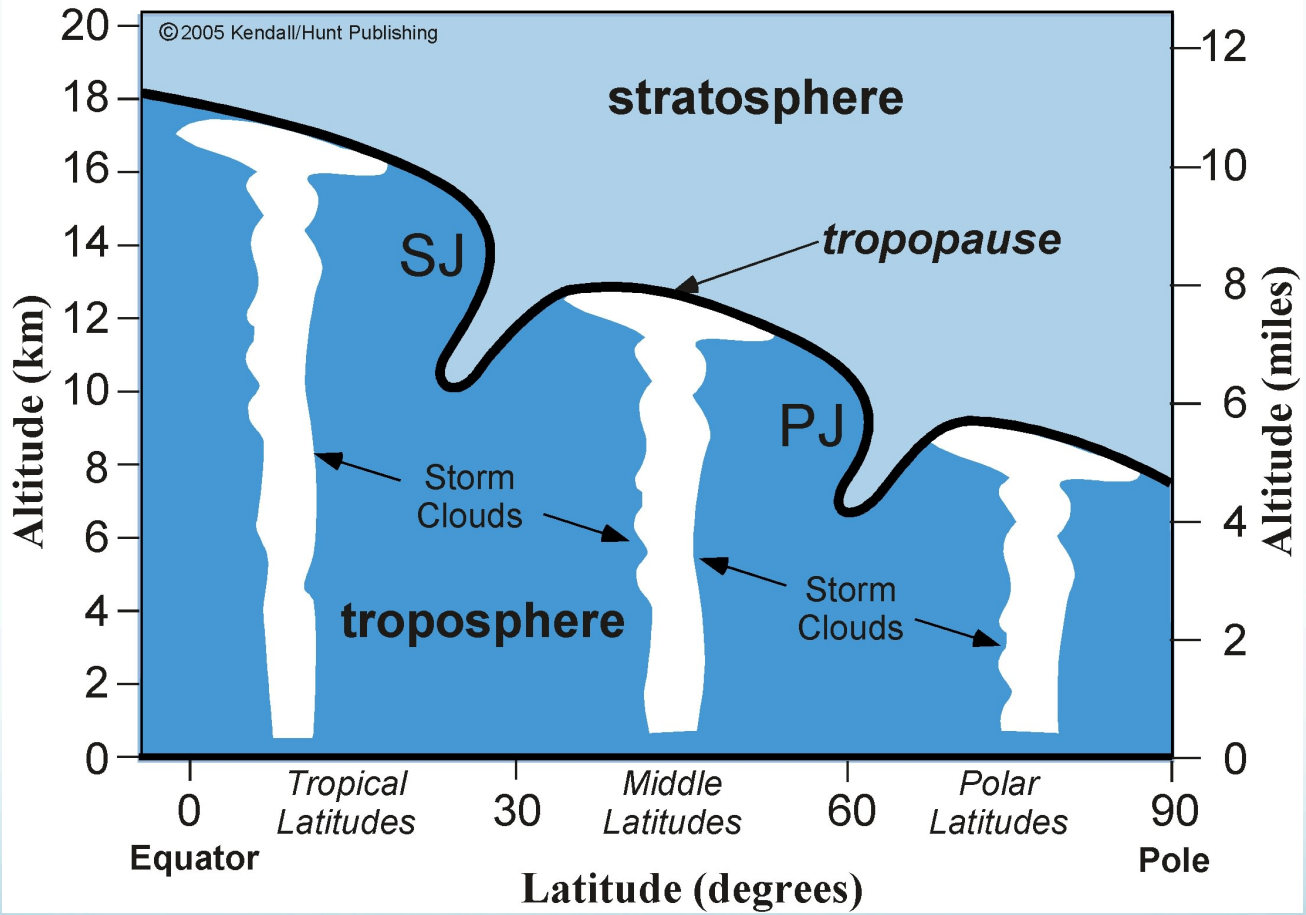
Temperature decrease

Temperature increase

OZONE LAYER

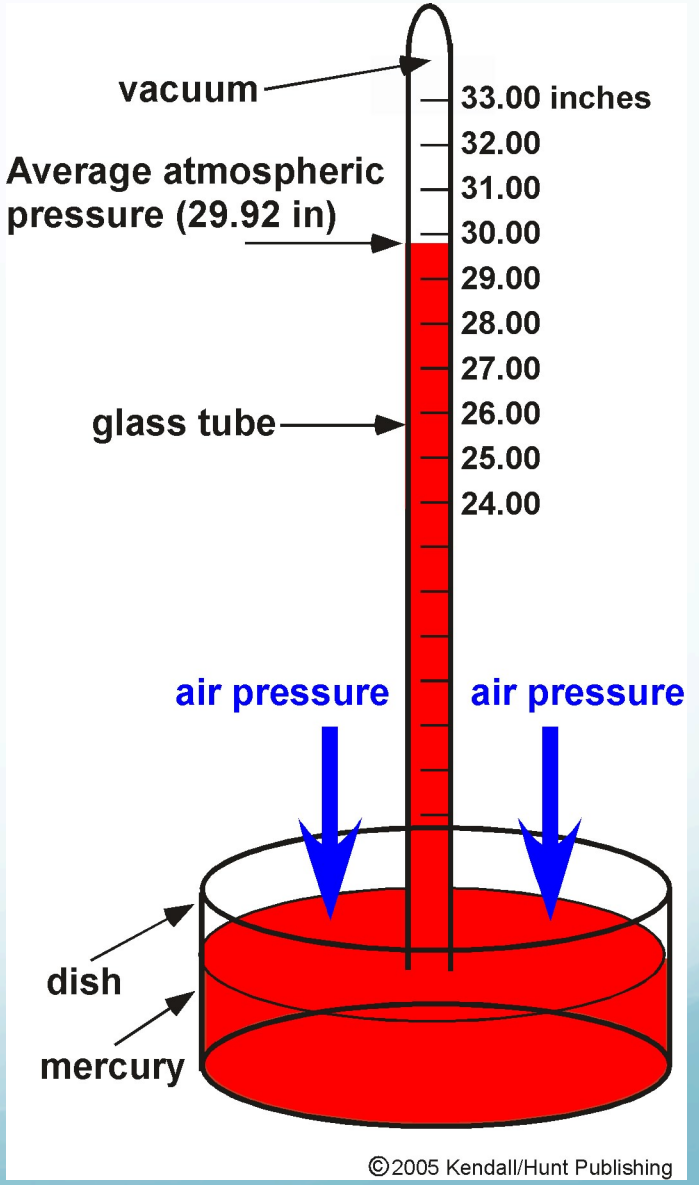
Temperature decrease

Tropopause height

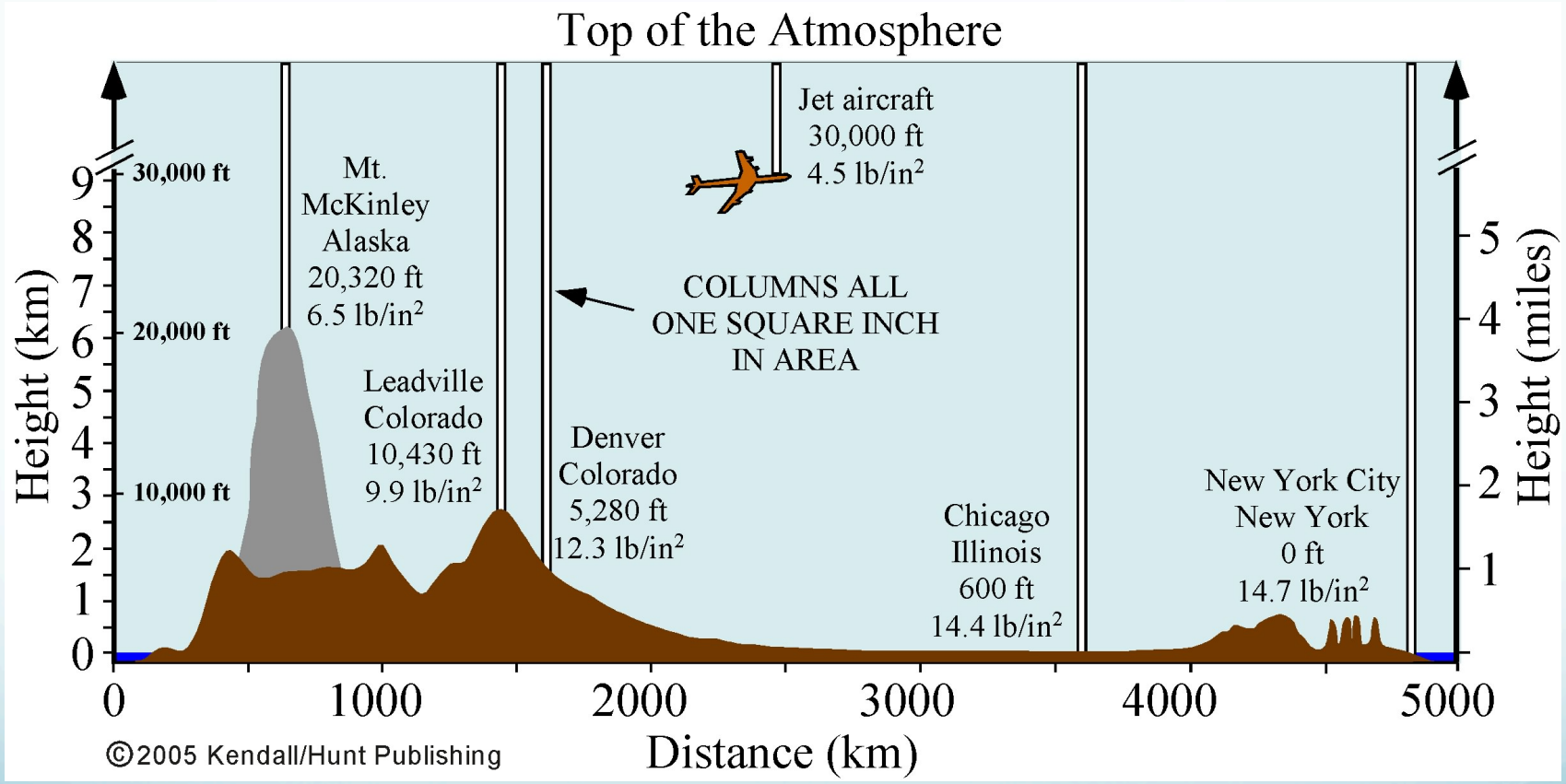


Pressure

- What is air pressure?
  - The force applied by air to a unit surface area
- How do we measure atmospheric pressure?
  - Barometer



Pressure by location

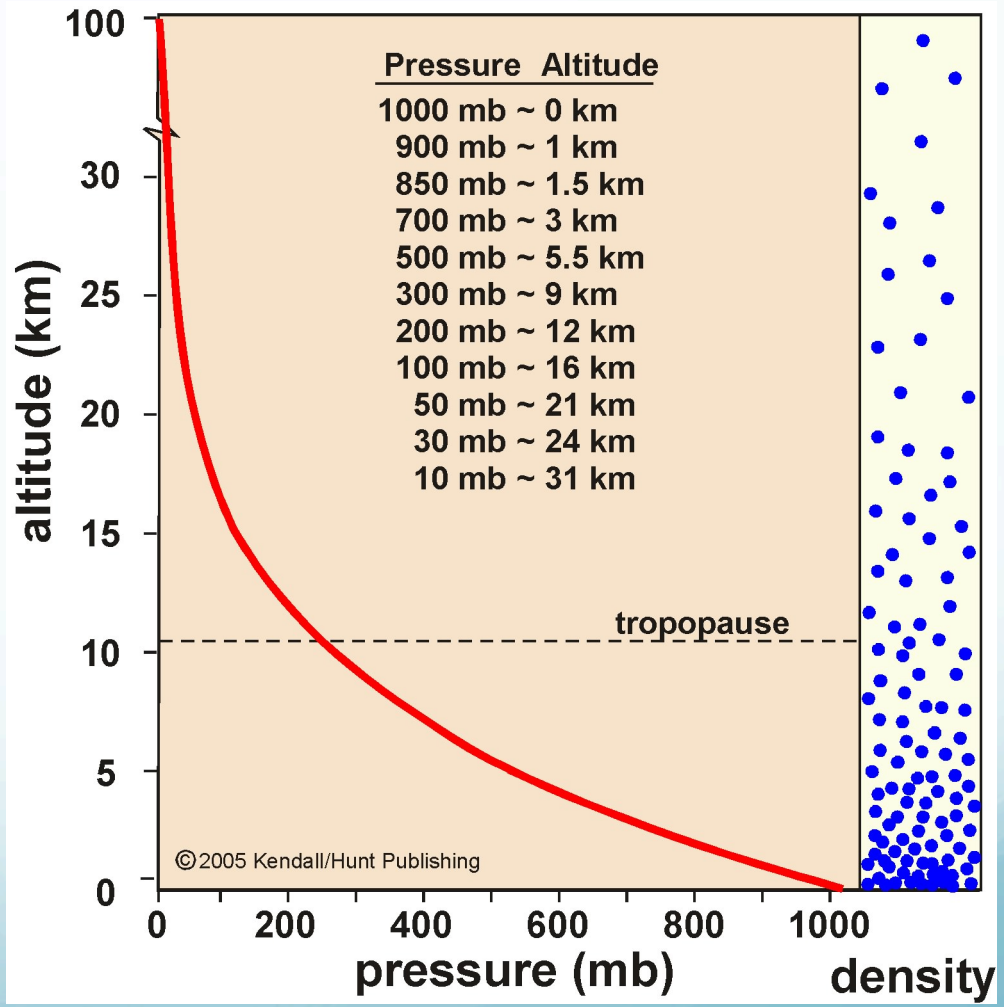


Clicker question

- What location would have the lowest surface pressure?
  A. Chicago, Illinois
  B. Denver, Colorado
  C. Miami, Florida
  D. Dallas, Texas
  E. Los Angeles, California

Pressure by altitude

- Why does pressure decrease so dramatically with altitude?
- Since pressure varies more slowly in the horizontal, how do we detect changes in pressure from one location to the next?



Sea level pressure

- Convert the surface pressure to a common altitude = sea level pressure
- A way to compare atmospheric surface pressures of different locations

Units of Pressure

$14.7\ lb / in^2 = 29.92\ in\ Hg = 1013.25\ mb$

Range of Sea Level Pressures observed on Earth

Inches of Mercury		Millibars
32.01	highest sea level pressure recorded	1084
30.86	strong high pressure system	1045
29.92	average sea level pressure	1013
28.94	deep low pressure system	980
25.70	lowest sea level pressure recorded	870

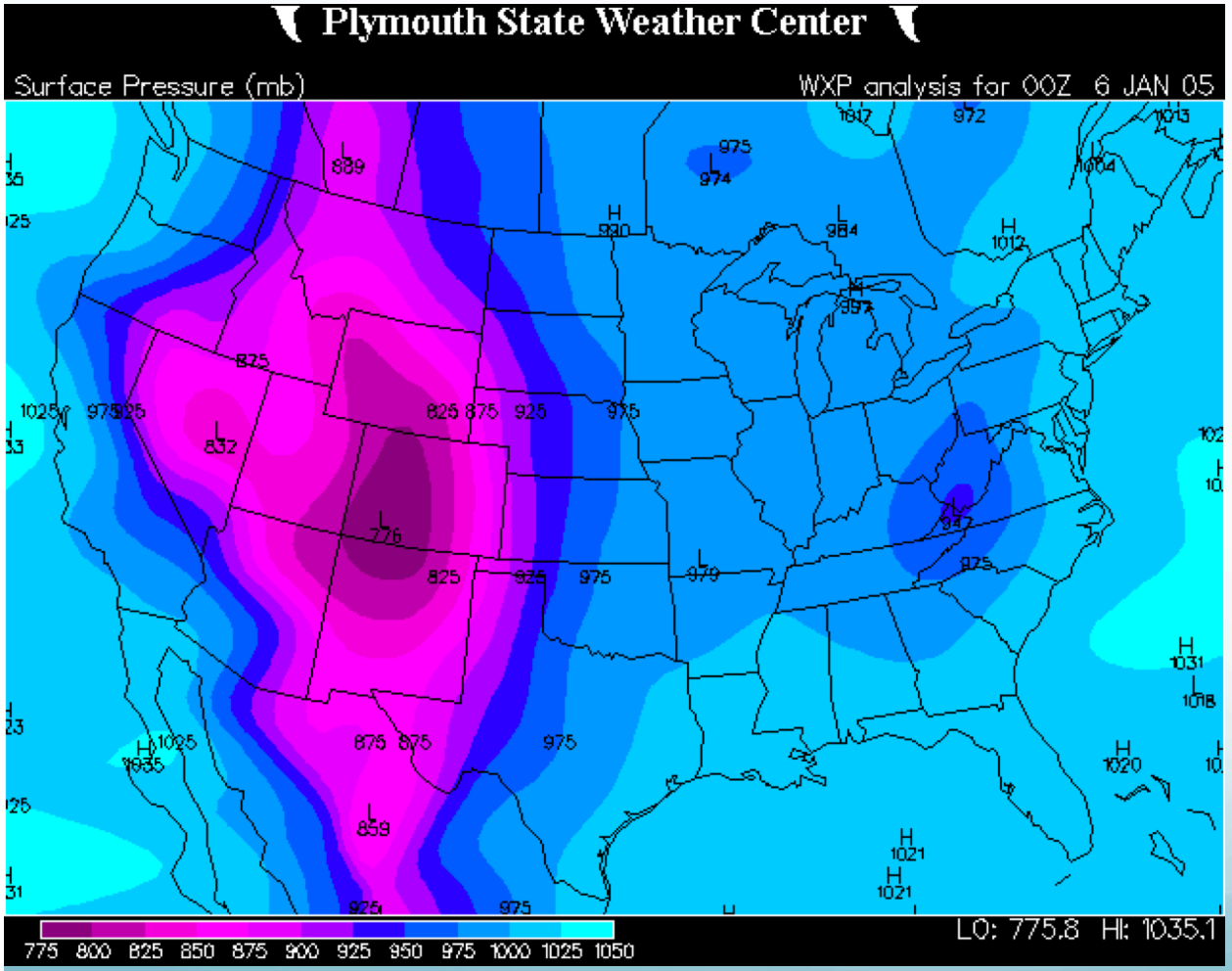
Units of pressure used by meteorologists:

Millibars (mb)

Sometimes will use:

Inches of mercury (in Hg)

Surface pressure map

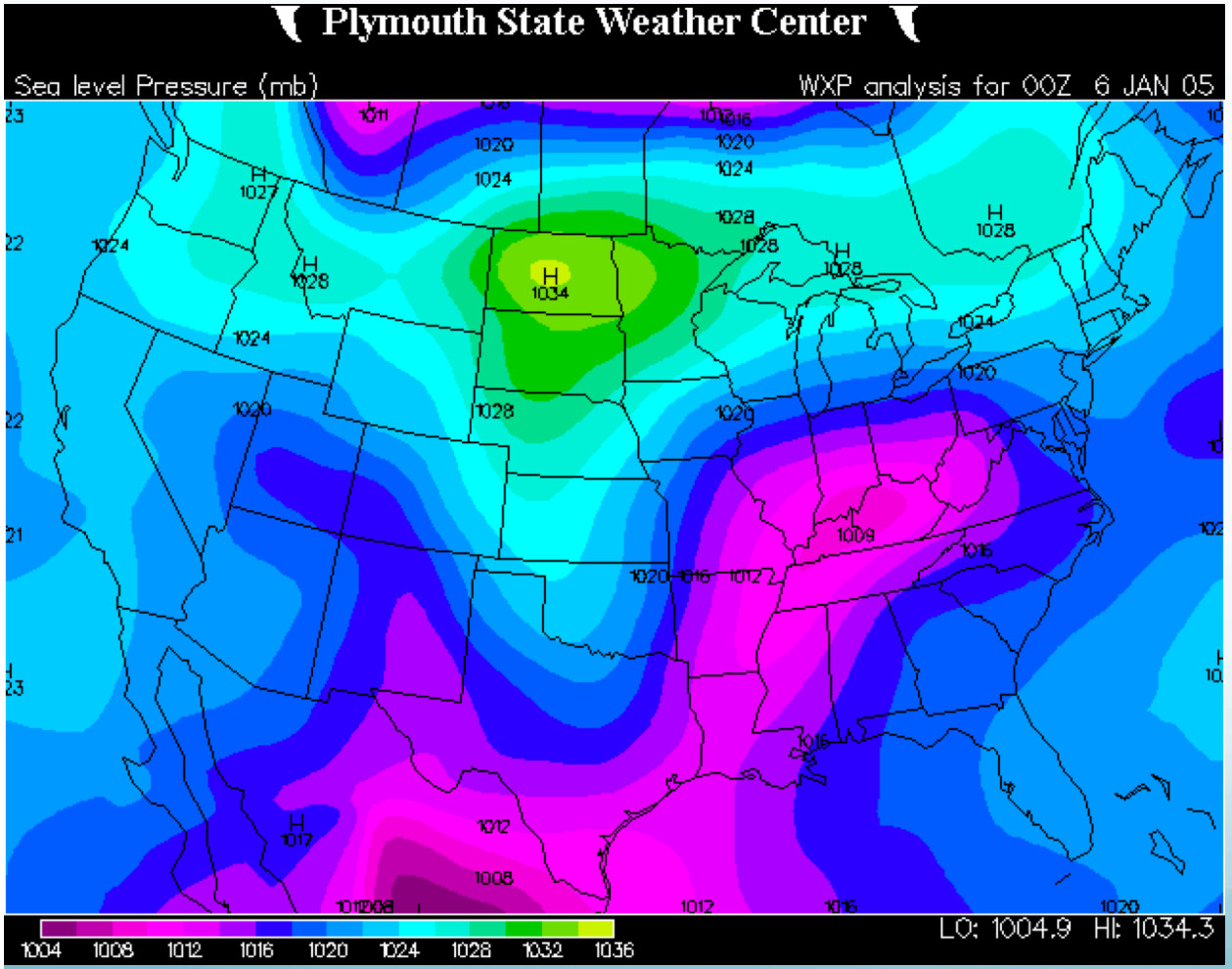


Where is the pressure high (or low) on this map?

Clicker question

- What is responsible for the distribution of surface pressure shown on the previous map?
  A. Temperature
  B. Elevation
  C. Weather
  D. Population

Mean sea level pressure map

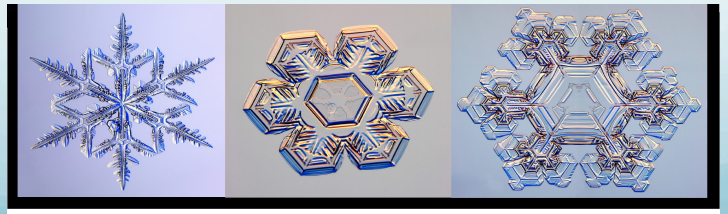


How does the location of the high (or low) pressure differ on this map compared to the map of surface pressure?

Which map is more useful for studying the weather?

Moisture

- Water is unique in our atmosphere, because it can exist in all three phases!
- Three phases of water in the atmosphere
  - Gas
    - Water vapor
  - Liquid
    - Water, rain drops, cloud droplets, fog droplets
  - Solid
    - Ice, snowflakes, graupel, hail



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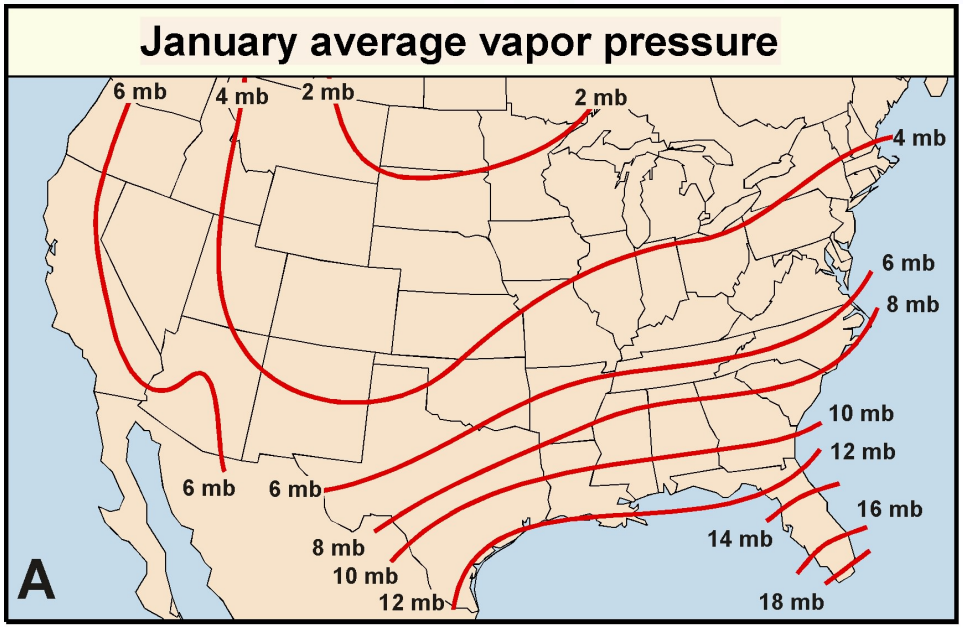
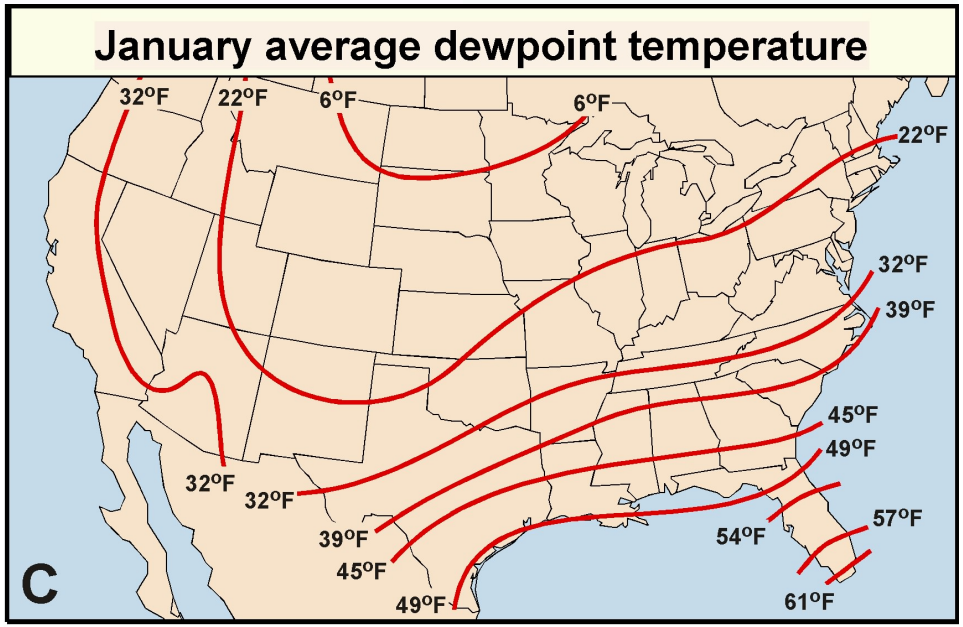
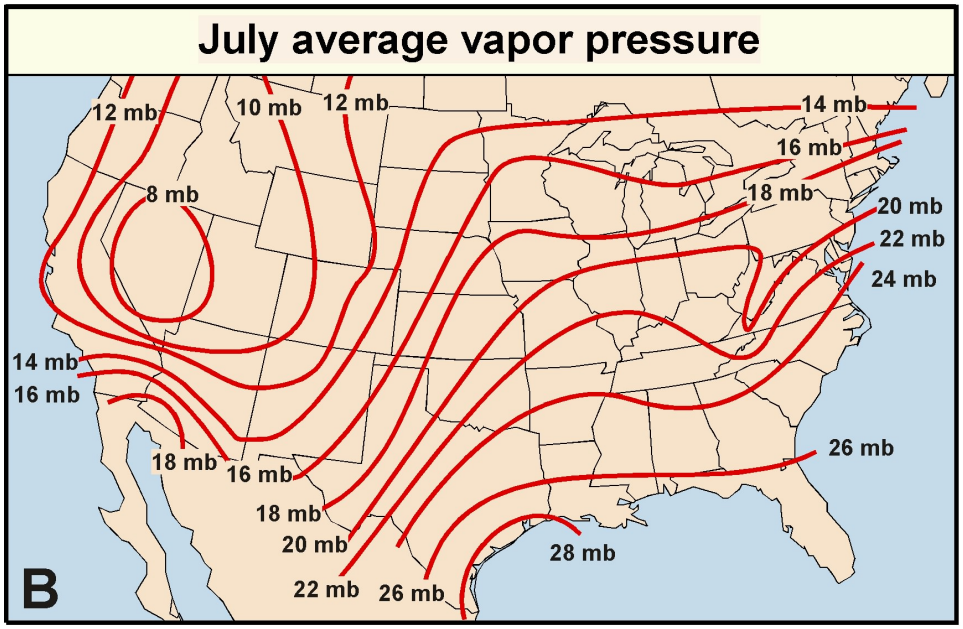
Measures of water vapor

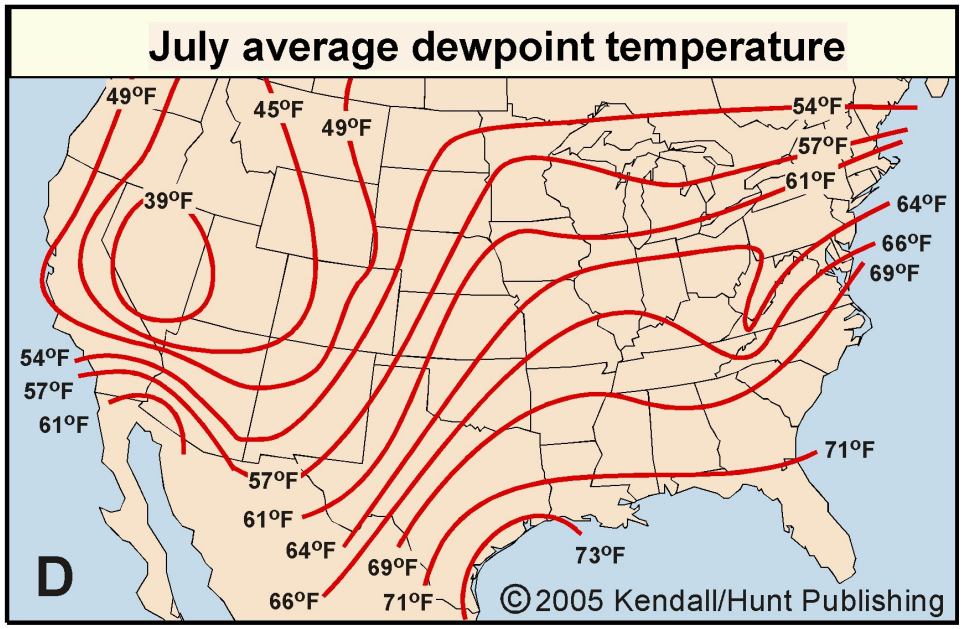
- Two categories of measurements:
  - **Absolute:** depends only on the water vapor amount
  - **Relative:** depends on the water vapor content AND the amount of water vapor the air can hold (based on the air temperature)
- Absolute measures of water vapor content increase as the amount of water vapor increases:
  - Vapor pressure: the pressure exerted by the water vapor molecules in the air
  - Dew point temperature: the temperature to which air must be cooled, at constant pressure, to just become saturated

Absolute measures of water vapor



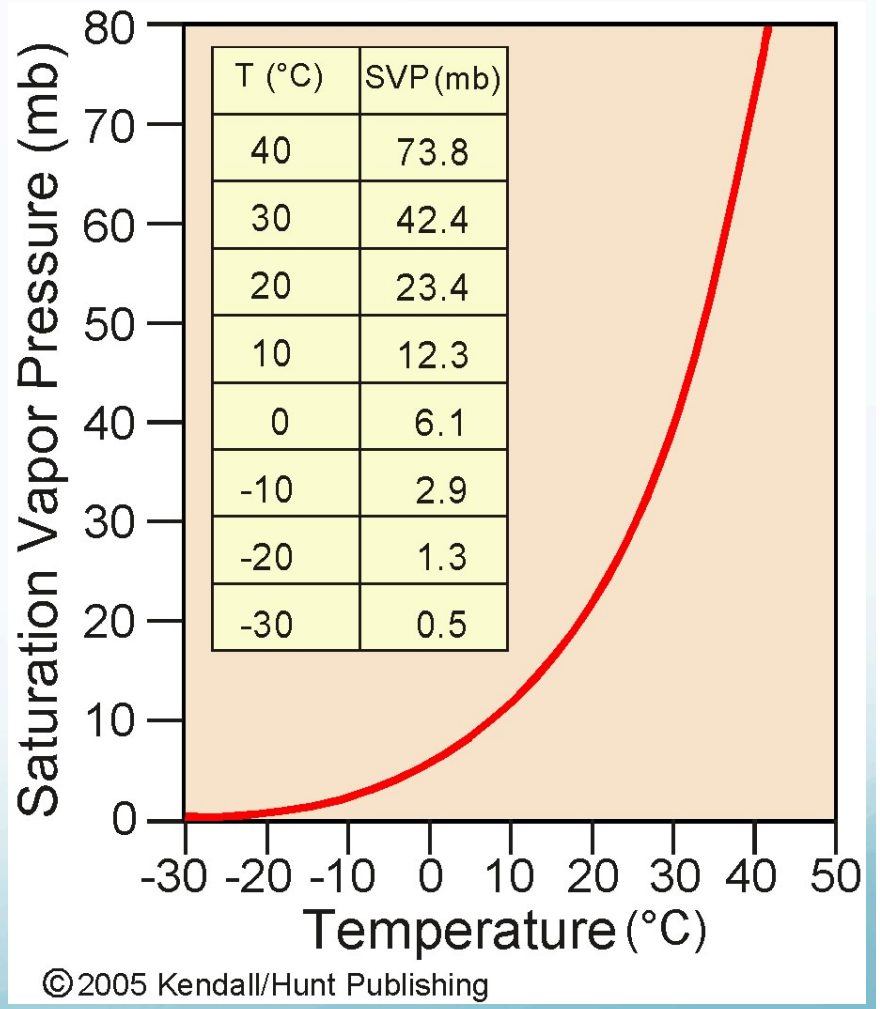






Saturation

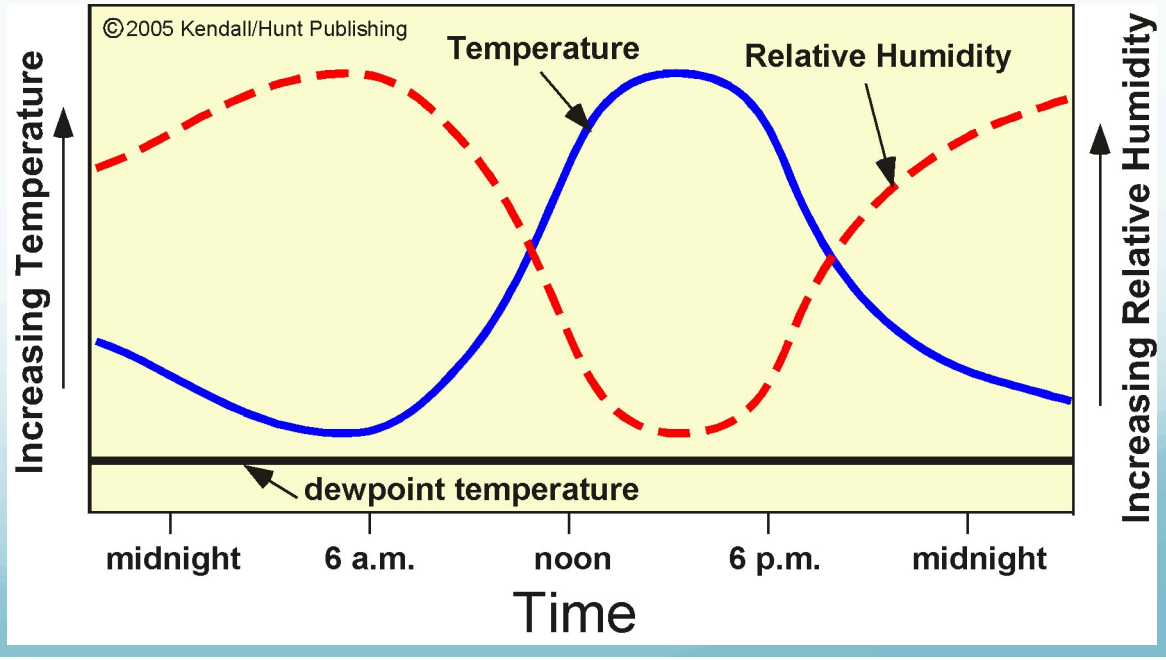
- When the atmosphere cannot contain any more water vapor without condensing into cloud droplets
- Saturation vapor pressure: The vapor pressure at which the atmosphere becomes saturated
- What determines how much water vapor the atmosphere can contain to be saturated?
  - Temperature!
  - Why does the saturation vapor pressure increase as the temperature increases?



Relative Humidity

- Relative humidity depends on both the amount of water vapor in the air (vapor pressure) and the amount of water vapor the air can hold (saturation vapor pressure) which depends on the temperature
- Relative humidity: (vapor pressure / saturation vapor pressure) x 100%

Relative humidity is a relative measure of water vapor!



Relative vs Absolute humidity

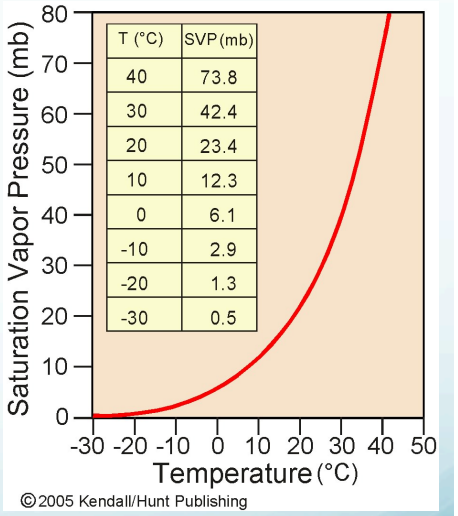
- **Which location has the higher absolute humidity?**
  - **What variable did you look at to answer the previous question?**
- **At which location is the air closer to being saturated?**
  - **What variable did you look at to answer the previous question?**

Location	Vapor pressure	Temperature	Saturation Vapor Pressure (mb)	Relative Humidity
Desert SW in summer	8 mb	35 C (95 F)	60 mb	13%
Northern plains in winter	2 mb	0 C (32 F)	6 mb	33%

Clicker discussion question

- If the relative humidity and the temperature at Denver, Colorado, compared to that at Miami, Florida, is as shown below, **how much absolute water vapor is in the air between these two locations**?

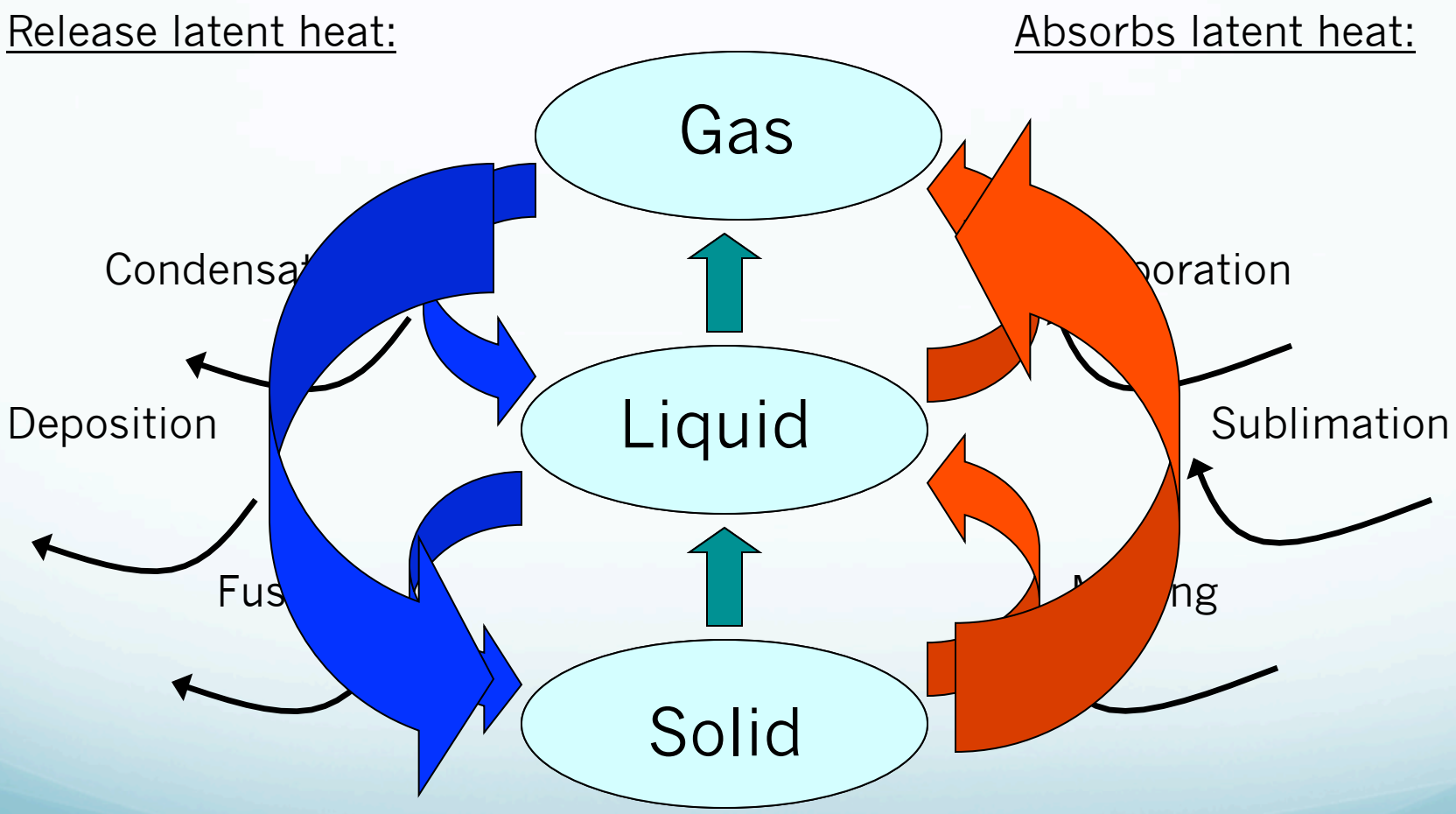
Denver	Miami
10°C Air temperature	20°C Air temperature
50% Relative humidity	50% Relative humidity



A. Denver has more absolute water vapor
B. Miami has more absolute water vapor
C. Both have the same amount of water vapor

$$RH = \frac{\text{vapor pressure}}{\text{saturation vapor pressure}} \times 100\%$$

Changing phase: Latent Heat transfer



Wind

- Wind speed and direction are the two properties of wind that meteorologists are concerned about
- Wind direction is referred to as the direction the *wind is blowing from!*
  - Why?
  - It is a sign of the properties of the air blowing in (from north is cold, from south is warm, etc)
- Wind speed is reported in units of knots
  - 1 knot = 1.15 mph

Reading winds on a weather map

- Wind barbs on a staff indicate both wind direction and speed
  - The staff indicates the direction (from tail to head is the direction the wind is blowing from)
  - The barbs indicate speed (the size and number of the barbs add up to the wind speed)