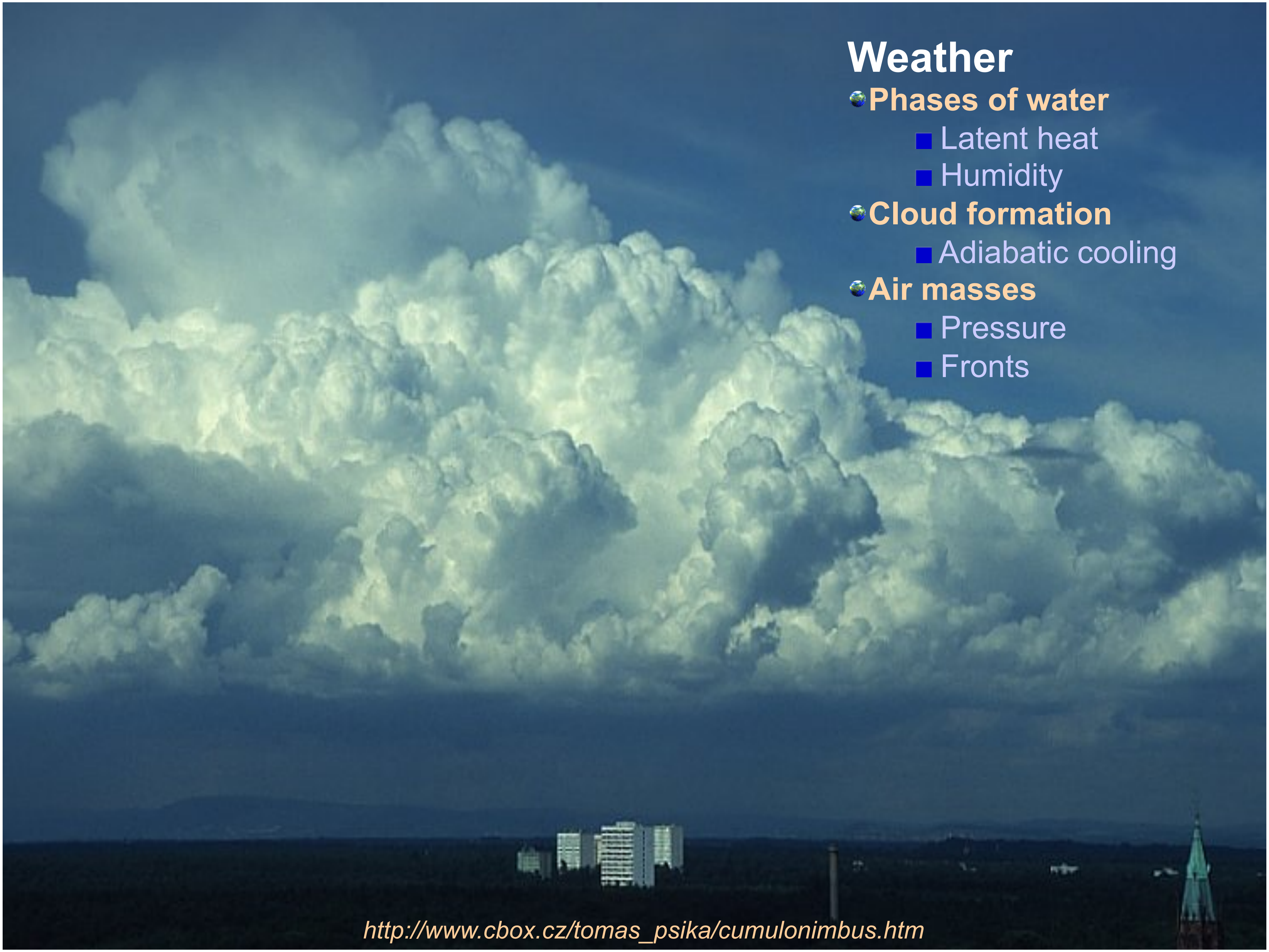
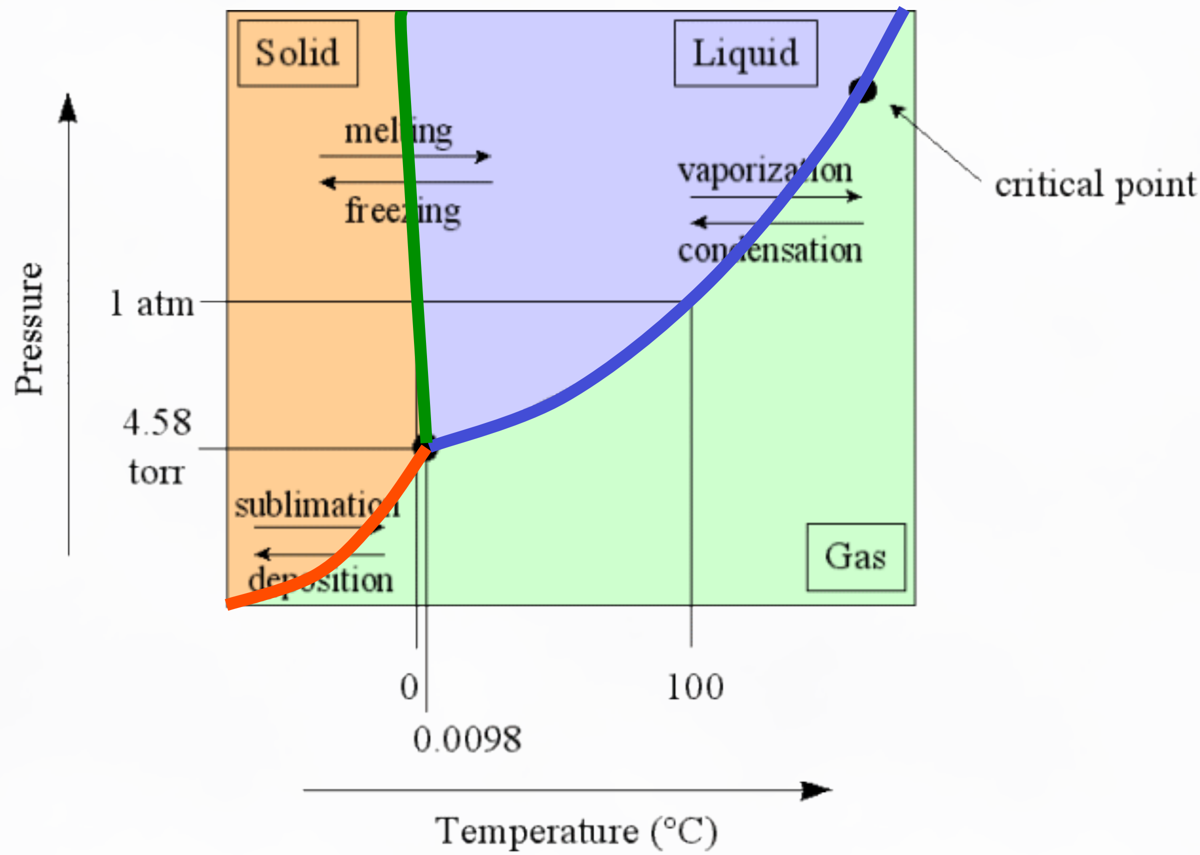

Weather
Phases of water
Latent heat
Humidity
Cloud formation
Adiabatic cooling
Air masses
Pressure
Fronts
http://www.cbox.cz/tomas_psika/cumulonimbus.htm

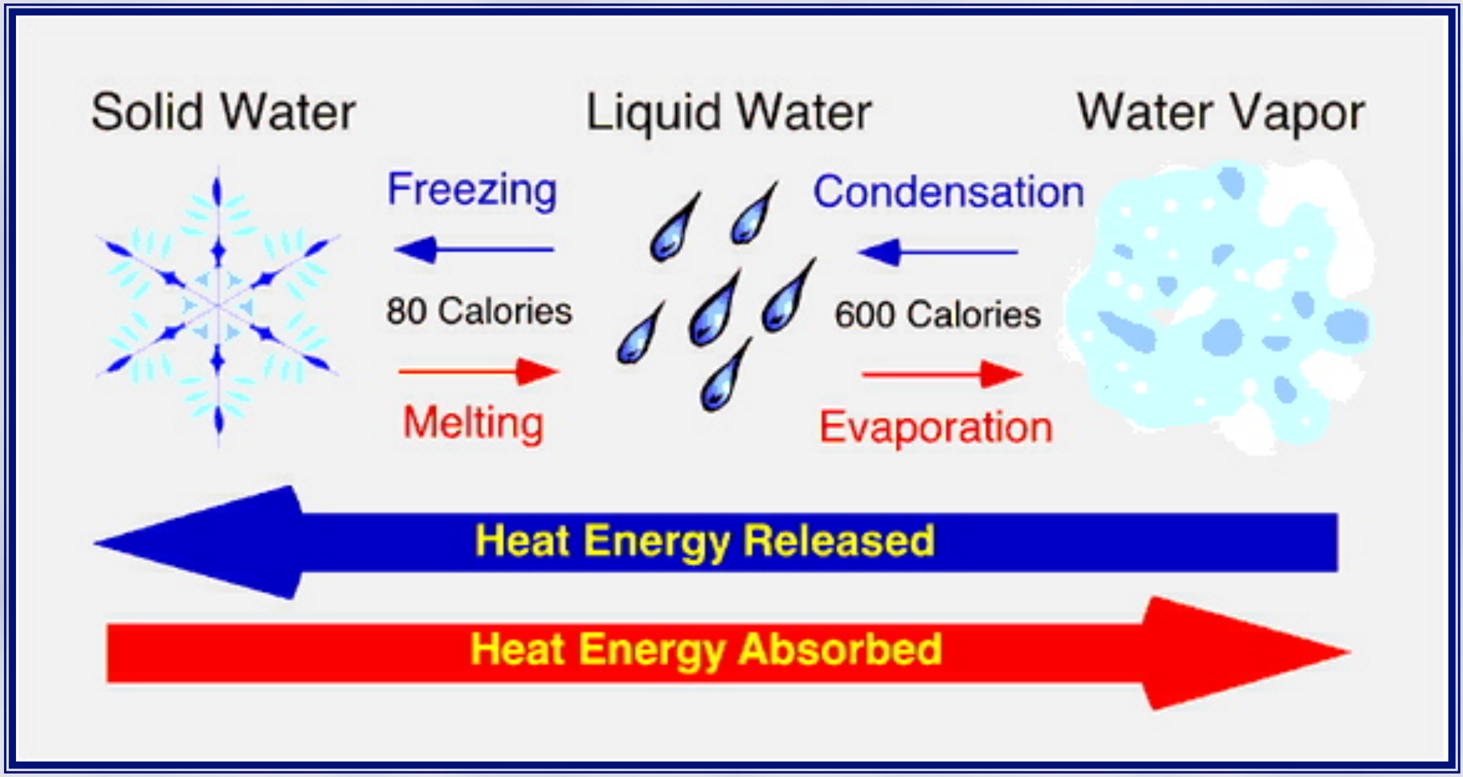
Phases of Water



The phase (solid, liquid, or gas) of any matter depends on both temperature and pressure. Converting from one phase to another requires the absorption or release of energy.

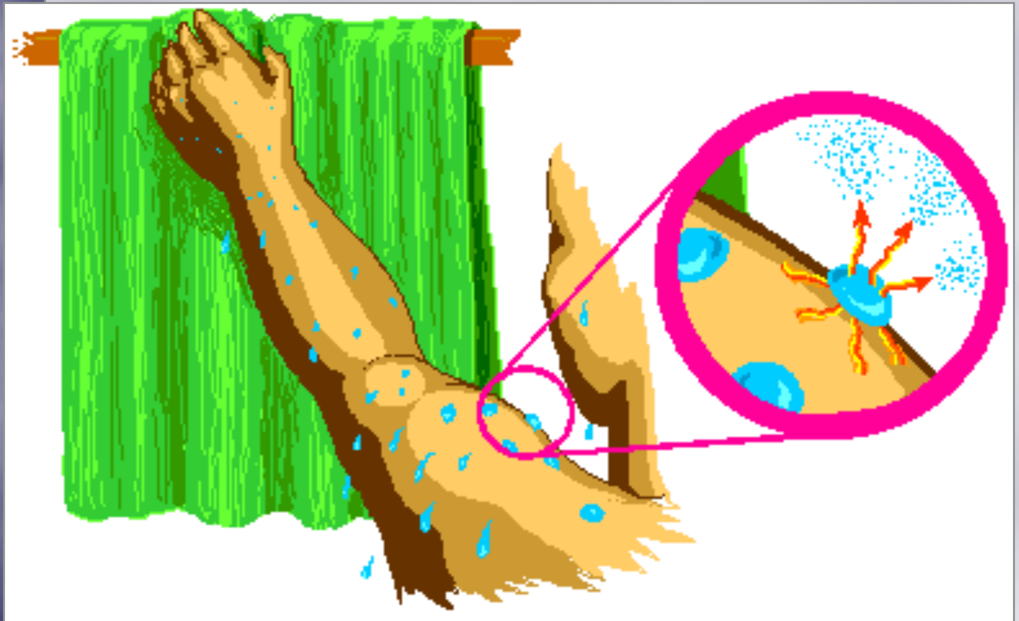
http://www.its.caltech.edu/~atomic/snowcrystals/

Latent Heat



Latent heat – energy consumed or released during a *phase change*.

http://www.sci.sdsu.edu/classes/biology/bio354/williams/Measurements.html



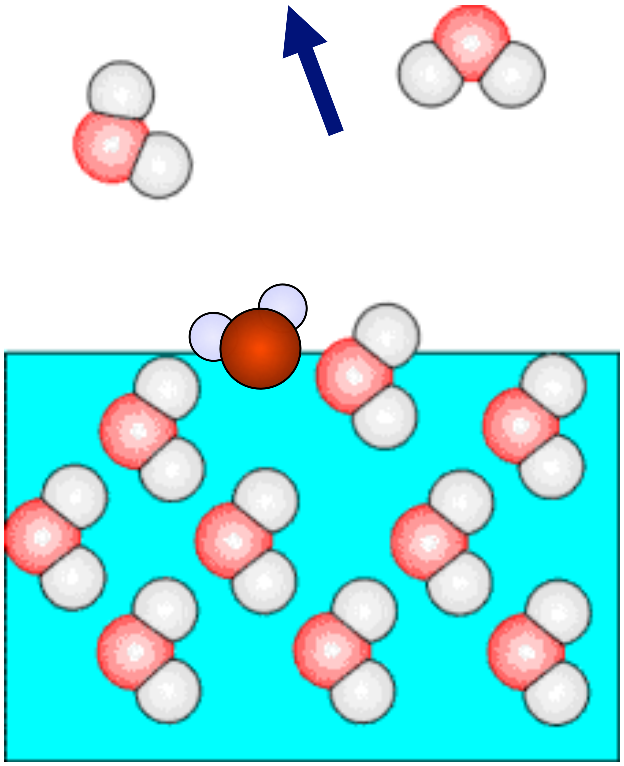
Latent Energy

Body heat is absorbed to change water from liquid to vapor.

As ice cubes melt, they absorb heat from the drink, cooling it.

http://okfirst.ocs.ou.edu/train/meteorology/HeatTransfer.html

Evaporation – water in liquid state escapes to become gaseous.



*Latent heat is **absorbed** by evaporating molecules*

Sublimation – molecules escape from solid to gaseous phase

*Latent heat energy is **absorbed** by escaping molecules*

http://www.historyoftheuniverse.com/

http://www.cobden.union.k12.il.us/

Deposition – In the atmosphere, freezing vapor (gas) can form the beautiful crystals called snowflakes.

*Latent heat energy is **released** by depositing molecules*

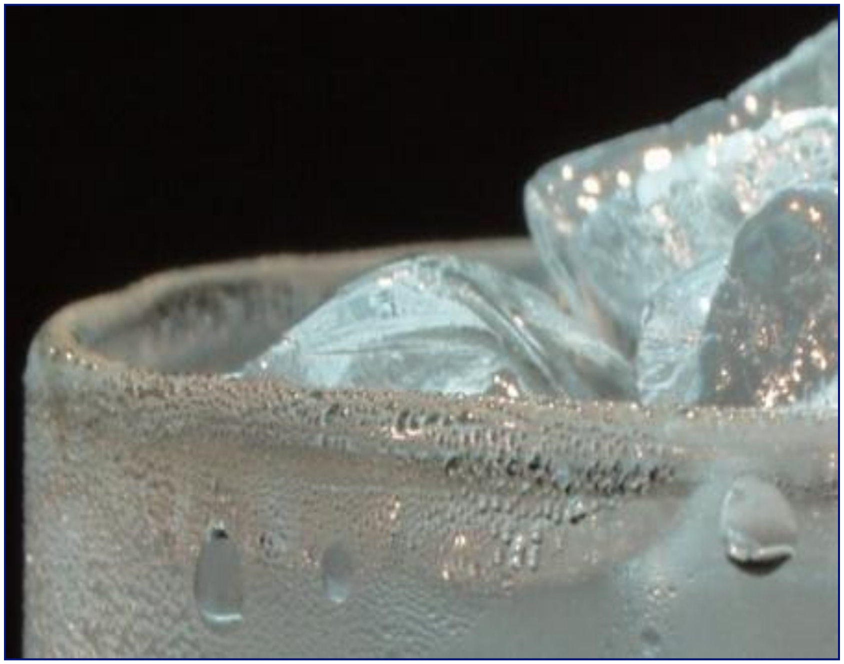
http://www.its.caltech.edu/~atomic/snowcrystals/

Freezing – water in liquid state crystallizes to form a solid.

*Latent heat energy is **released** by freezing molecules*

http://www.brockportfire.org/

Condensation – water molecules in gaseous state stick together, forming liquid

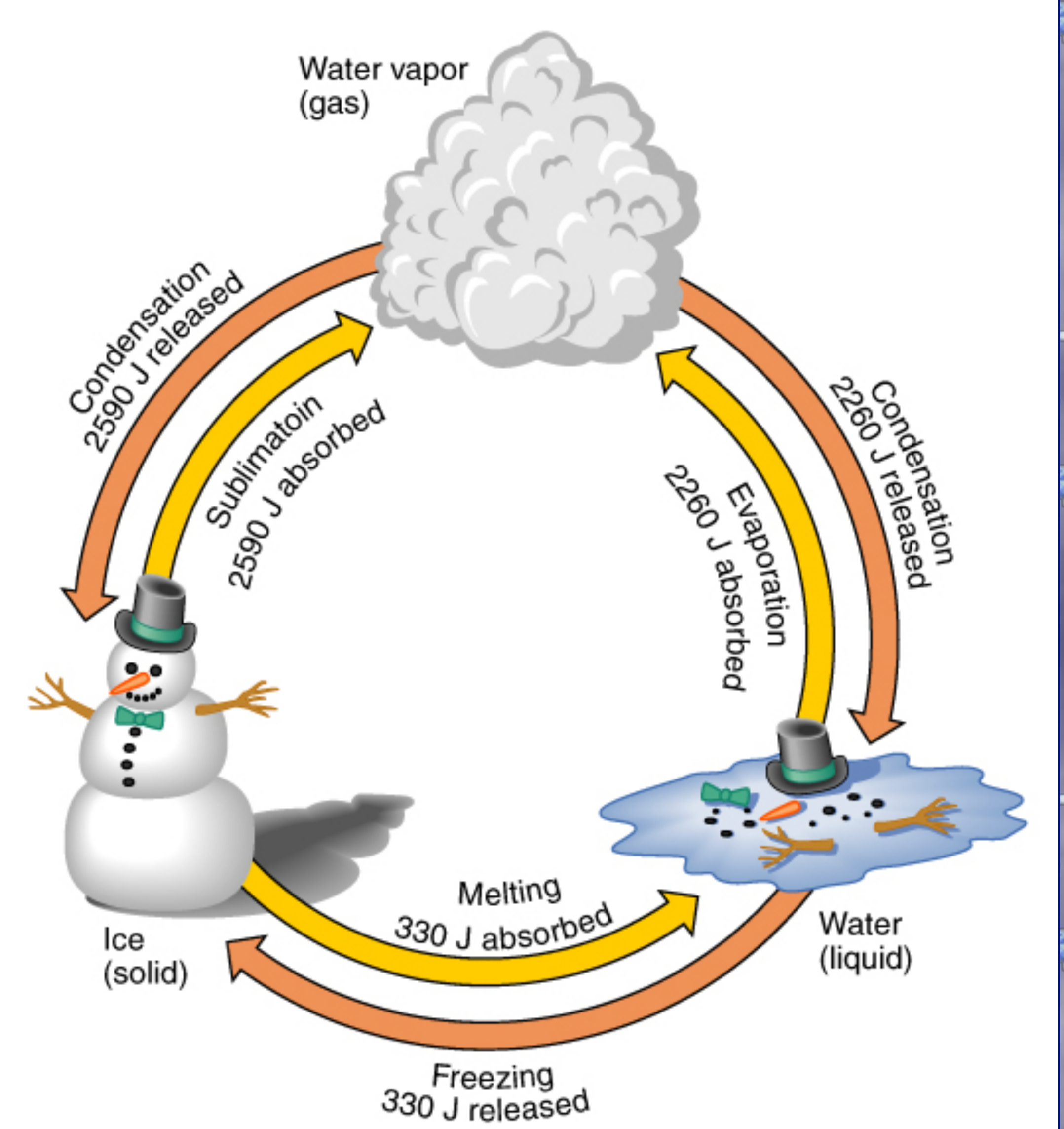


*Latent heat is **released** by condensing molecules*

In the atmosphere, condensation produces clouds and fog.

Condensation occurs more readily when the air contains aerosols, which act as condensation surfaces.

http://dl.uncwil.edu/chemistry/general/



http://www.usd.edu/esci/

Humidity

Humidity – quantity of water vapor in a packet of air.

The actual amount of water vapor in the atmosphere rarely exceeds 4%. However, this “absolute” humidity is not a very useful measurement.

Instead, meteorologist measure *relative humidity*, which is the ratio of the measured humidity to the humidity at which condensation would occur for an air packet.

http://www.geog.susx.ac.uk/fieldclasses/seychelles/

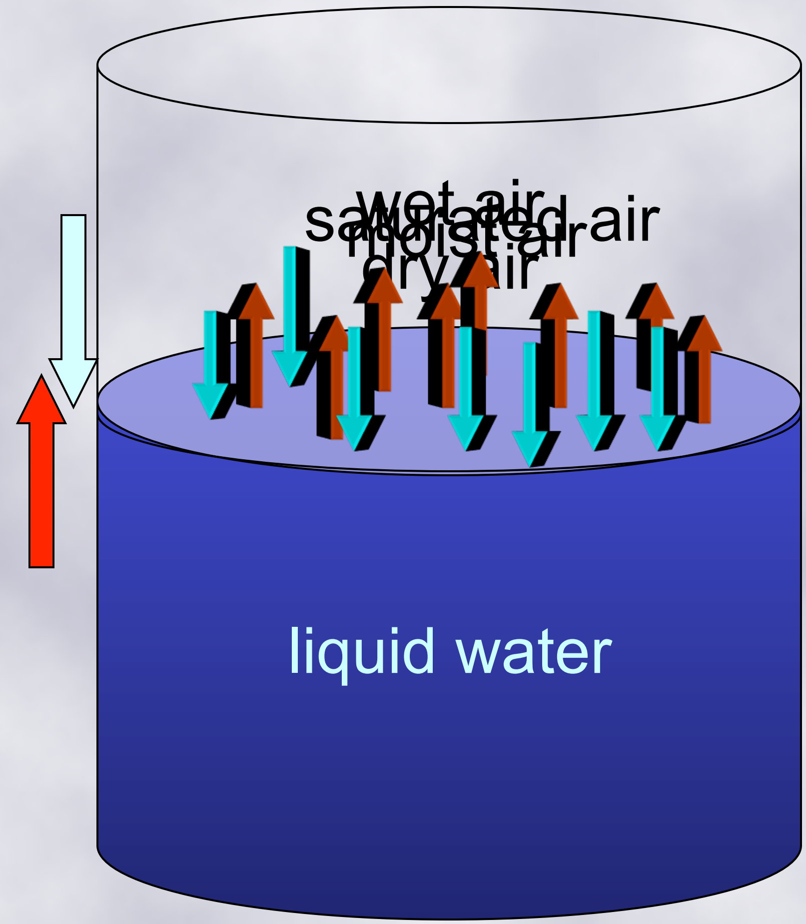
Humidity

Saturation – Point of dynamic equilibrium between water in liquid and gaseous form.

1. Water evaporates into the dry air, gradually increasing the water pressure in the formerly dry air.

2. As water in the air builds up, some makes the return trip, becoming liquid again.

3. When the amount of water evaporation equals the amount of air condensing, saturation is reached.



Saturation is controlled primarily by temperature

Temperature	Saturation at:
-40°C (-40°F)	0.1 g_{water}/kg_{air}
0°C (32°F)	3.5 g_{water}/kg_{air}
20°C (68°F)	14.0 g_{water}/kg_{air}
35°C (95°F)	35.0 g_{water}/kg_{air}

A human body will feel much more atmospheric moisture at saturation at 95° than -40°.

Relative Humidity

Ratio of a parcel of air's measured water vapor and the saturation water vapor for that temperature

$$\text{Relative Humidity} = 100\text{x} \frac{\text{water vapor}_{\text{measured}}}{\text{water vapor}_{\text{at saturation}}}$$

Example: **Parcel of air at 10°C (50°F), measured water vapor = 5 $g_{water\ vapor}/kg_{air}$**

Water vapor at saturation (10°C) = **7 $g_{water\ vapor}/kg_{air}$**

$$\text{Relative Humidity} = 100\text{x} \frac{5\ g_{water\ vapor}/kg_{air}}{7\ g_{water\ vapor}/kg_{air}} = 71.4\%$$

Dew Point

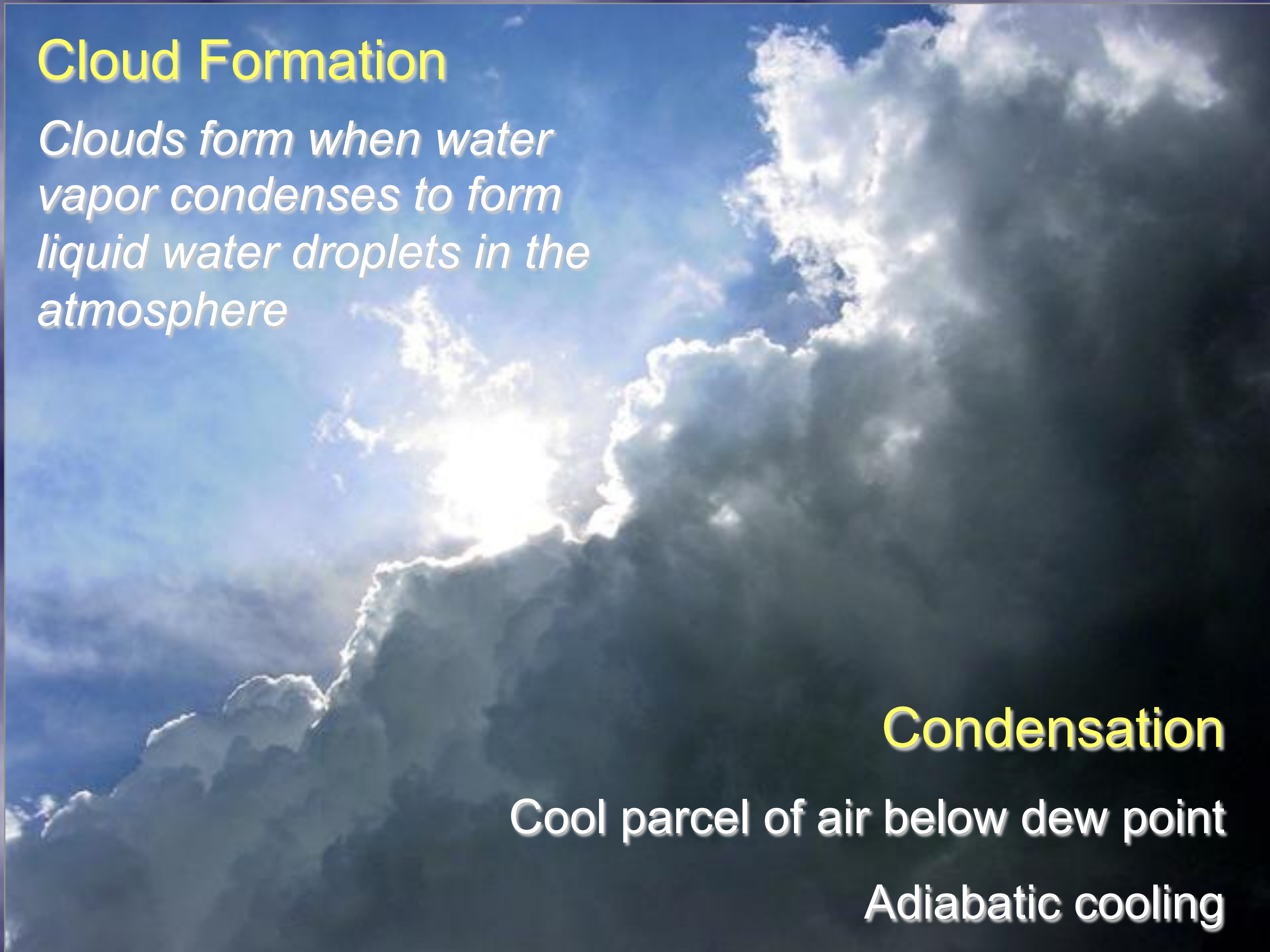
Temperature to which a parcel of air would need to be cooled to reach saturation

Example: **Parcel of air at 10°C (50°F), measured water vapor = 5 $g_{water\ vapor}/kg_{air}$**

Temperature at which 5 $g_{water\ vapor}/kg_{air}$ is the saturation point (100% humidity) = 5°C (41°F)

Dew Point = 5°C

Cooling a parcel of air below its dew point results in condensation (water vapor → liquid water)



Cloud Formation

Clouds form when water vapor condenses to form liquid water droplets in the atmosphere

Condensation

Cool parcel of air below dew point

Adiabatic cooling

http://www.wunderground.com/

Adiabatic Cooling

Drop in temperature brought about by change in volume

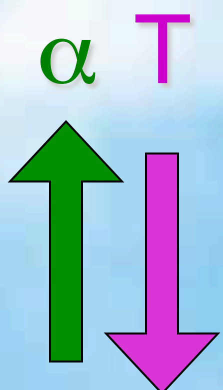
First Law of Thermodynamics

pressure

$$\Delta H = p(\Delta\alpha) + c_v\,(\Delta T)$$

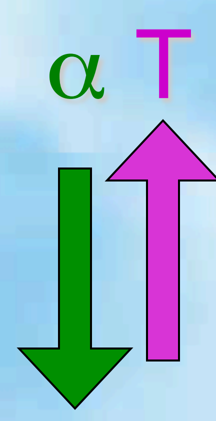
change in heat energy — change in volume — change in temperature

for adiabatic cooling, $\Delta H = 0$



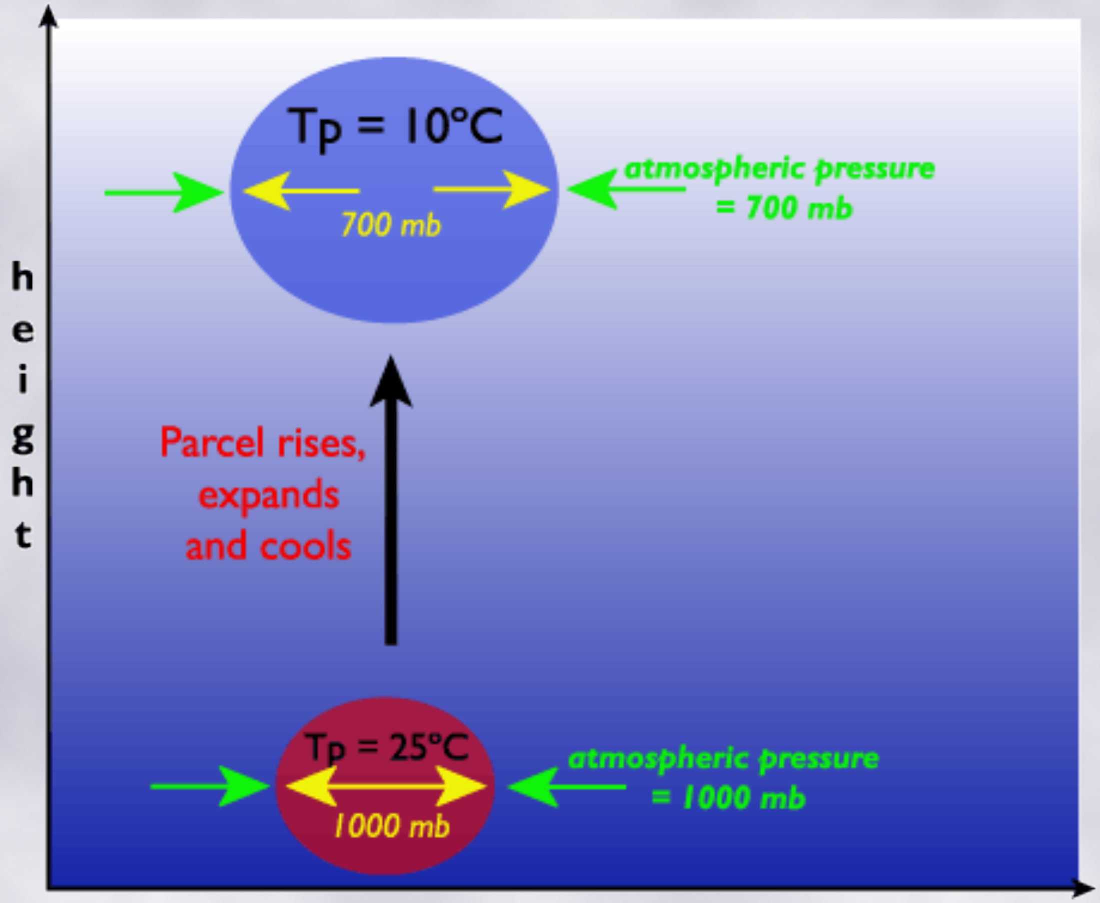
$$-\,c_v\,(\Delta T) = p(\Delta\alpha)$$

temperature — volume



Adiabatic Cooling

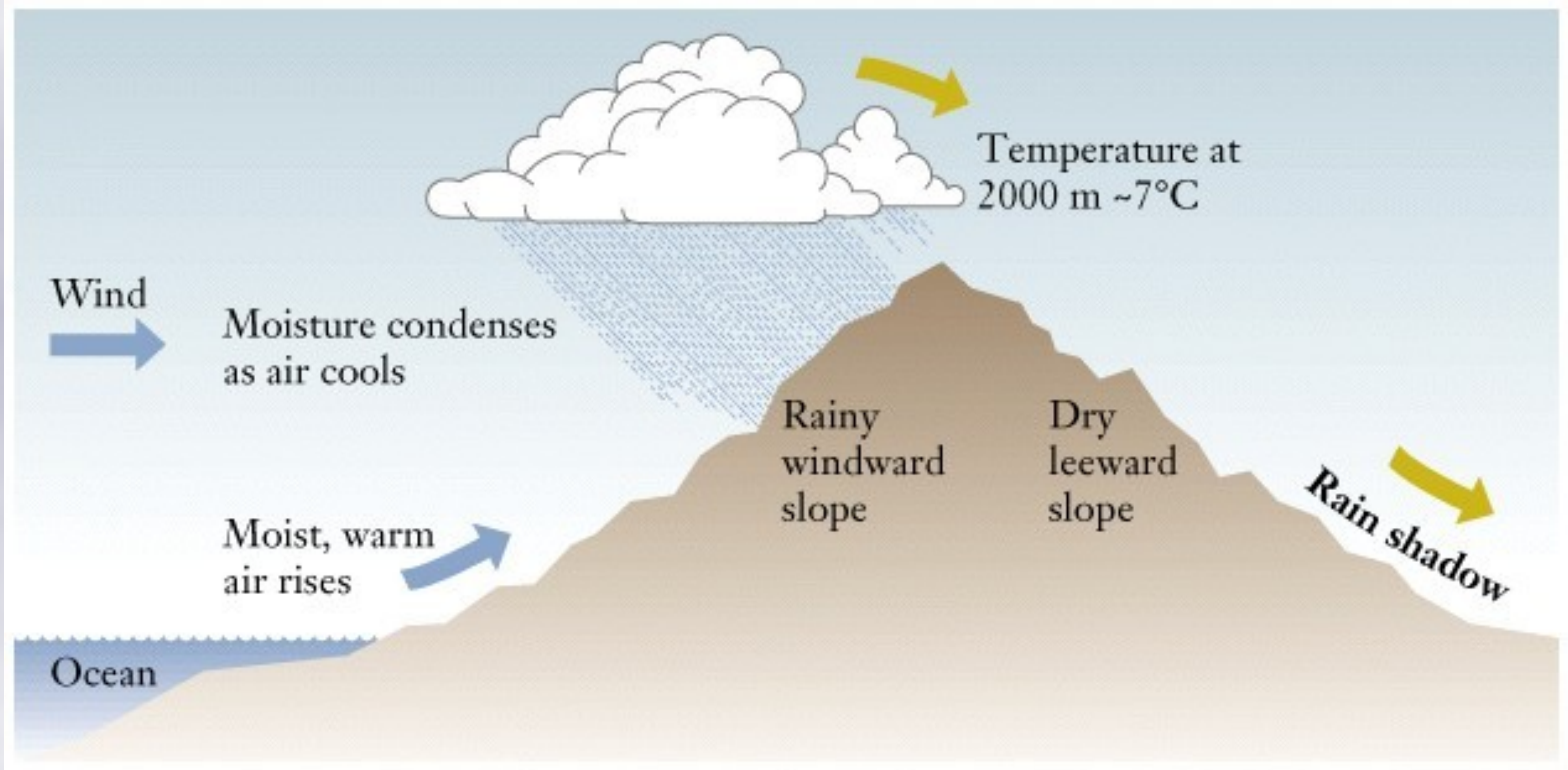
As a parcel of air rises and expands, it cools



When the parcel has cooled to the dew point, condensation occurs and clouds form

http://apollo.lsc.vsc.edu/

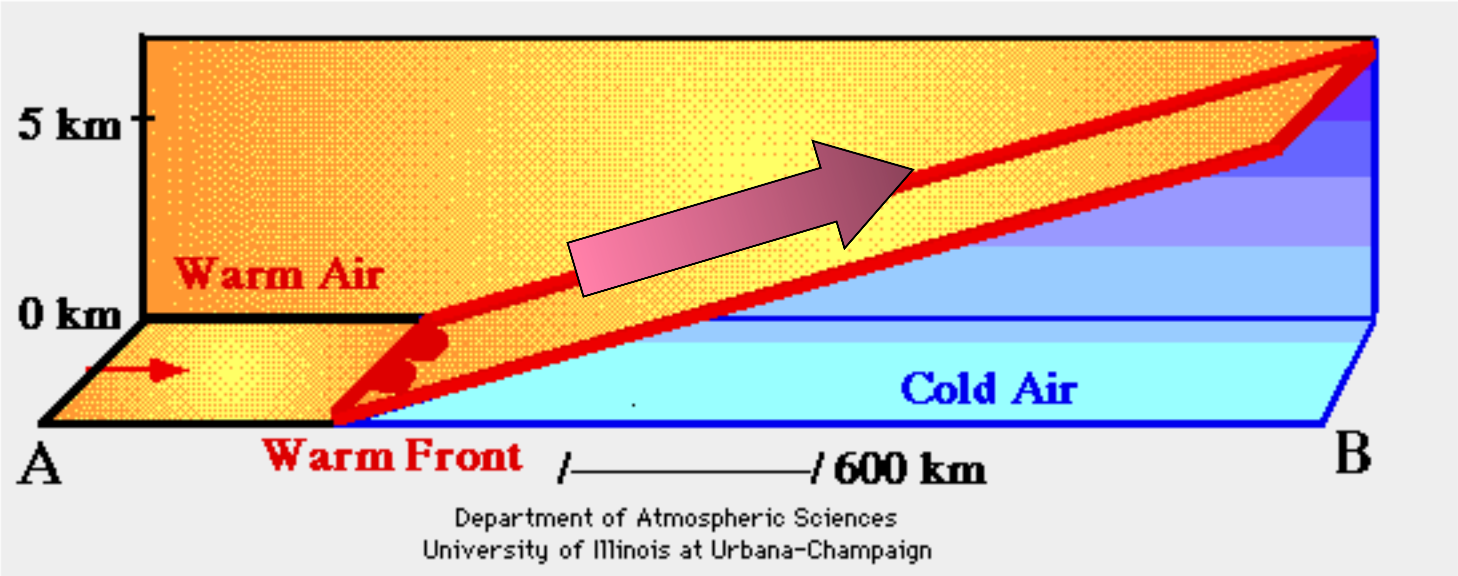
Orographic Lifting



http://www.cyber.vt.edu/geog1014/

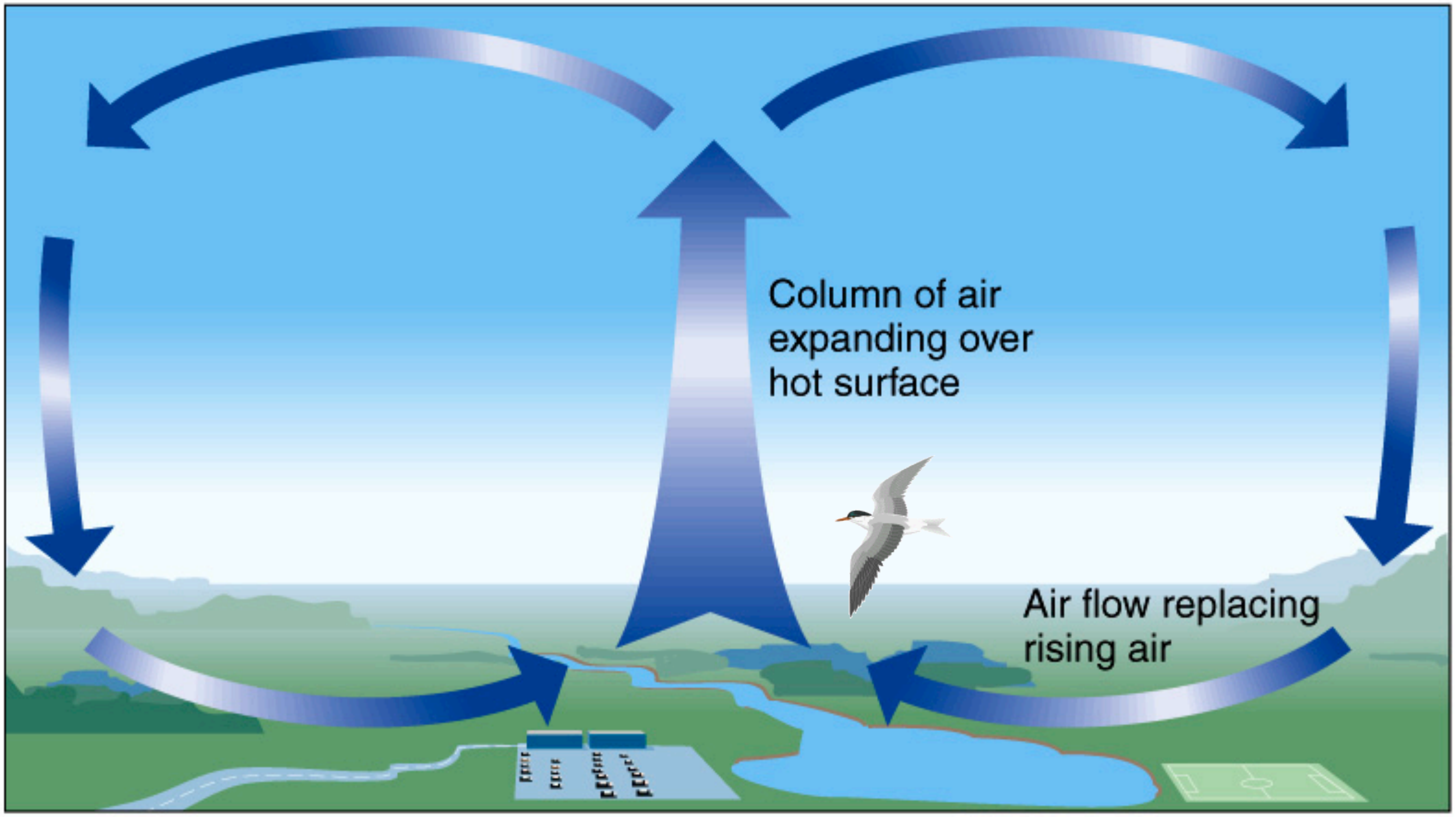
Frontal Wedging

warm parcel of air rises over cold parcel of air



http://ww2010.atmos.uiuc.edu/(Gh)

Local Convection



Watch for birds spiraling upwards on "thermals" created by local convection off large parking lots

http://www.uwinnipeg.ca/~blair/0203/met2002/sep26.htm

Atmospheric Stability and Instability

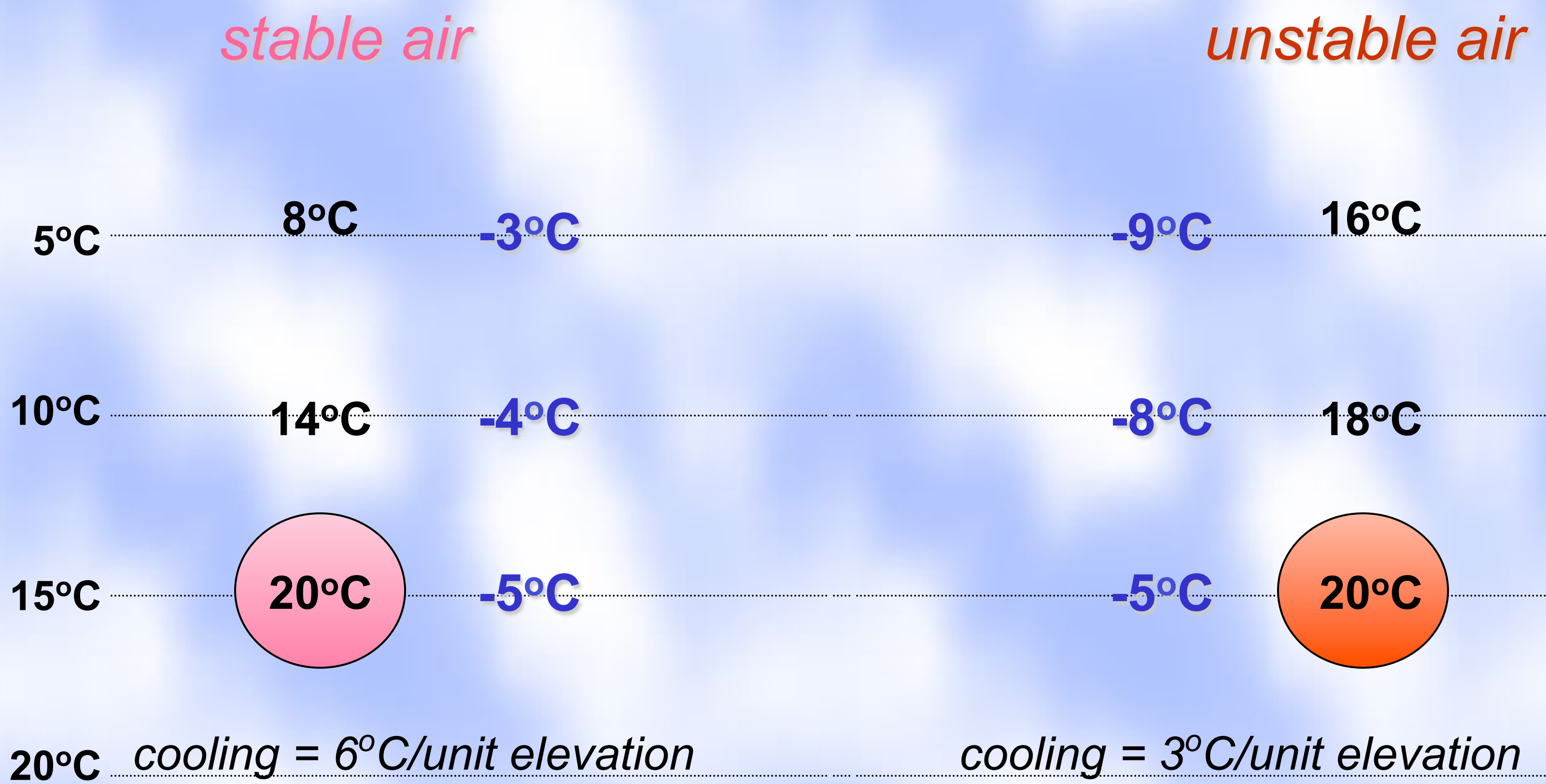
Parcels of air will rise as long as the temperature of the parcel is greater than the surrounding air.

For stable air, there is some elevation during rising where the internal and external temperatures equalize, and the parcel will not rise any further

For unstable air, that equilibrium point is never reached by the rising air, and the hot parcel of air displaces the cold air above, causing turnover.

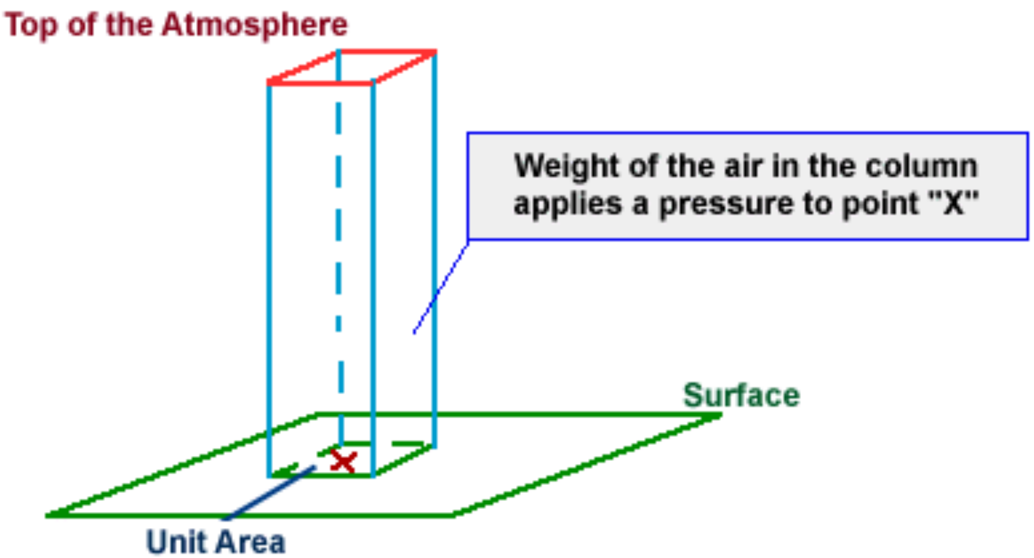
Stable and Unstable Air

As warm air rises, it expands and cools adiabatically

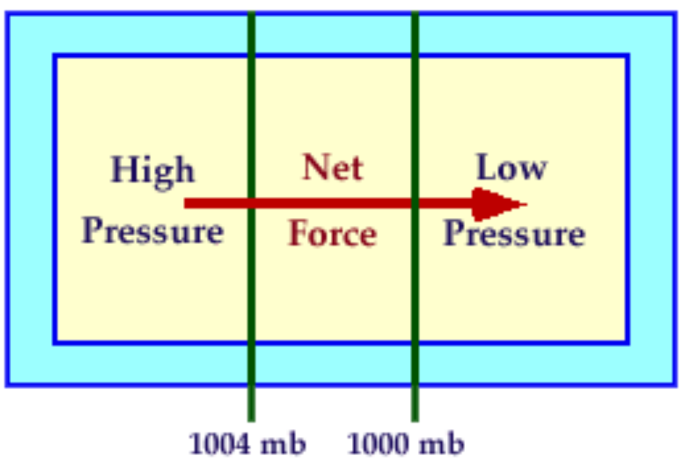


If the cooling is slower than the rate at which the surrounding air cools with elevation (the *environmental lapse rate*), then the parcel will remain warmer than the air through which it rises.

Atmospheric Pressure



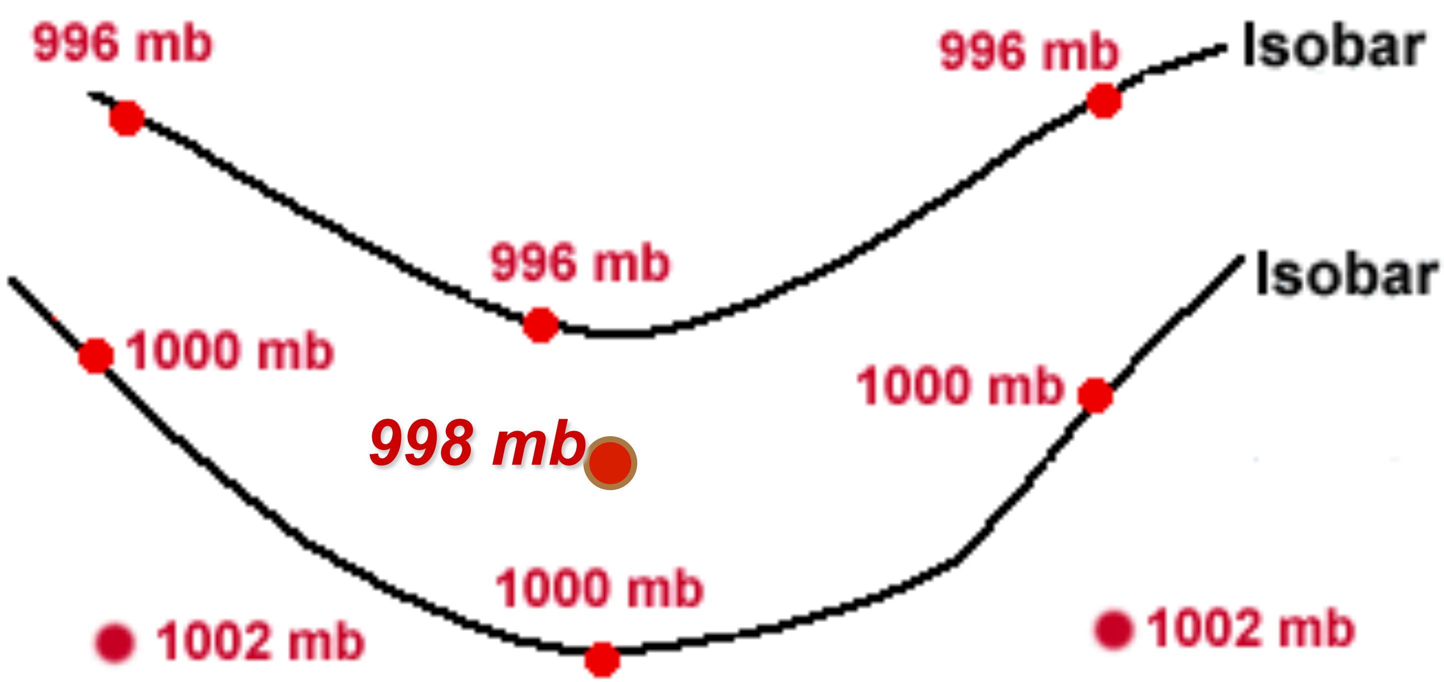
The amount of air "pressing down" determines pressure.



In general, air (and thus wind) flows from high pressure to low pressure.

Atmospheric Pressure

Weather maps usually display *isobars* (lines connecting points of equal pressure, like contour lines on a topographic map).



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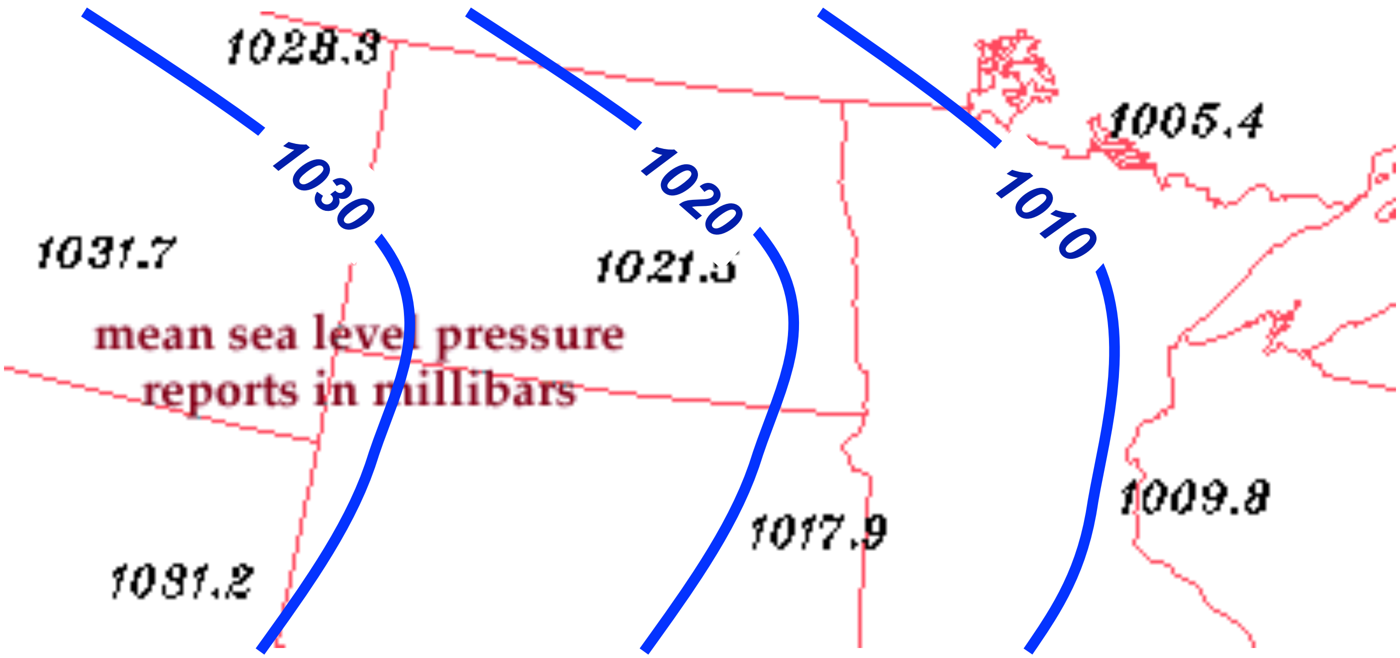
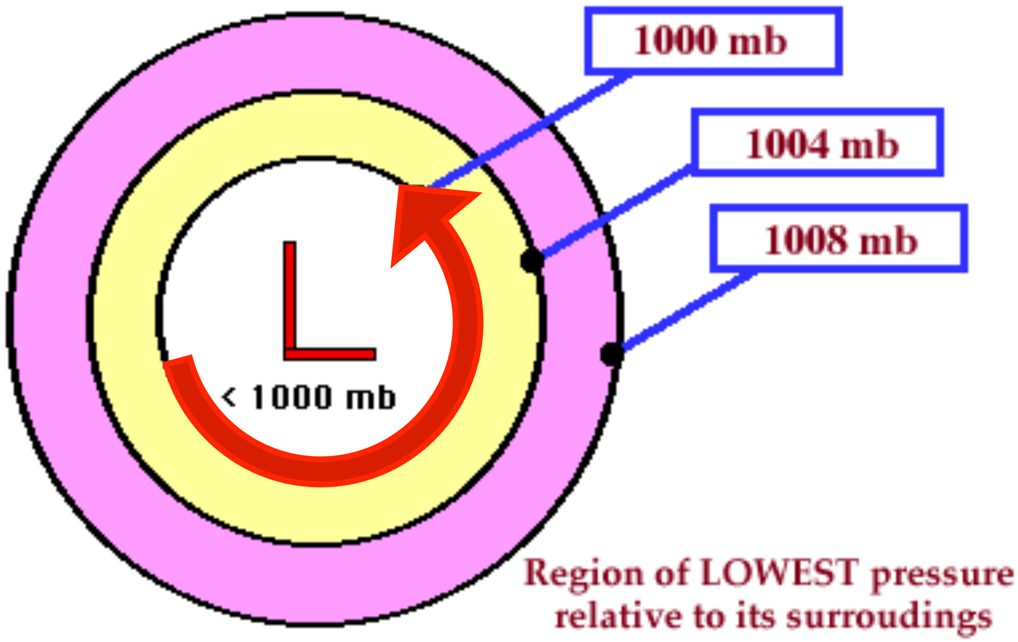
Atmospheric Pressure



http://ww2010.atmos.uiuc.edu/

Low Pressure Systems

Northern Hemisphere

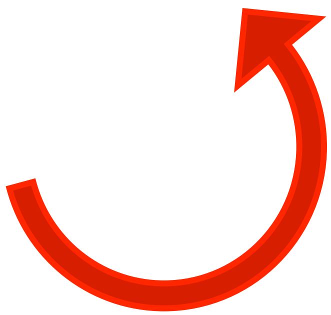


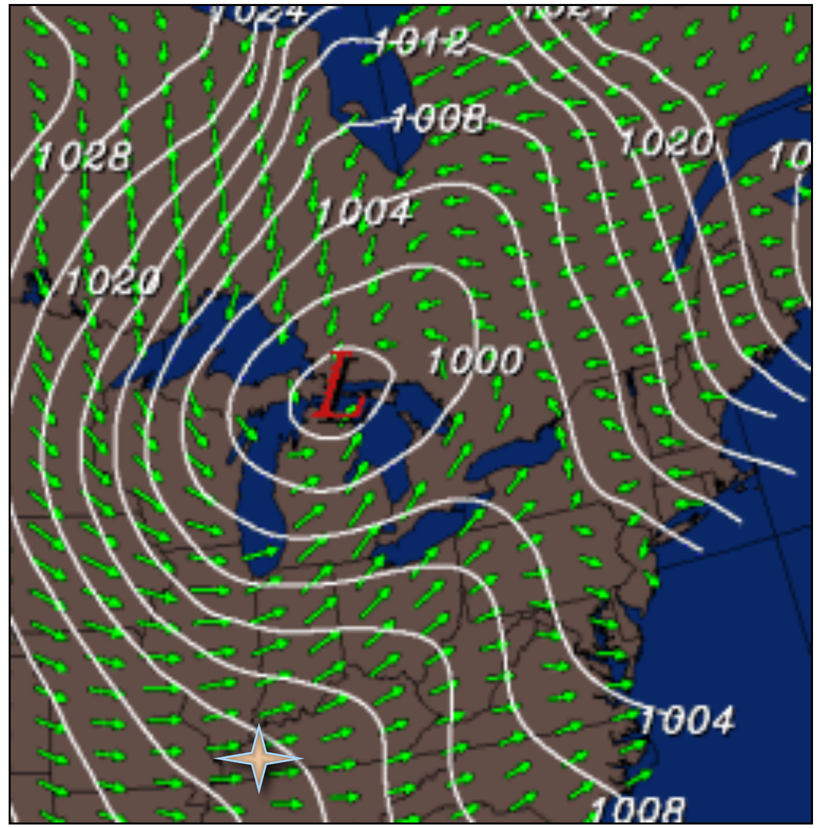
Winds tend to spiral in counter-clockwise to the center of a low pressure system (cyclone)

http://ww2010.atmos.uiuc.edu/

Low Pressure System

Northern Hemisphere

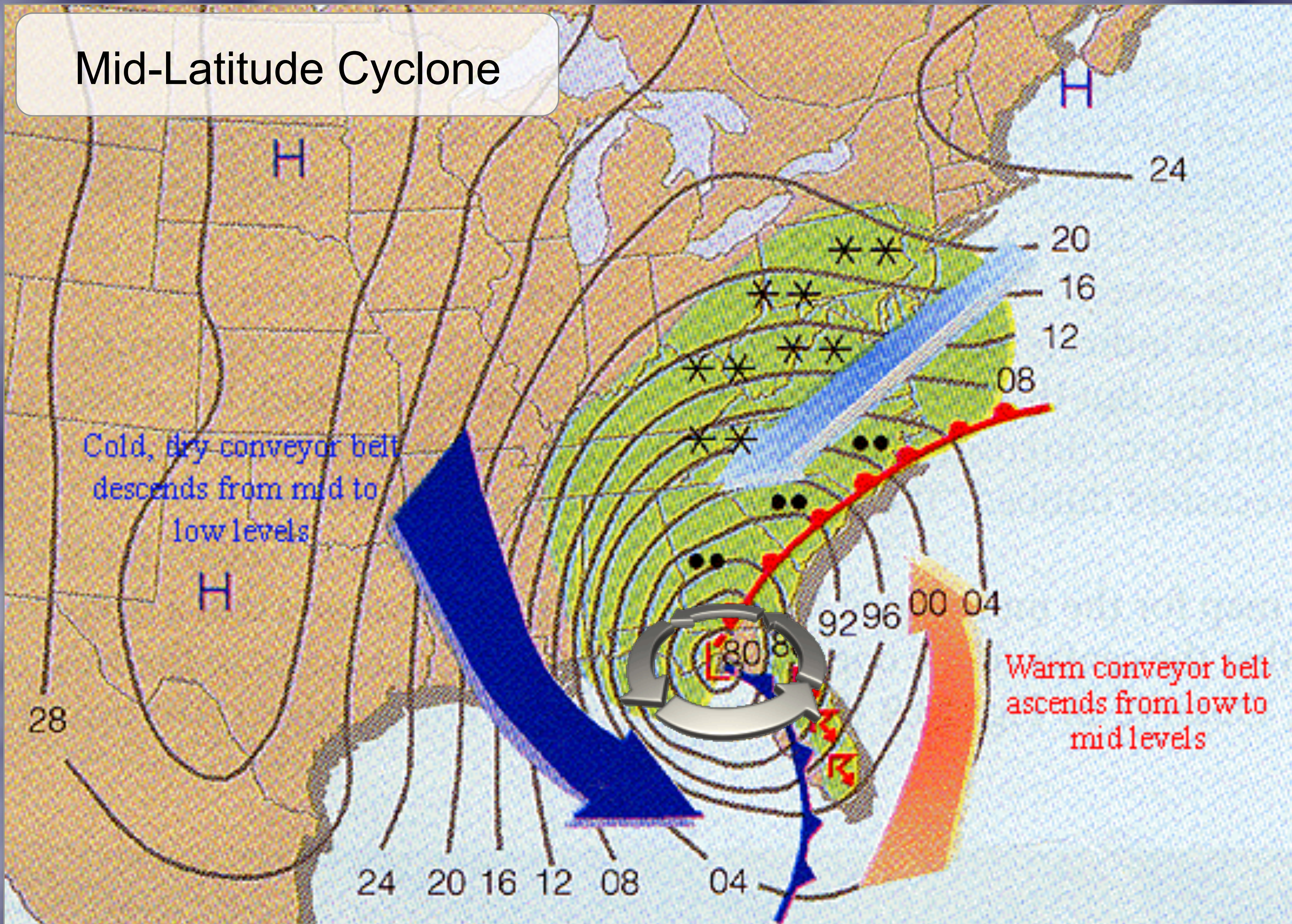




Winds tend to spiral in counter-clockwise from the center of a low pressure system (cyclone)

http://ww2010.atmos.uiuc.edu/

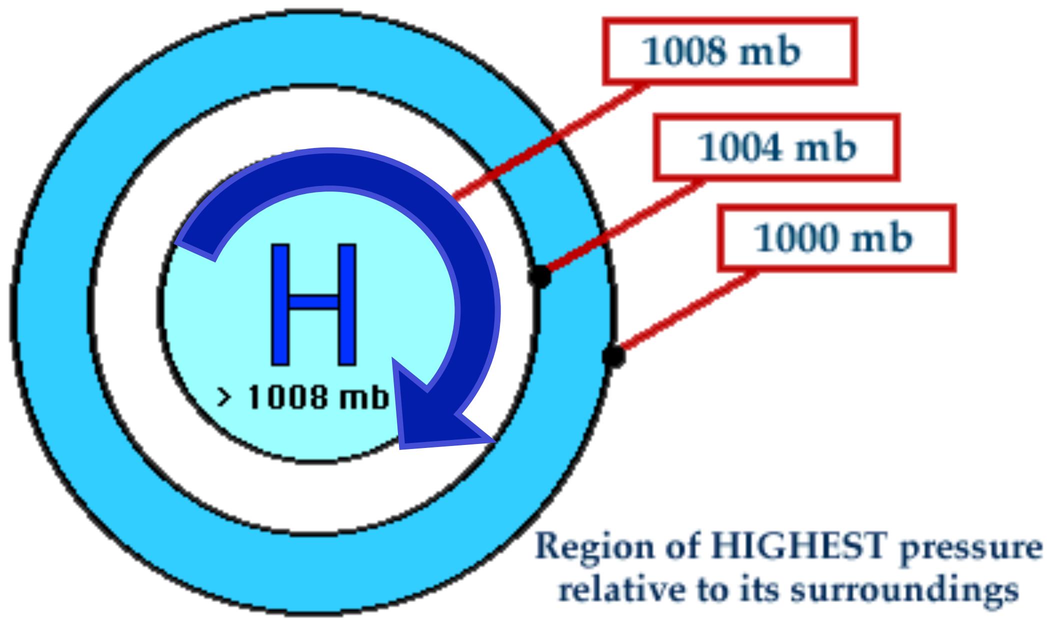
Mid-Latitude Cyclone



http://apollo.lsc.vsc.edu/classes/met130/notes/chapter13/warm_cold_conveyor.html

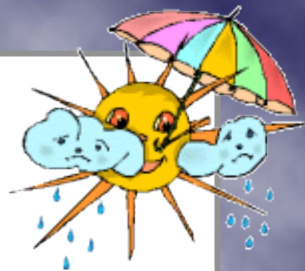
High Pressure System

Northern Hemisphere



Winds tend to spiral out clockwise from the center of a high pressure system (anti-cyclone)

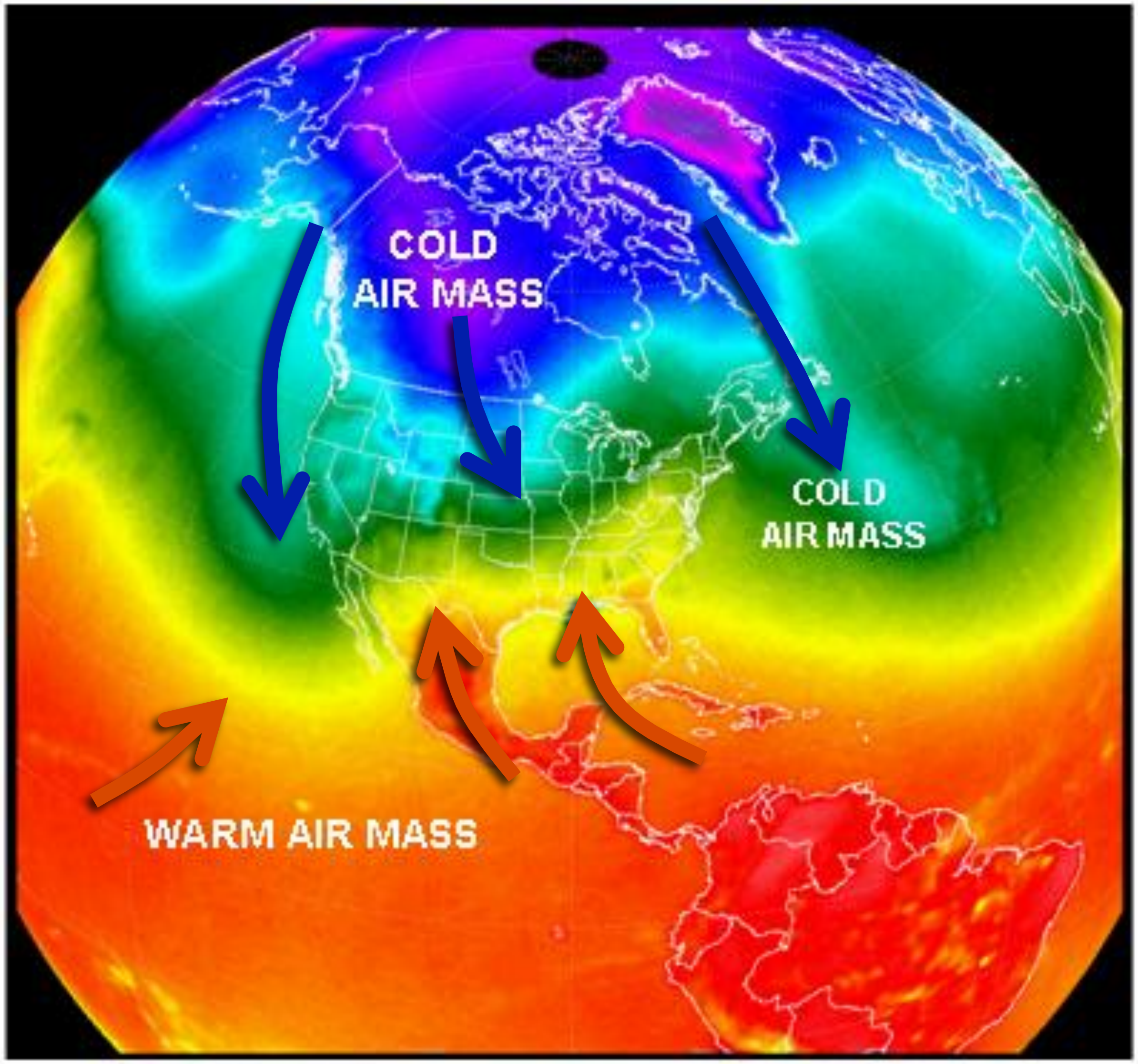
http://ww2010.atmos.uiuc.edu/



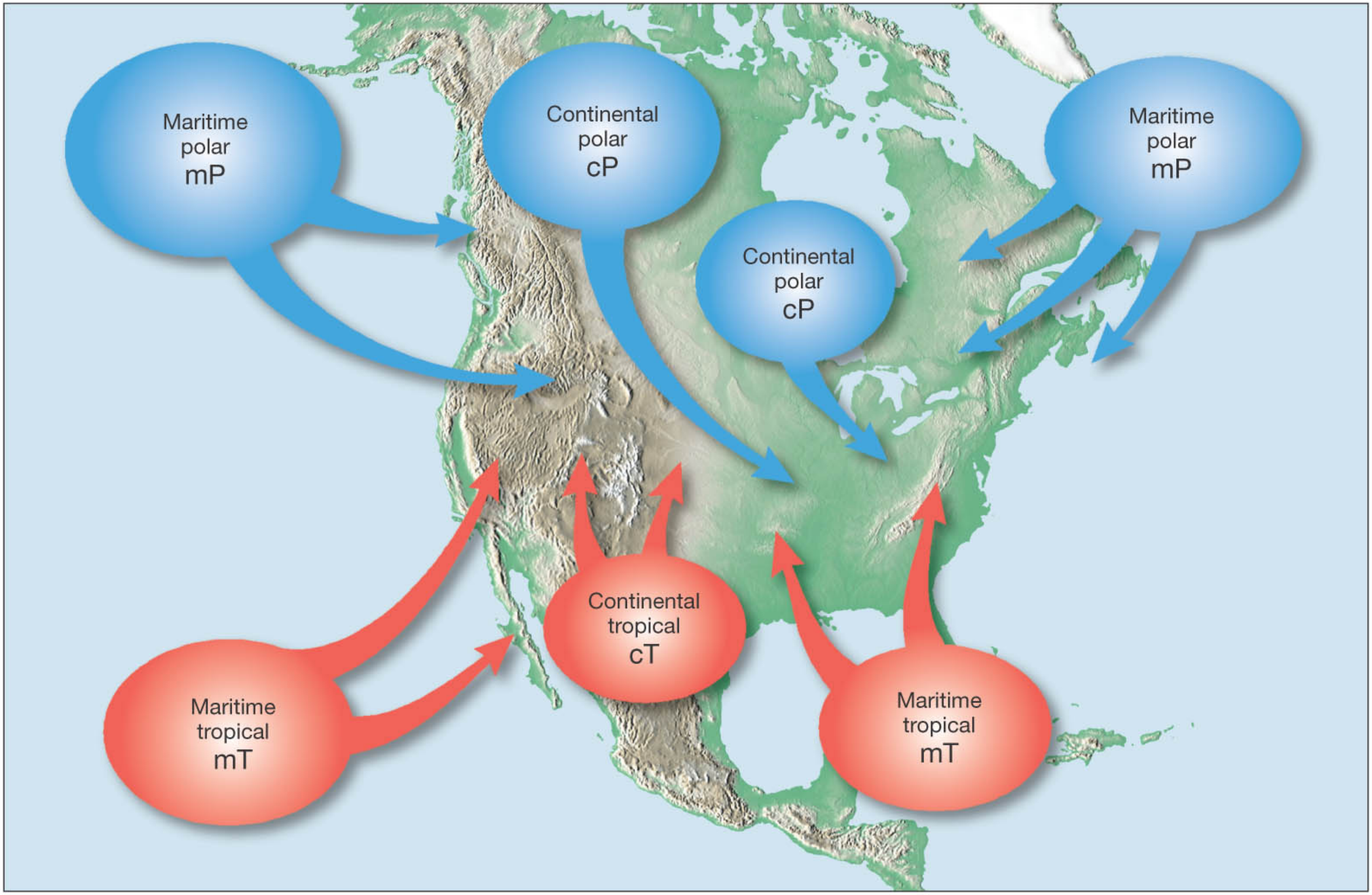
Air Masses

Extensive body of air (100's of miles horizontal extent) with mostly uniform temperature, moisture content, and atmospheric pressure

Interactions of air masses cause many kinds of large weather system.



http://www.weatherquestions.com/What_is_an_air_mass.htm


Maritime
polar
mP
Continental
polar
cP
Maritime
polar
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polar
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Continental
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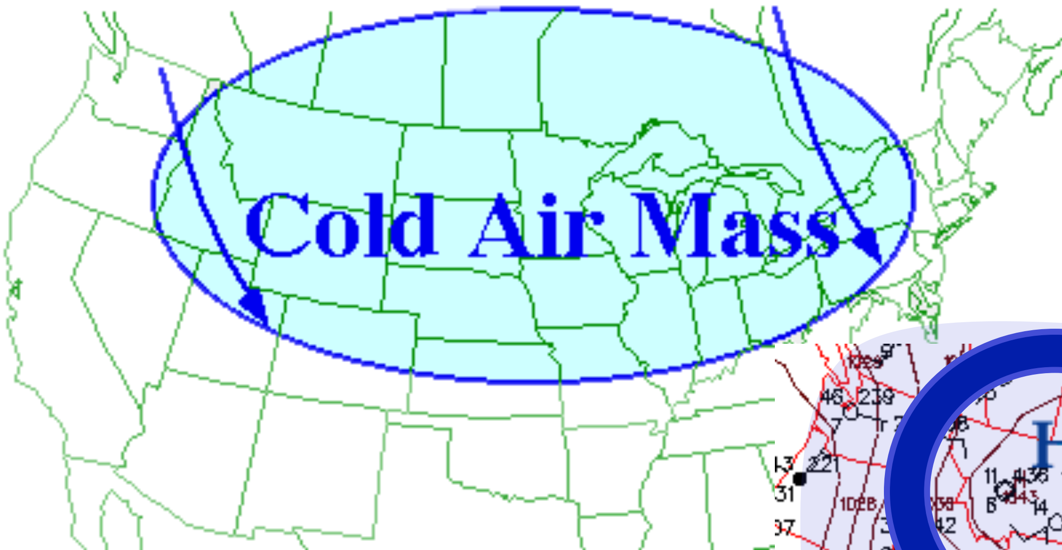
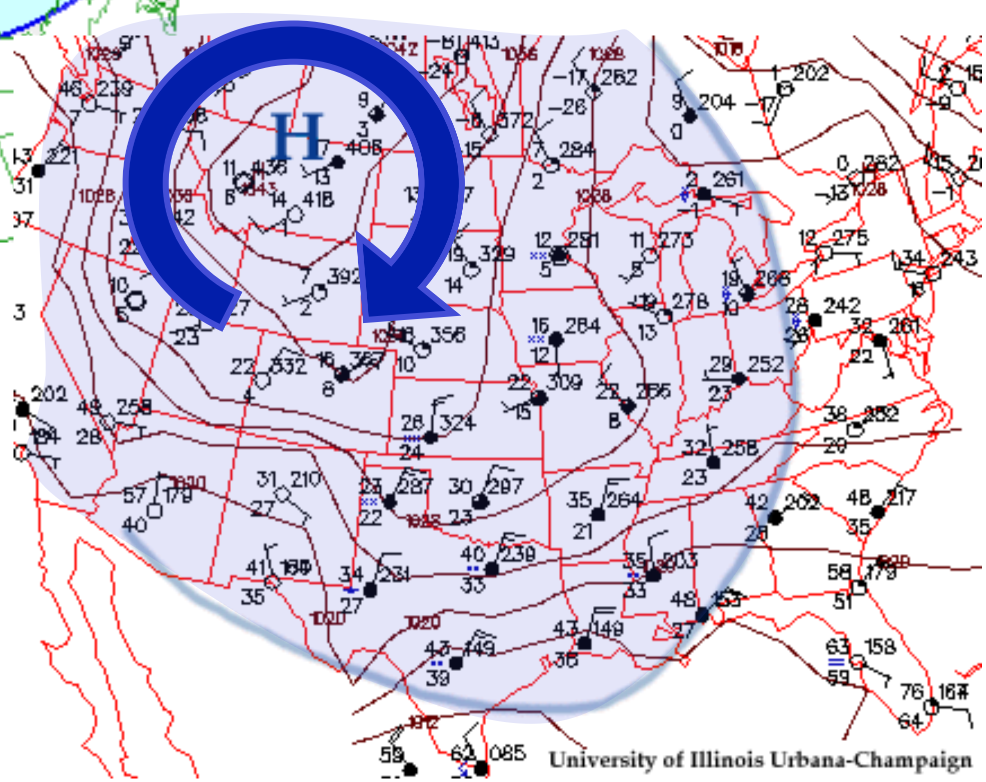
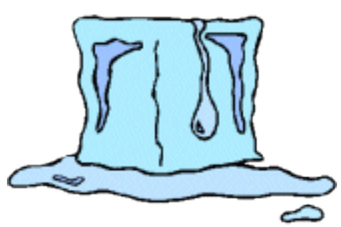
Maritime
tropical
mT



Continental Polar Air Mass



high pressure, cold, dry



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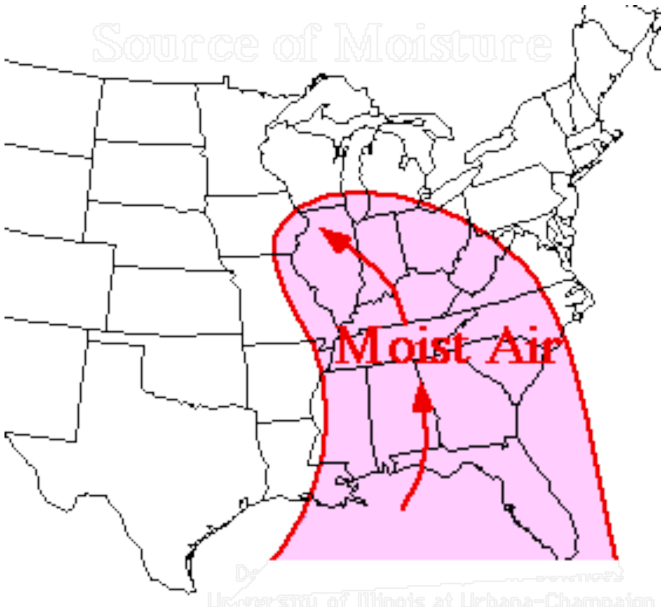
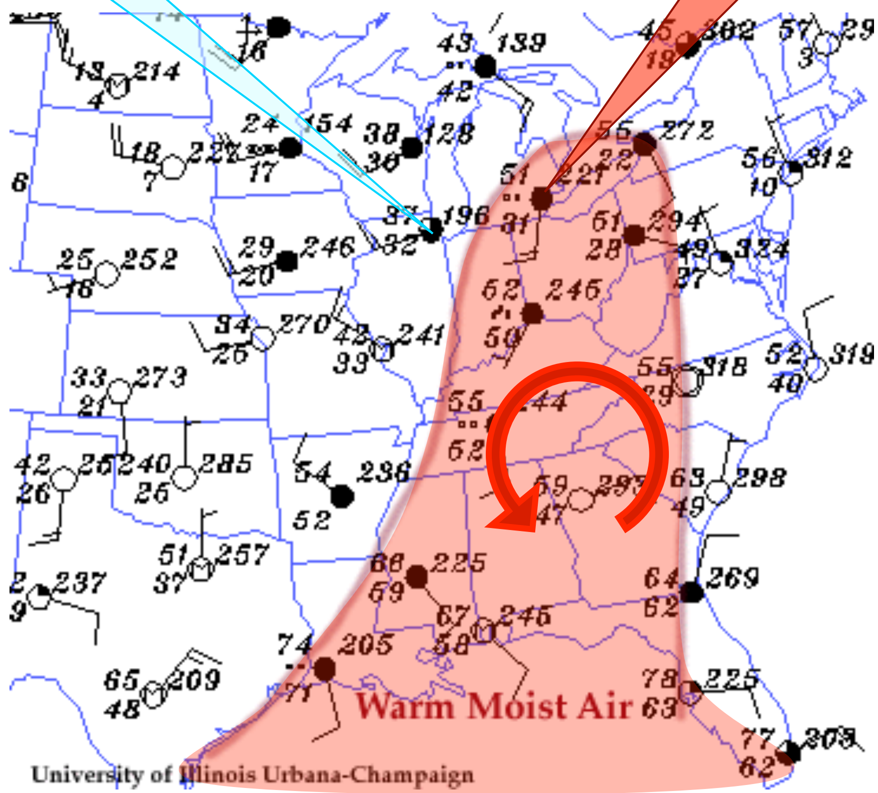


Maritime Tropical Air Mass

37^{o}F

51^{o}F



low pressure, warm, wet

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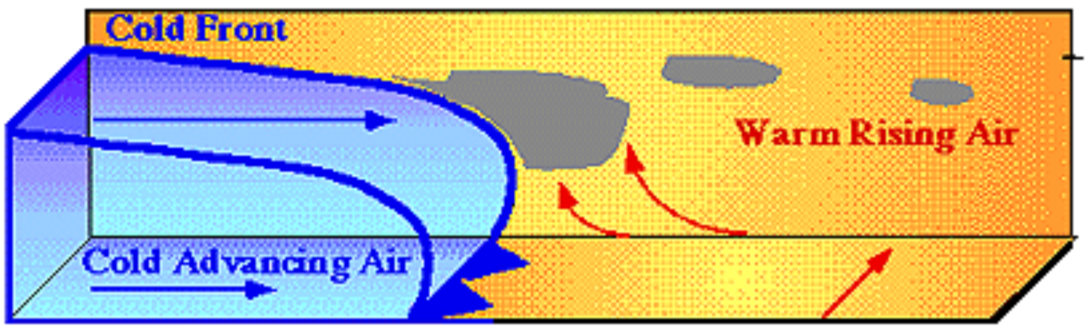
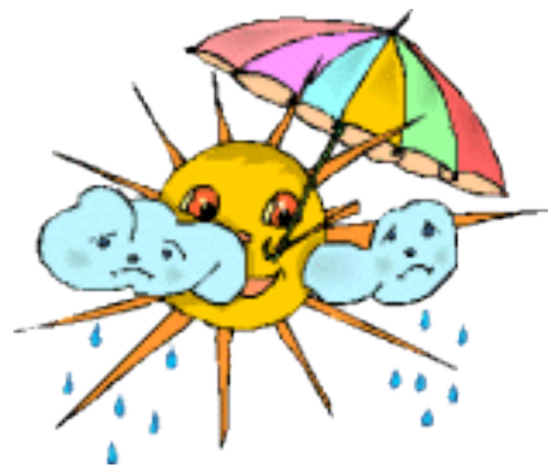
Front - interaction between two air masses with different characteristics (pressure, temperature, moisture content)





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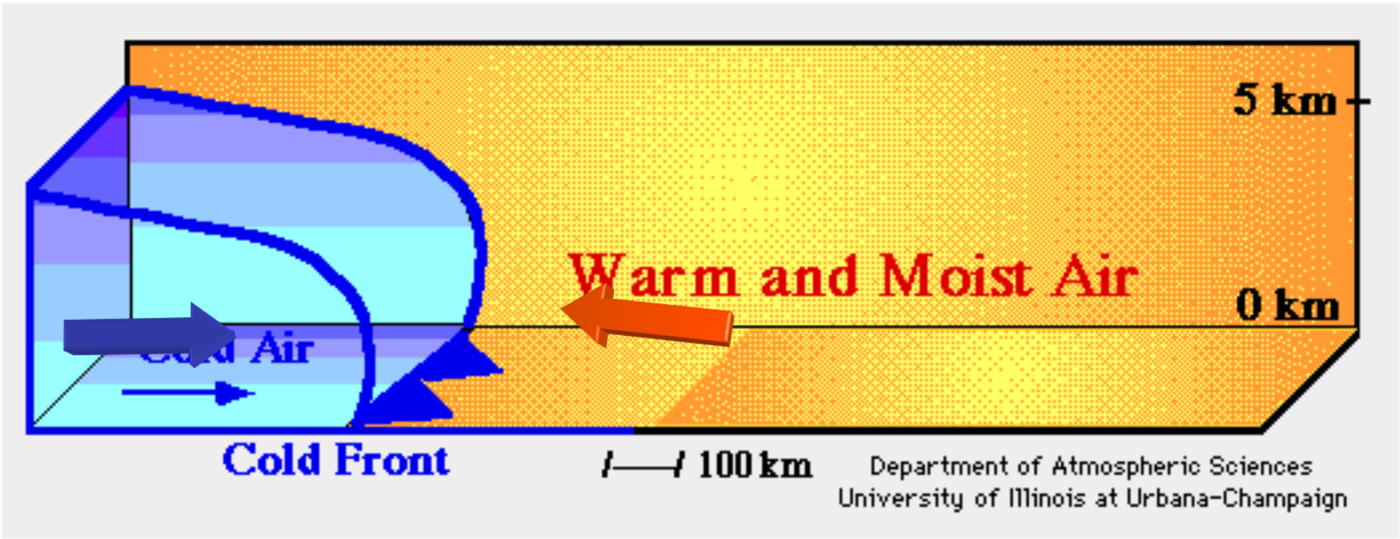
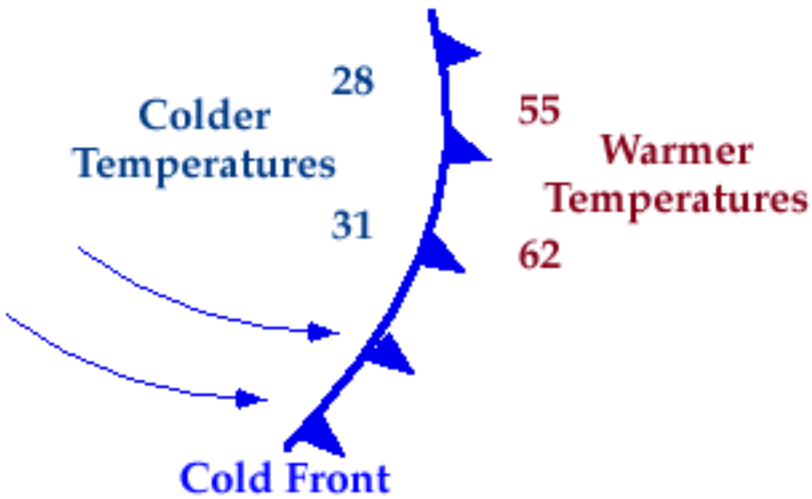
Cold Front



Cold air mass moves through warm air mass

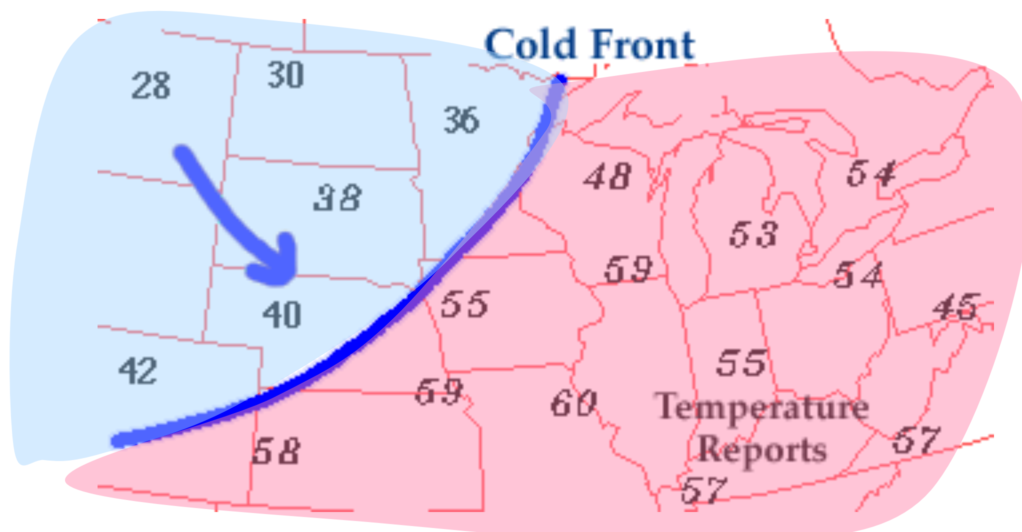
http://ww2010.atmos.uiuc.edu/(Gh)

Cold Front



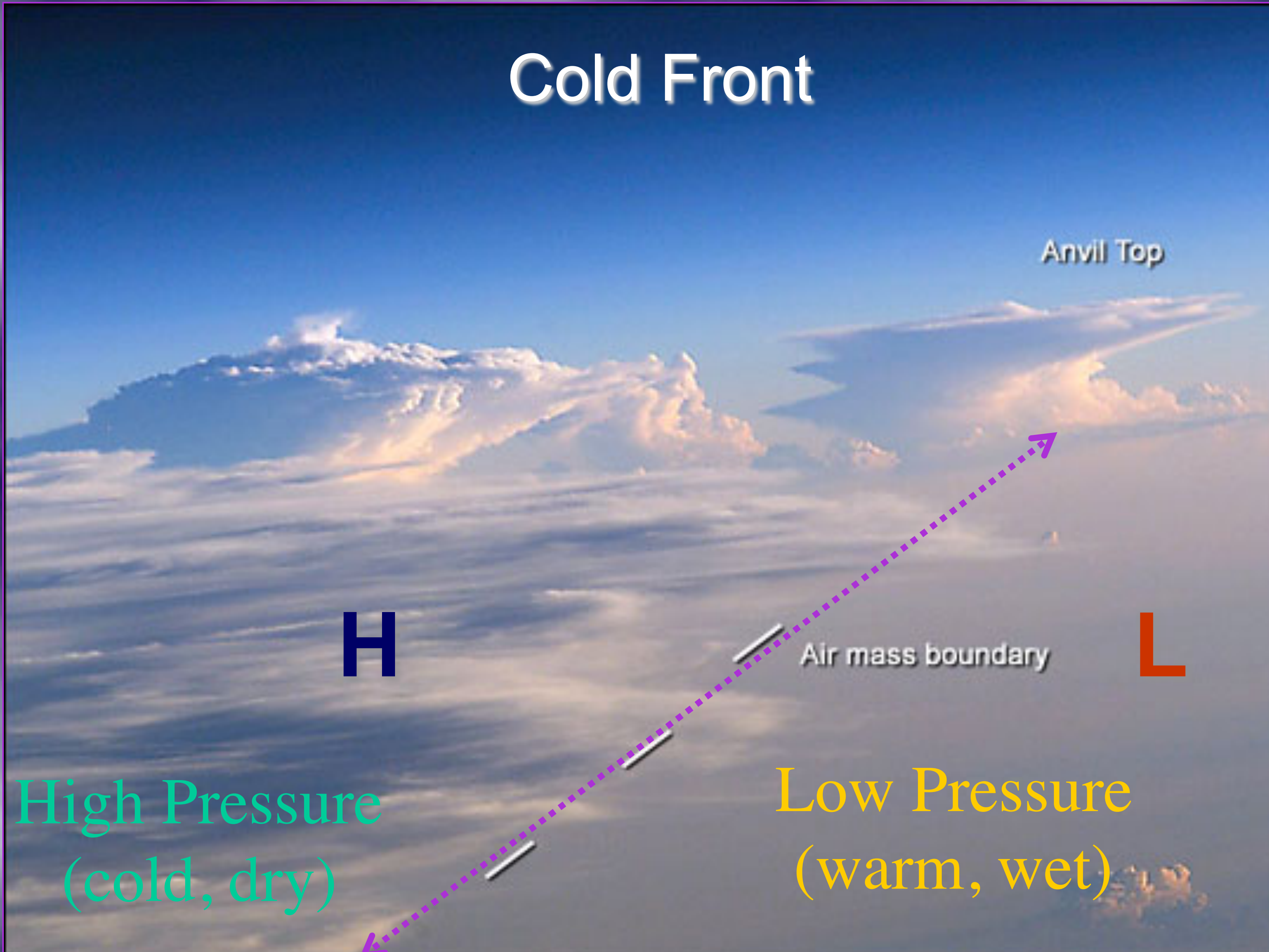
Moving front in which cold air mass replaces warm air mass

Sharp drop in temperature leads to precipitation and storms as front passes, followed by clear weather.



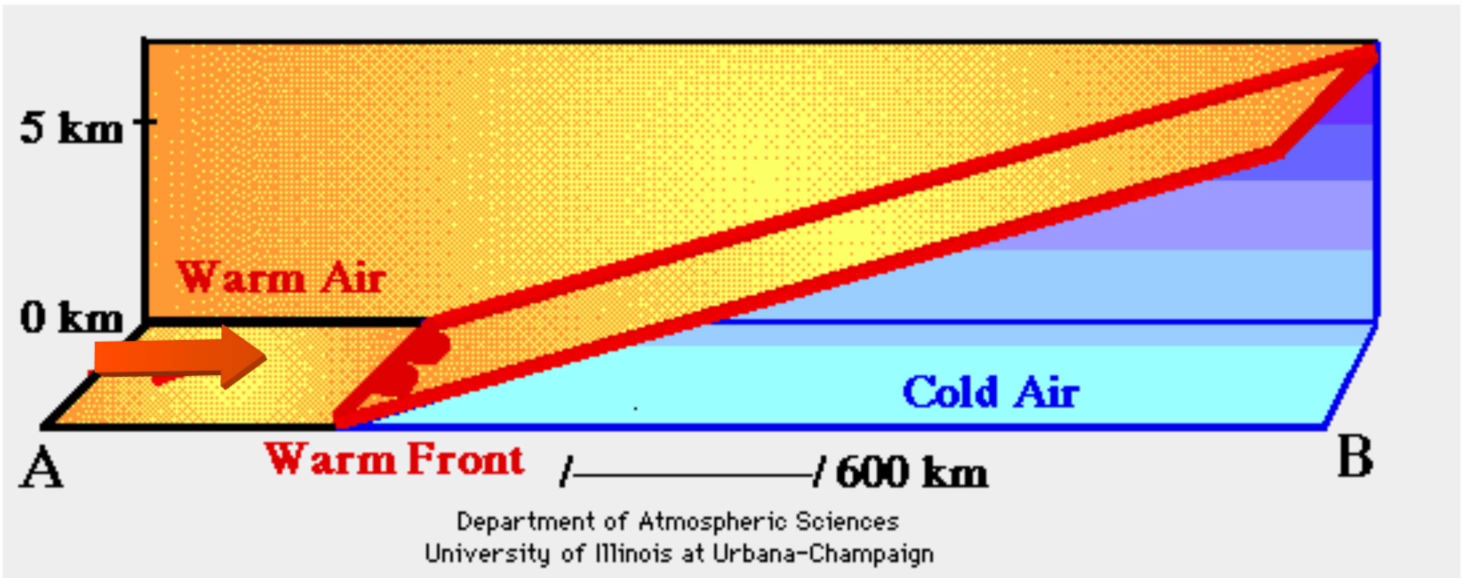
http://ww2010.atmos.uiuc.edu/(Gh)

Cold Front



http://earthobservatory.nasa.gov/

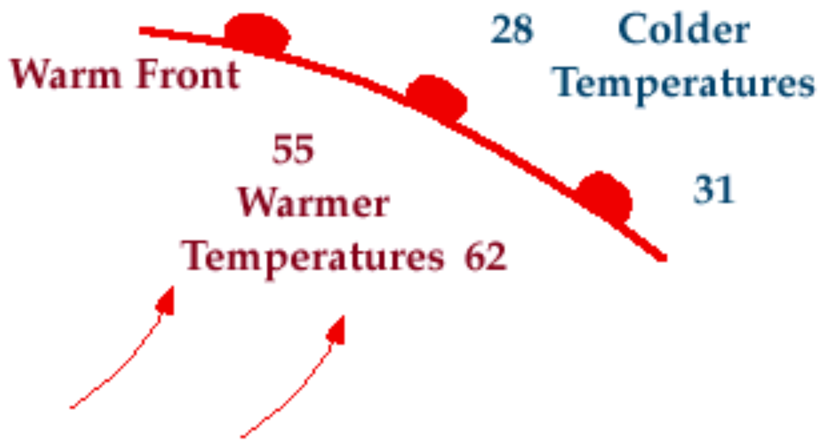
Warm Front



Warm air mass moves through cold air mass

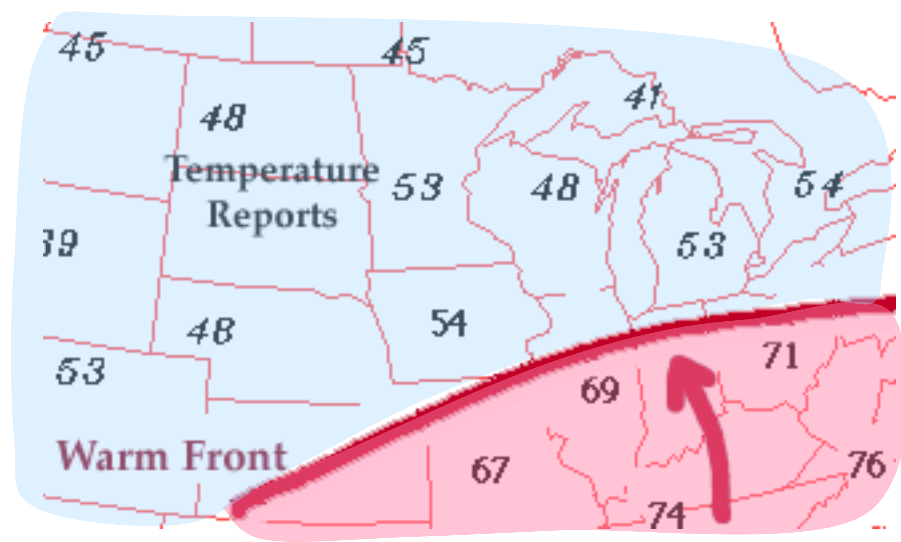
http://ww2010.atmos.uiuc.edu/(Gh)

Warm Front



Moving front in which warm air mass replaces cold air mass

Mixture leads to precipitation before and during frontal pass, followed by hazy and sometimes drizzly weather.



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