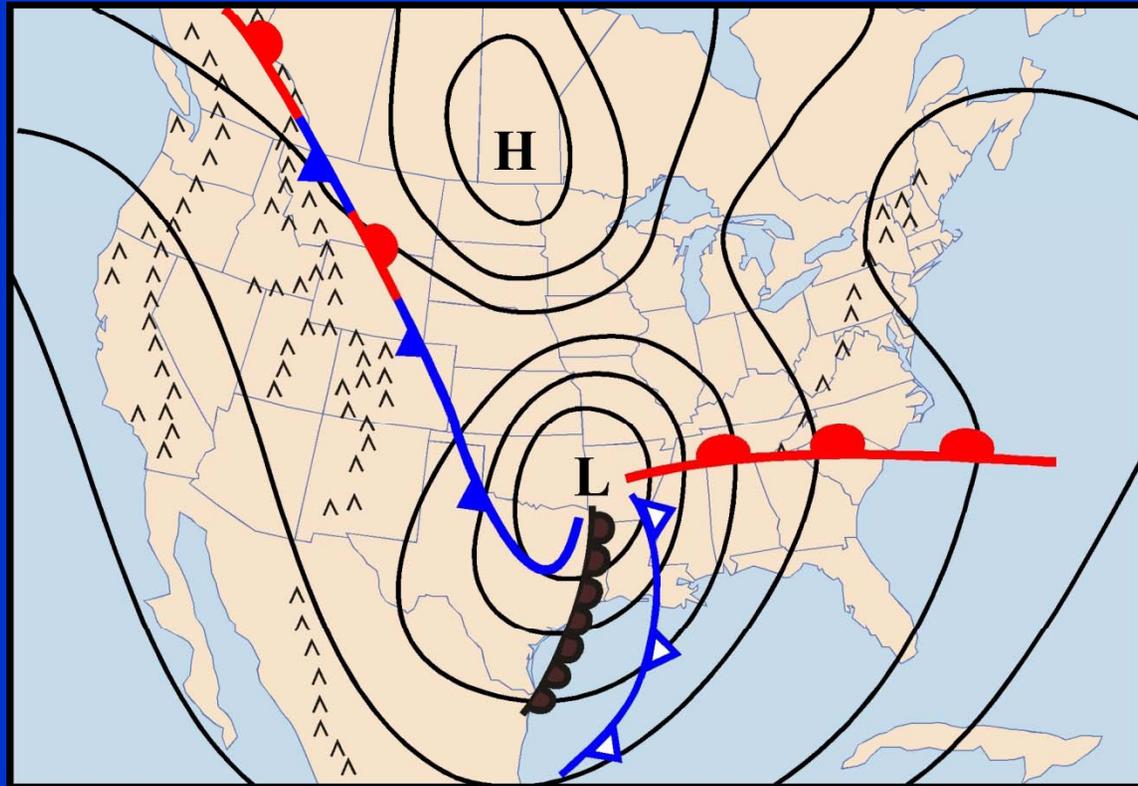


Chapter 9 : Air Mass



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- Air Masses
- Fronts
- Fronts on Weather Maps



- **Air masses**

Contain uniform temperature and humidity characteristics.

- **Fronts**

Boundaries between unlike air masses.



Air Masses

- Air masses have fairly uniform temperature and moisture content in horizontal direction (but not uniform in vertical).
- Air masses are characterized by their temperature and humidity properties.
- The properties of air masses are determined by the underlying surface properties where they originate.
- Once formed, air masses migrate within the general circulation.
- Upon movement, air masses displace residual air over locations thus changing temperature and humidity characteristics.
- Further, the air masses themselves moderate from surface influences.



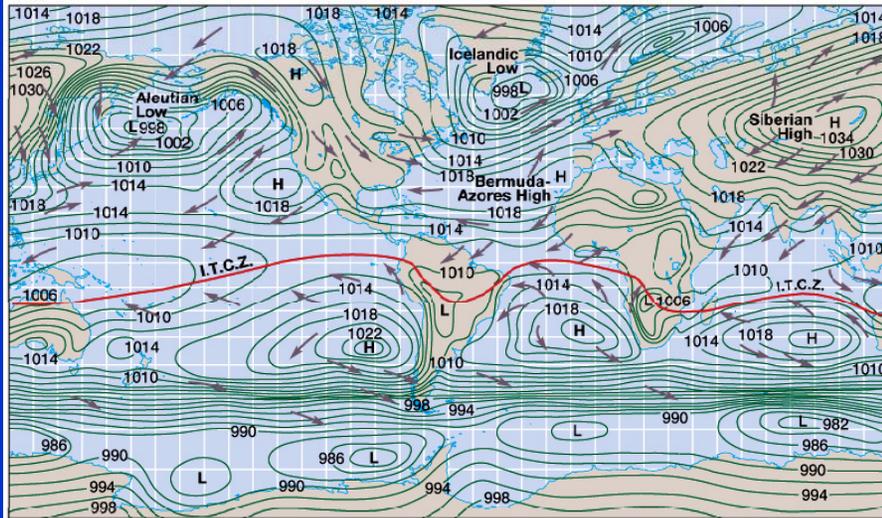
Source Regions

- The areas of the globe where air masses form are called source regions.
- A source region must have certain temperature and humidity properties that can remain fixed for a substantial length of time to affect air masses above it.
- Air mass source regions occur only in the high or low latitudes; middle latitudes are too variable.

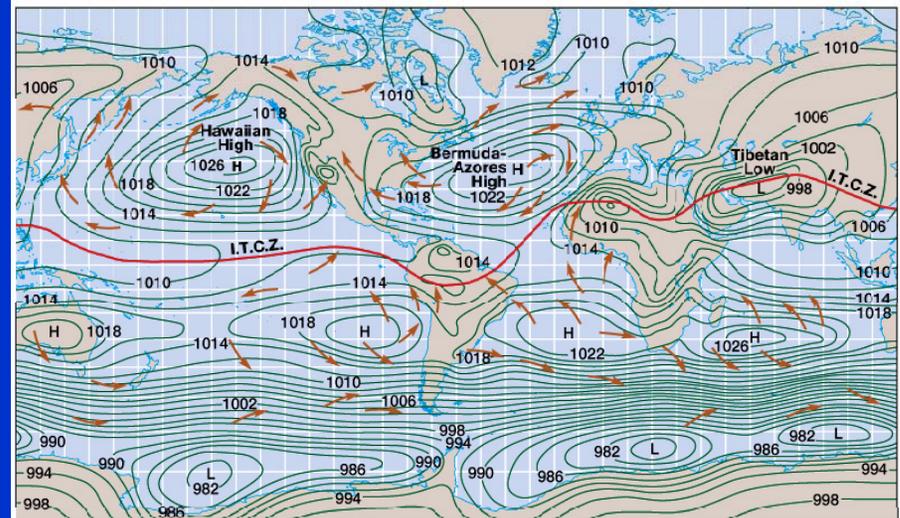


Cold Air Masses

January



July

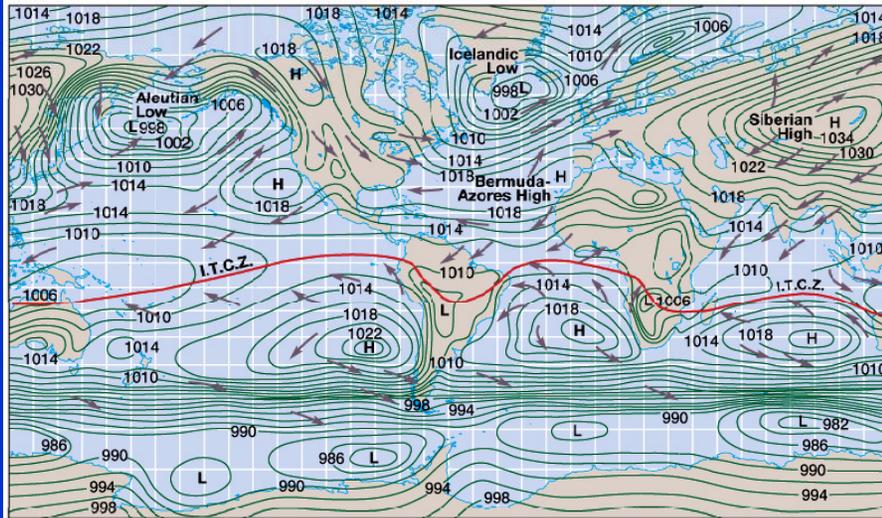


- The centers of cold air masses are associated with high pressure on surface weather maps.
- In summer, when the oceans are cooler than the landmasses, large high-pressure centers appear over North Atlantic (*Bermuda high*) and Pacific (*Pacific high*).
- In winter, high-pressure centers form over the northern parts of Asian continent (*Siberian high*) and North America.

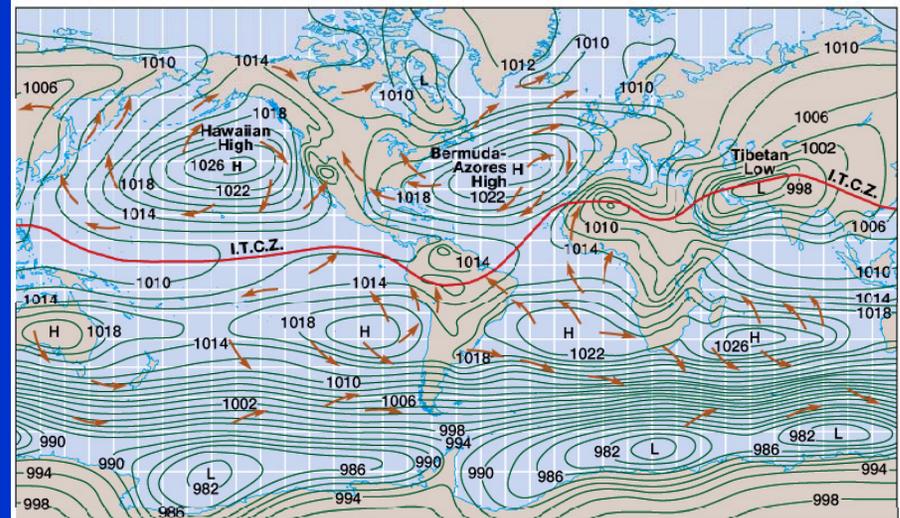


Warm Air Masses

January



July



- The centers of very warm air masses appear as semi-permanent regions of low pressure on surface weather maps.
- In summer, low-pressure areas appear over desert areas such as American Southwest, Southeast Asia, Central Africa, and near the equator.
- In winter, the semi-permanent low-pressure appear over the northern Pacific (Aleutian low) and northern Atlantic (Icelandic Low).



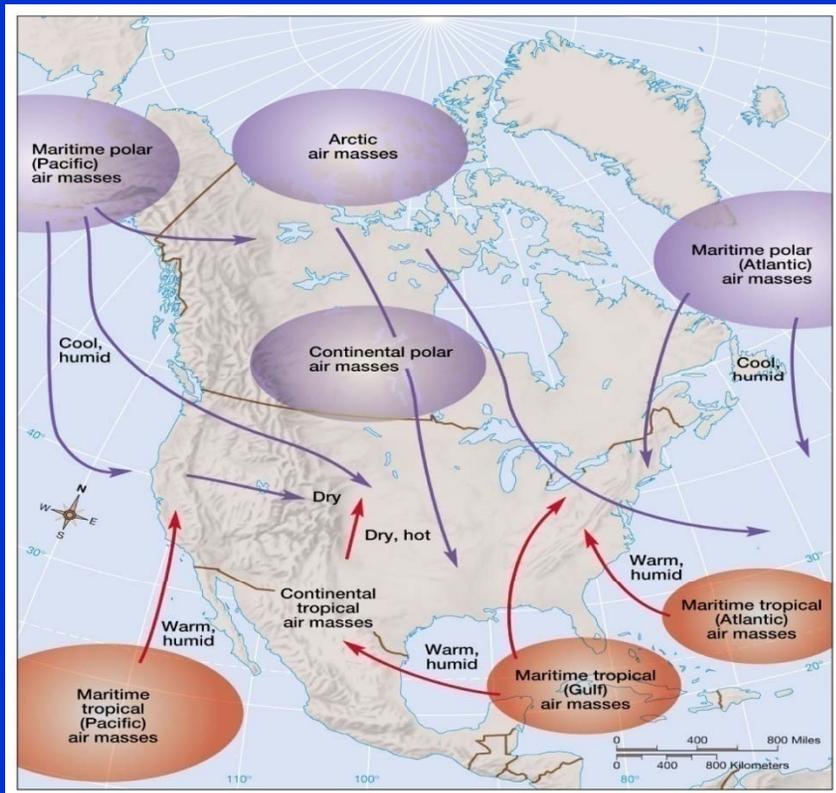
Classification of Air Masses

- Air masses are classified according to the temperature and moisture characteristics of their source regions.
- Bases on moisture content: continental (dry) and maritime (moist)
- Based on temperature: tropical (warm), polar (cold), arctic (extremely cold).
- Naming convention for air masses: A small letter (*c*, *m*) indicates the moist content followed by a capital letter (*T*, *P*, *A*) to represent temperature.



Five Types of Air Masses

- Theoretically, there should be 6 types of air masses (2 moisture types x 3 temperature types).
- But mA-type (maritime Arctic) does not exist.
- cA: continental Arctic
- cP: continental Polar
- cT: continental Tropical
- mP: maritime Polar
- mT: maritime Tropical



Continental Polar (cP) Air Mass

- Continental Polar air masses form over large, high-latitude land masses, such as northern Canada or Siberia.
- cP air masses are cold and extremely dry.
- Wintertime cooling over these land areas cause the atmosphere to become very stable (even inversion).
- The combination of dry and stable conditions ensure that few if any clouds form over a cP source region.
- Summer cP air masses are similar to winter cP, but much less extreme and remain at higher latitudes.



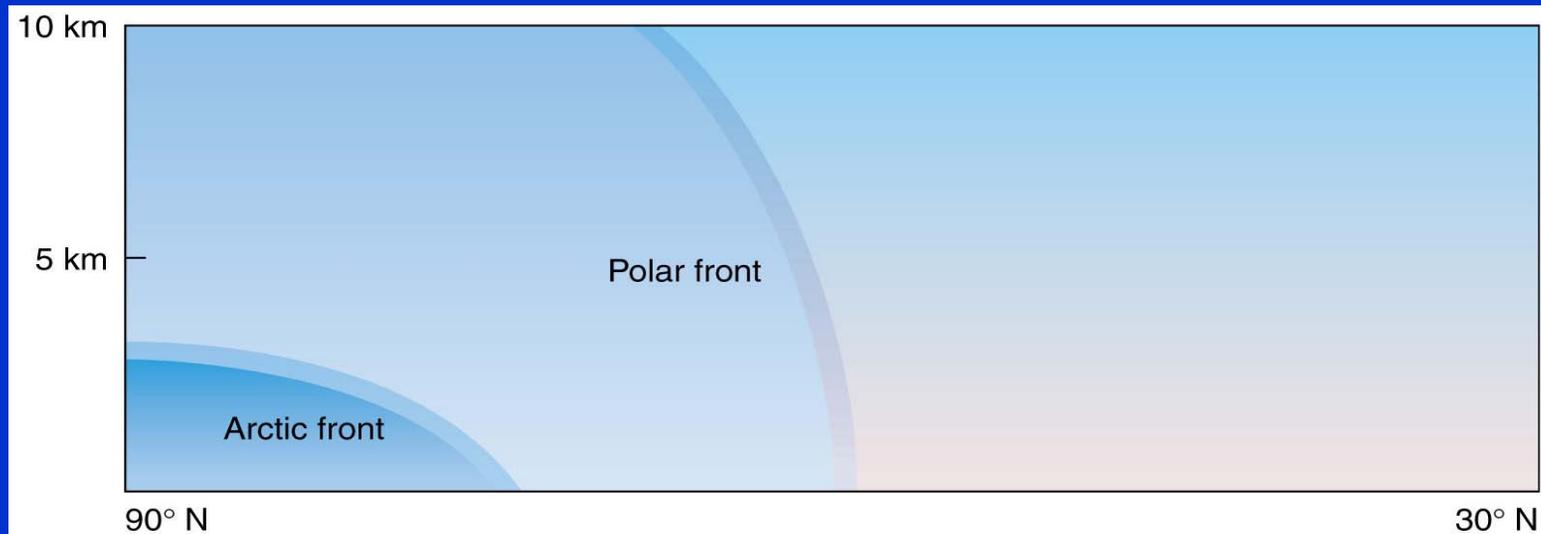
Modification of cP Air Masses



- Migrations of cP air induce colder, drier conditions over affected areas.
- As cP air migrates toward lower latitudes, it warms from beneath.
- As it warms, moisture capacity increases while stability decreases.



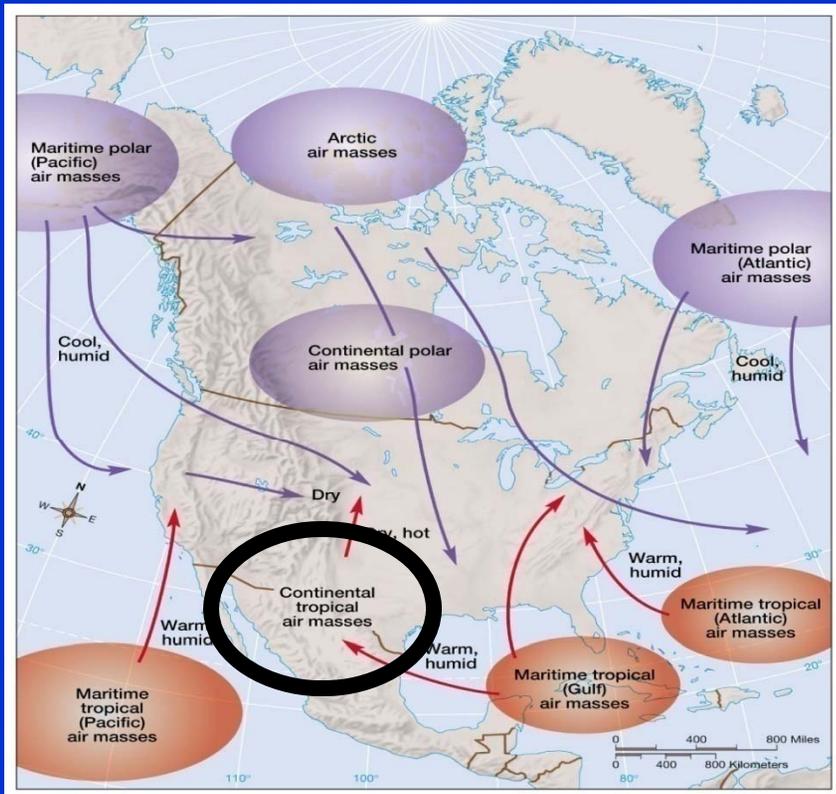
Continental Arctic (cA) Air Masses



- *Continental Arctic (cA)* air represents extremely cold and dry conditions as, due to its temperature, it contains very little water vapor.
- The boundary between cA and cP air is the shallow (~1-2 km) arctic front.
- cA air masses can extend as far southward as the Canadian-United State.



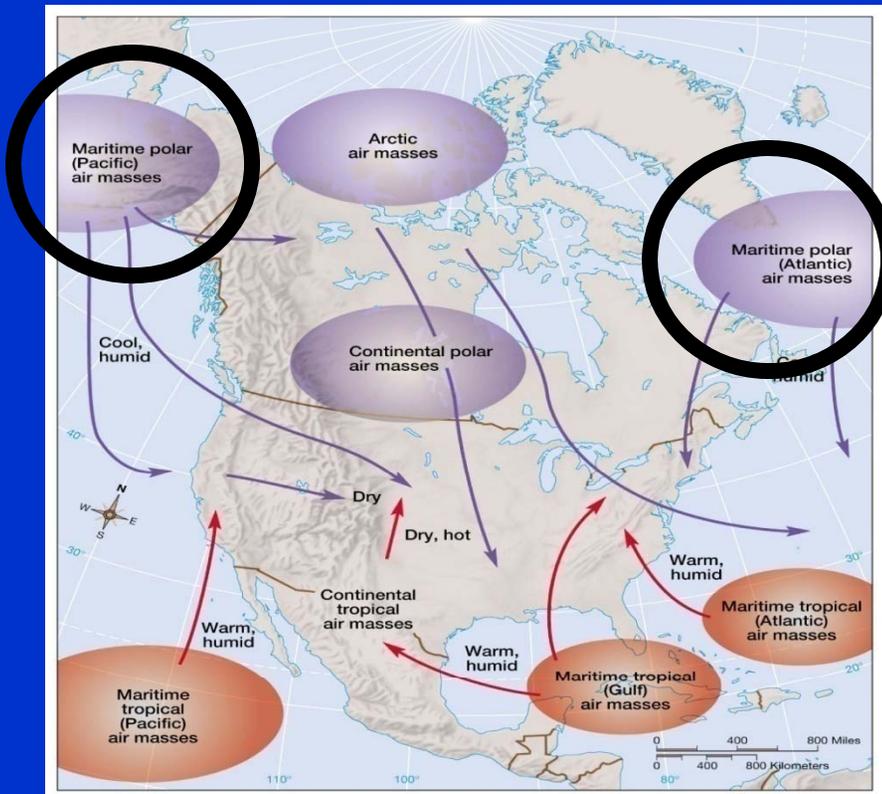
Continental Tropical (cT) Air Masses



- Mainly a summertime phenomenon exclusive to the desert southwest of the U.S. and northern Mexico.
- Characteristically hot and very dry.
- Very unstable, yet clear conditions predominate due to a lack of water vapor.
- Thunderstorms may occur when moisture advection occurs or when air is forced orographically.



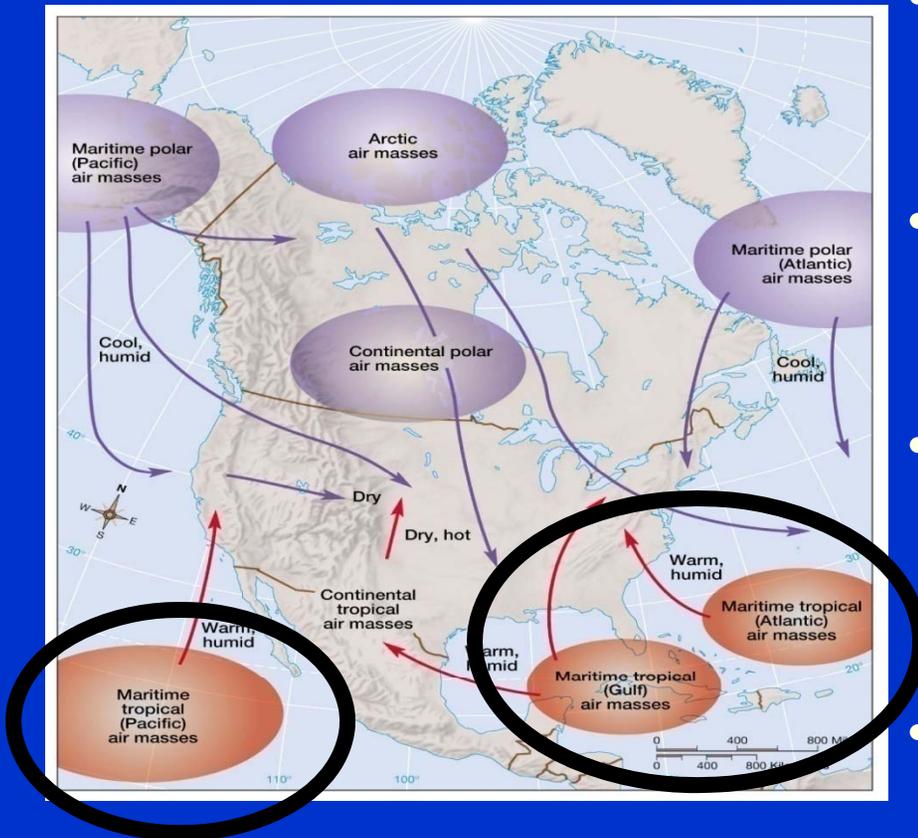
Maritime Polar (mP) Air Masses



- Maritime polar air masses form over upper latitude oceanic regions and are cool and moist.
- mP air masses form over high-latitude ocean as cP air masses move out from the interior of continents. (i.e., cP \rightarrow mP).
- Oceans add heat and moisture into the dry and cold cP air masses.
- Along the west coast of the U.S., mP air affects regions during winter and may be present before mid-latitude cyclones advect over the continent.
- Along the east coast, mP air typically affects regions after cyclone passage as the mP air wraps around the area of low pressure.



Maritime Tropical (mT) Air Masses

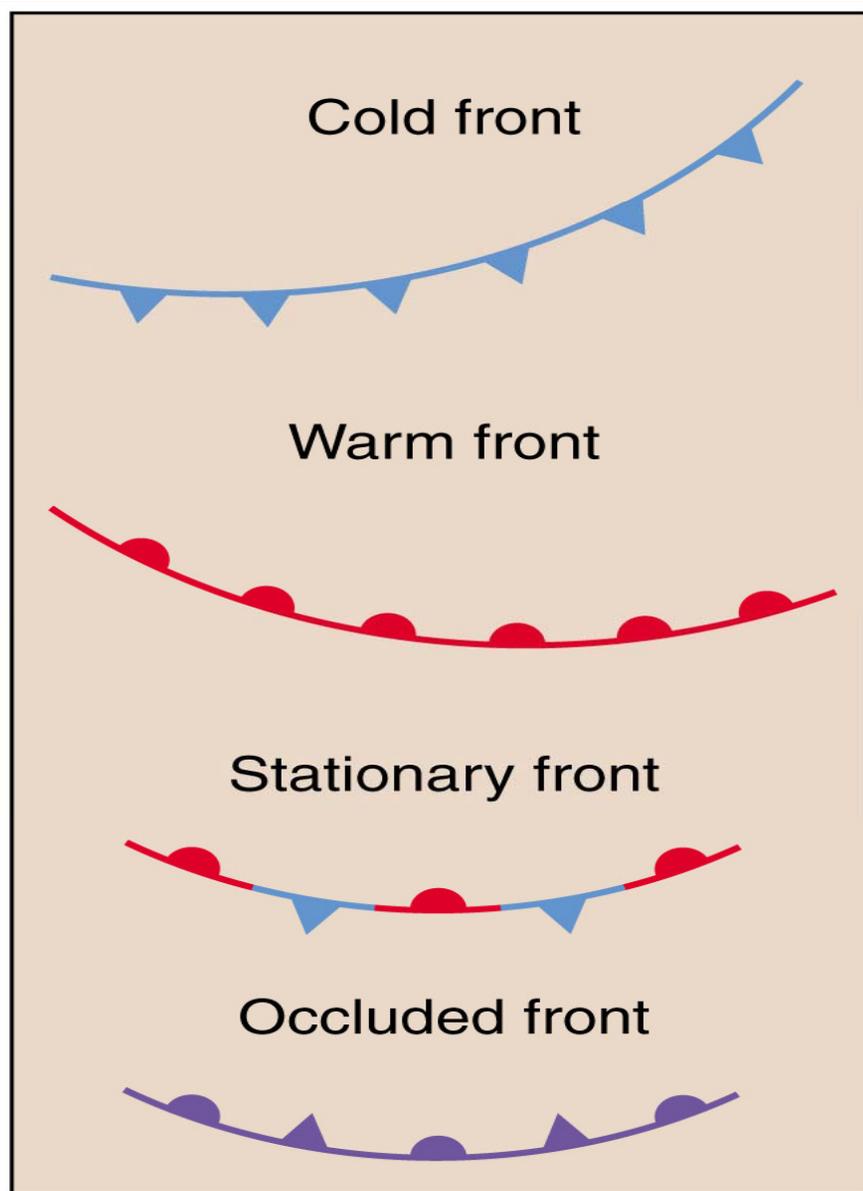


- Form over low latitude oceans and as such are very warm, humid, and unstable.
- mT air masses from Atlantic and Gulf of Mexico is the primary source region for the eastern U.S.
- As air advects over the warm continent in summer the high humidity and high heat occasionally combine to dangerous levels.
- mT air masses have an enormous influence on the southwestern U.S, particularly in summer.

□ Advection of mT air also promotes the so-called Arizona monsoon.



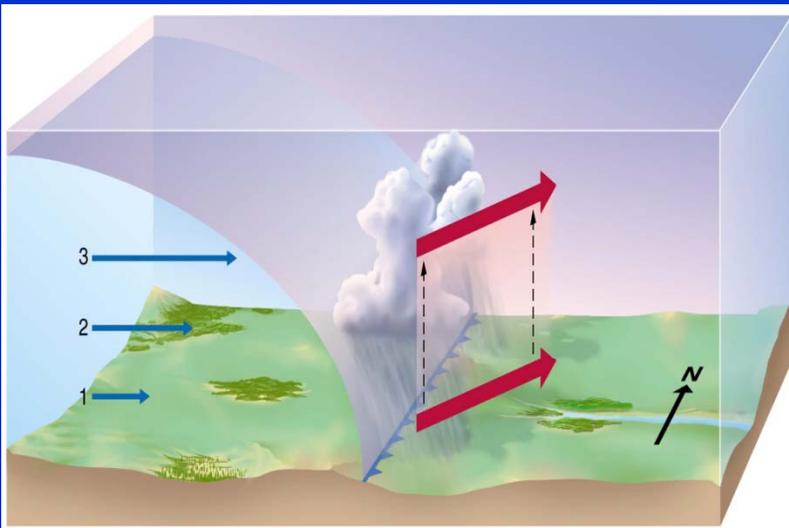
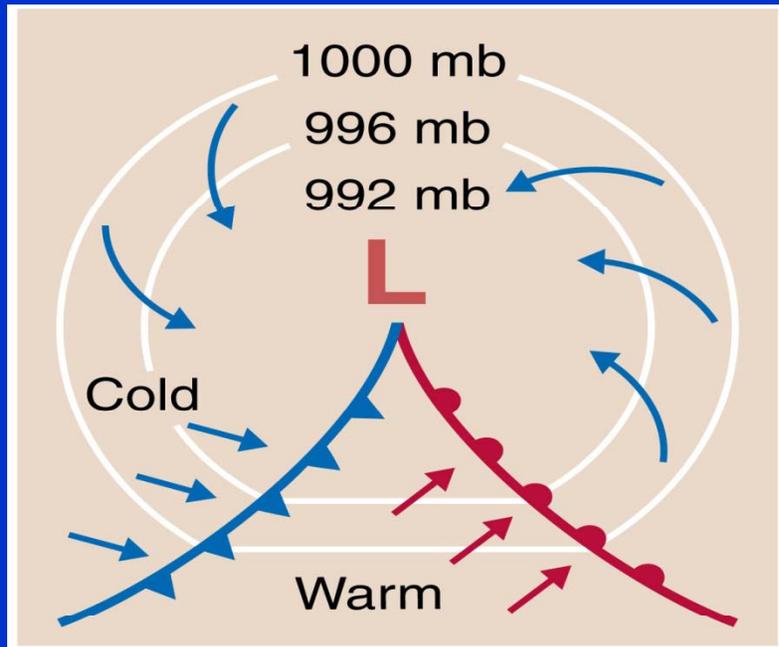
Fronts



- Meteorologists classify fronts based on the thermal and moisture characteristics of the air masses, the direction of the movement of the air masses, and whether the boundary between the airmasses is in contact with the ground (a surface front), or can be found aloft (an upper level front).
- There are four general types of fronts associated with mid-latitude cyclones with the name reflective of the advancing air mass.



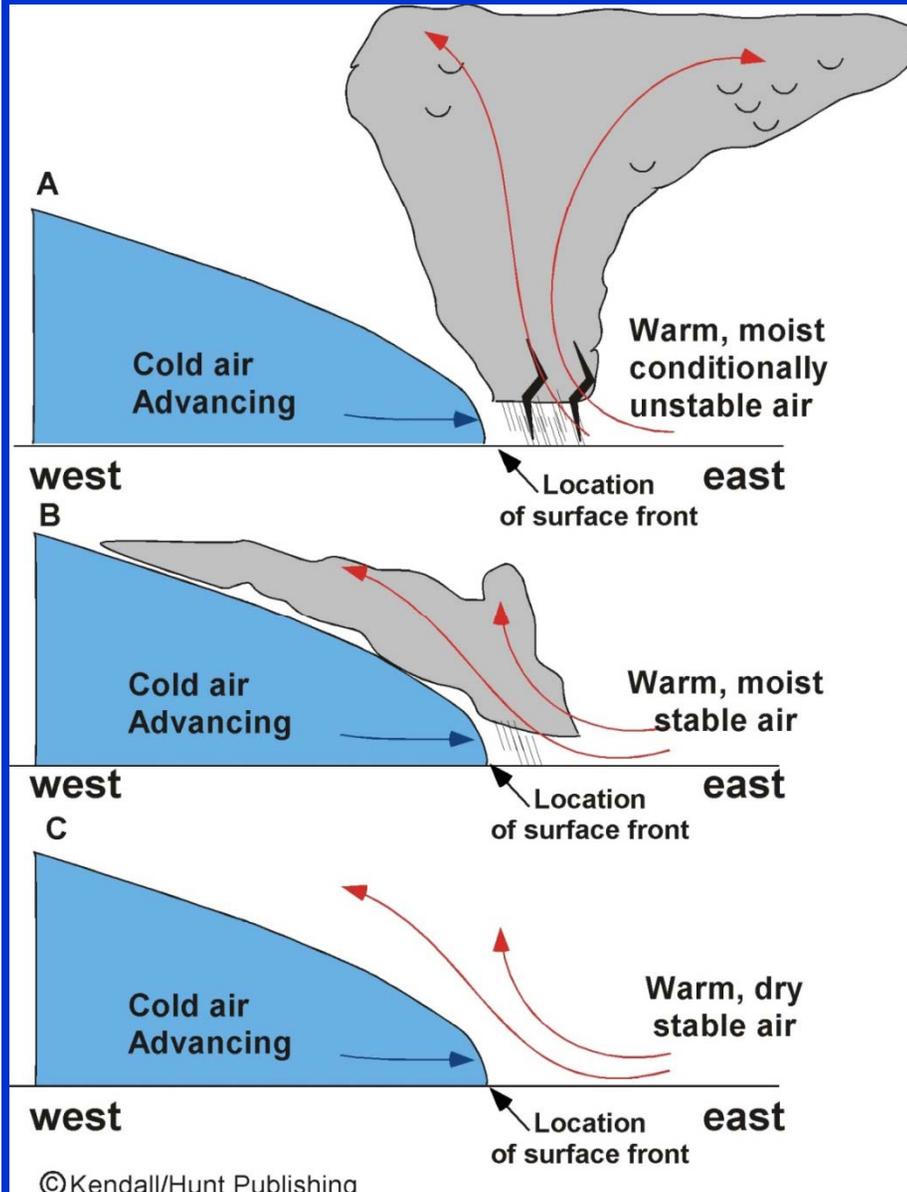
Cold Fronts



- Cold fronts form when cold air displaces warm air.
- Indicative of heavy precipitation events, rainfall or snow, combined with rapid temperature drops.
- Steep front slope, typically 1:100.
- Moving faster, up to 50 km/hr (30 mph).
- Northwesterly winds behind a cold front, and southwesterly in ahead of the front.



Cold Front Weather

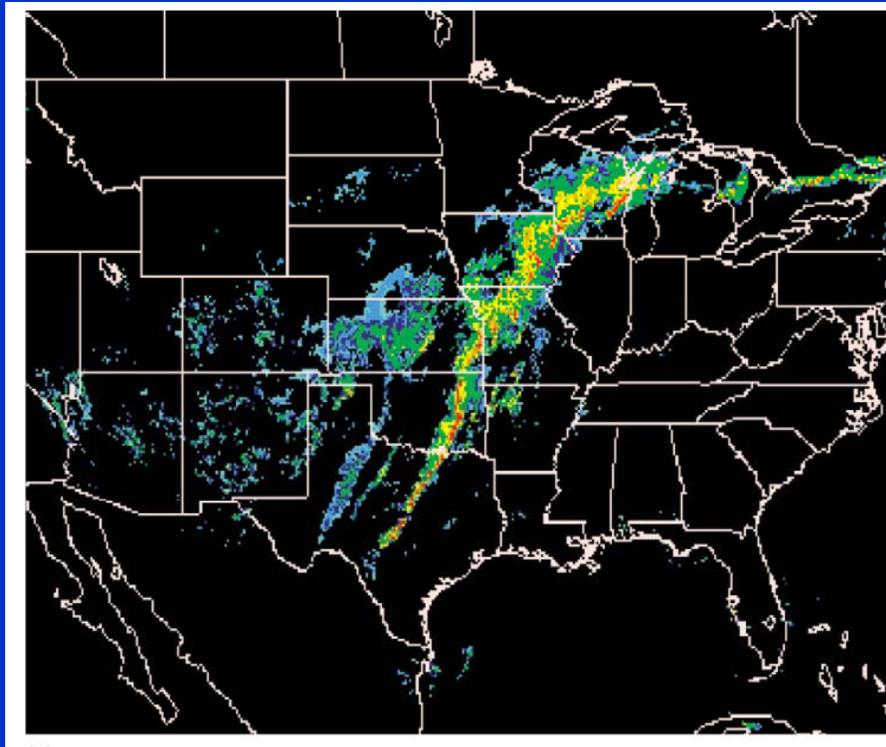


- The type of precipitation that will occur along a cold front depends on the characteristics of the warm air ahead of the front.
- If the warm air is moist and conditionally unstable, thunderstorms can be triggered ahead of the cold front; the thunderstorms will form in a line called squall line; if supercell thunderstorms form, tornadoes, hail, damaging wind can occur.
- If the warm air is stable, the clouds that form by lifting only produce light rain.
- If the warm air is dry and stable, no clouds will form at all.

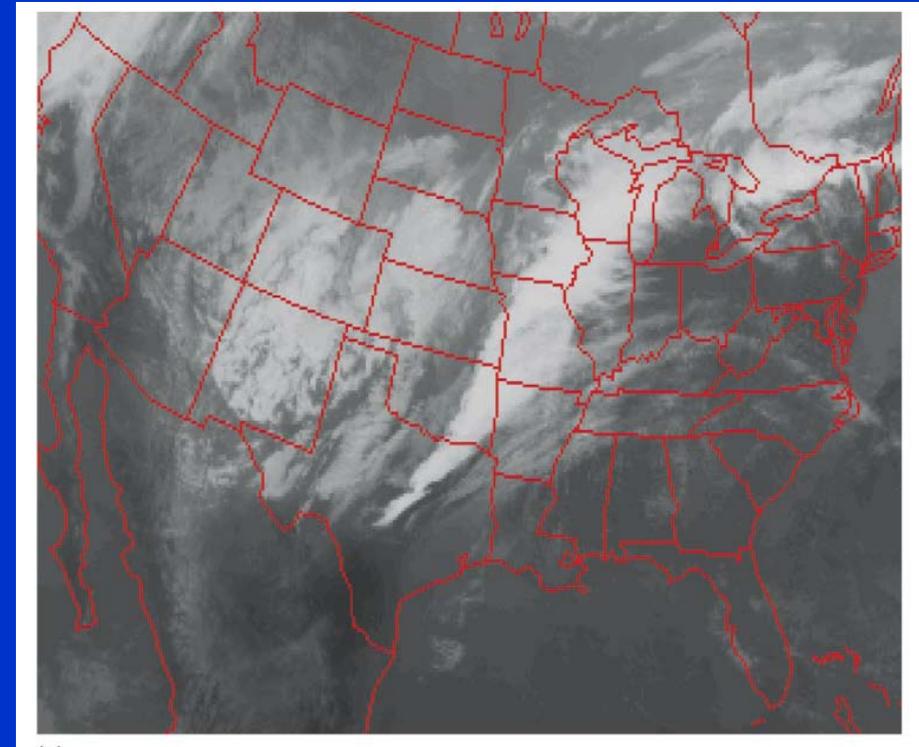


Radar/Satellite Views of Cold Fronts

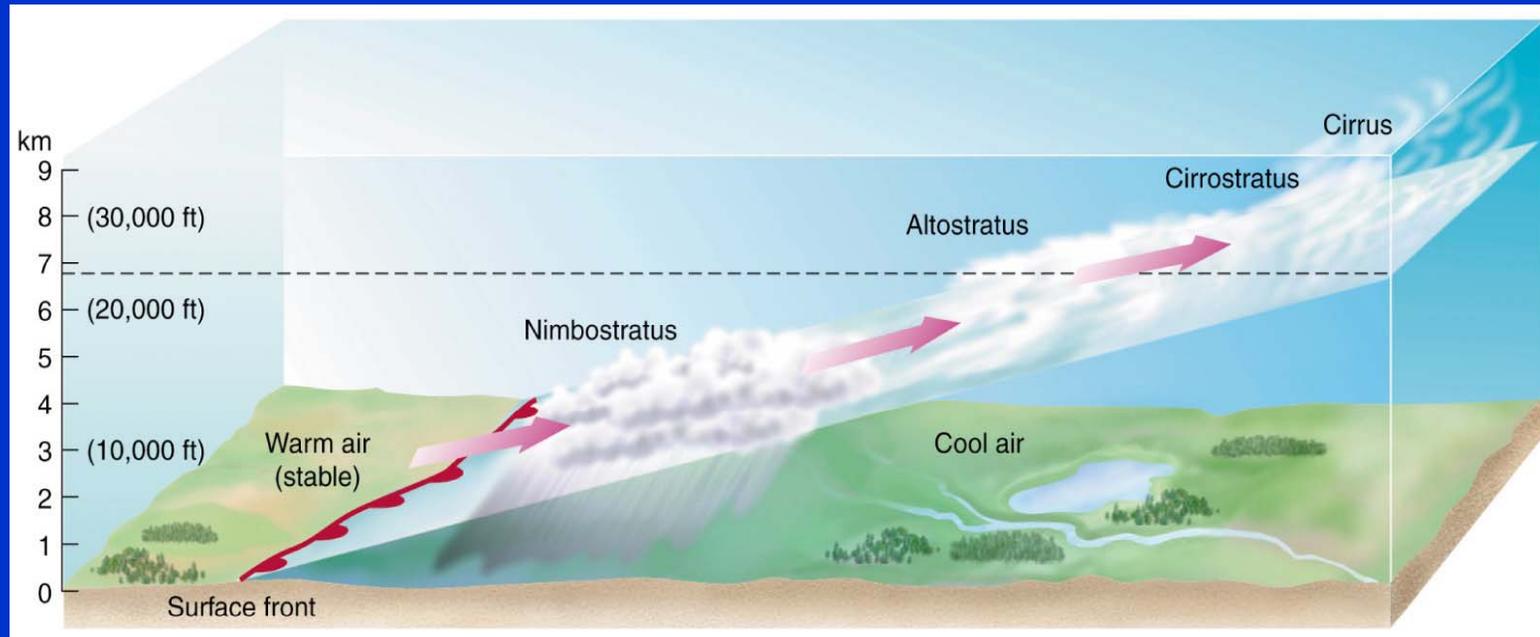
Radar Picture



Satellite Picture



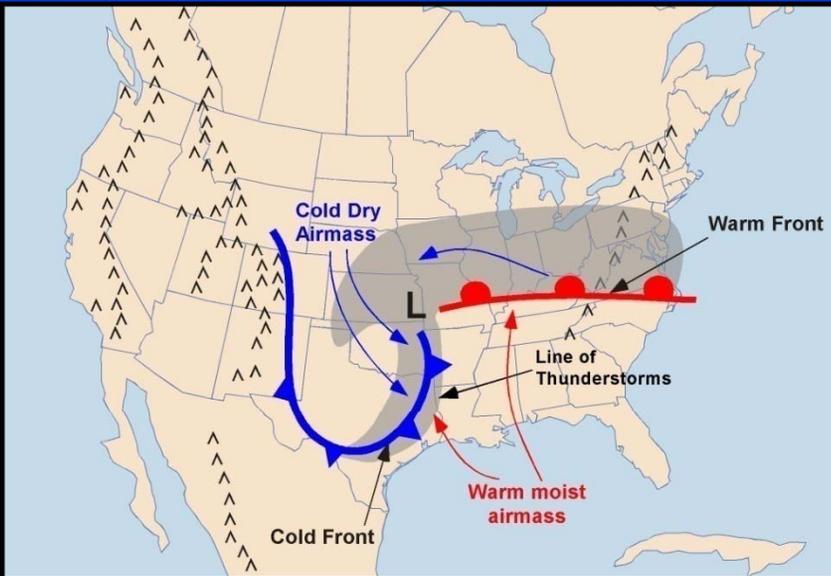
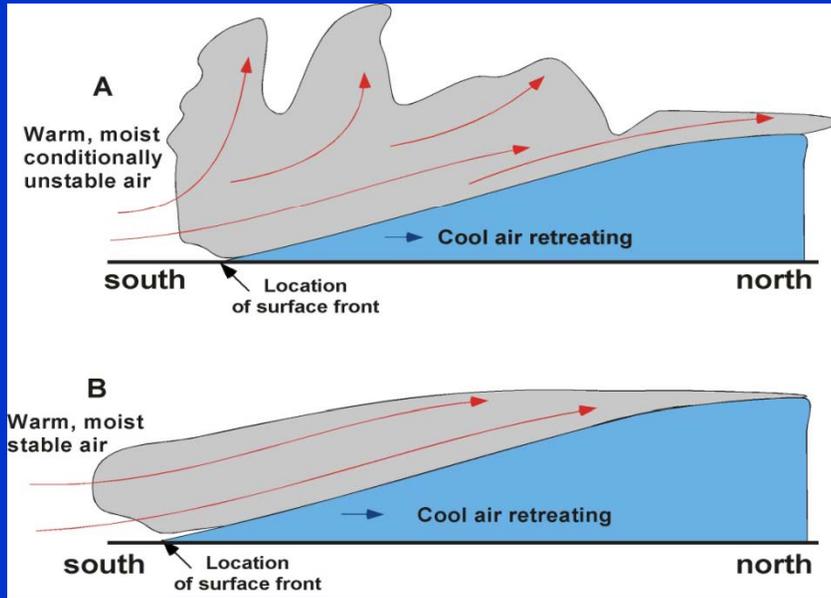
Warm Fronts



- Created when warm air displaces colder air.
- Shallow horizontal stratus clouds and light precipitation.
- Frontal fogs may occur as falling raindrops evaporate in the colder air near the surface. Sleet and freezing rain may also formed.
- Half the slope of cold fronts, typically (1:200).
- Moving slower, about 20 km/hr (12 mph).



Warm Front Weather

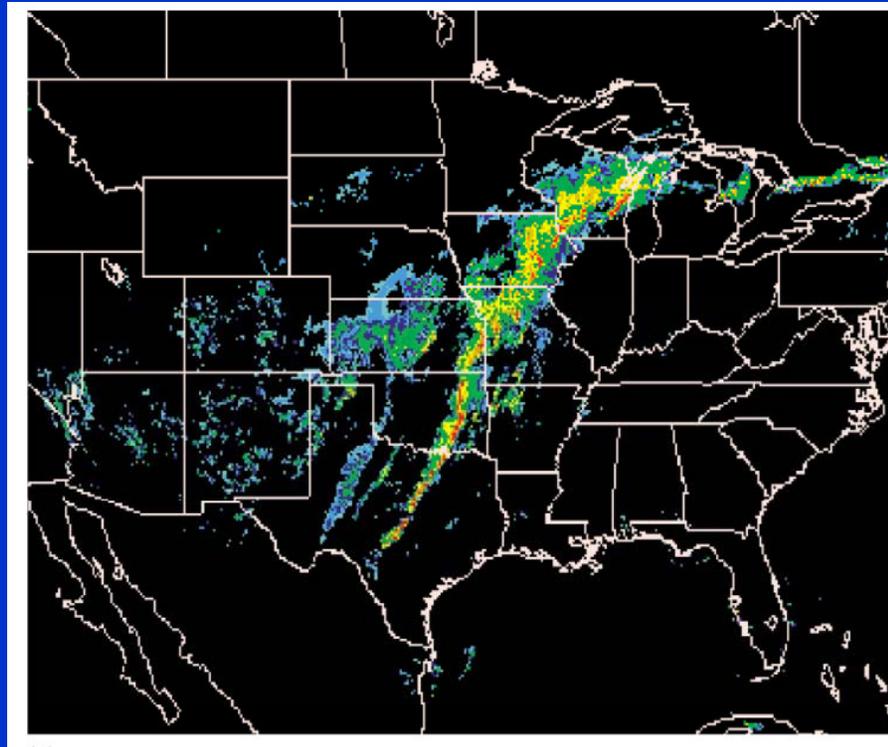


- Clouds are deepest just north of the warm front boundary and progressively becomes thinner and higher toward the north.
- The intensity of the precipitation depends on the stability of the warm air.
- If the warm air is conditionally unstable, thunderstorms may develop over the warm front.
- If the warm air is stable, the clouds will be layered.
- If the temperature in the cold air is below freezing, snow, ice pellets, or freezing rain may occur.

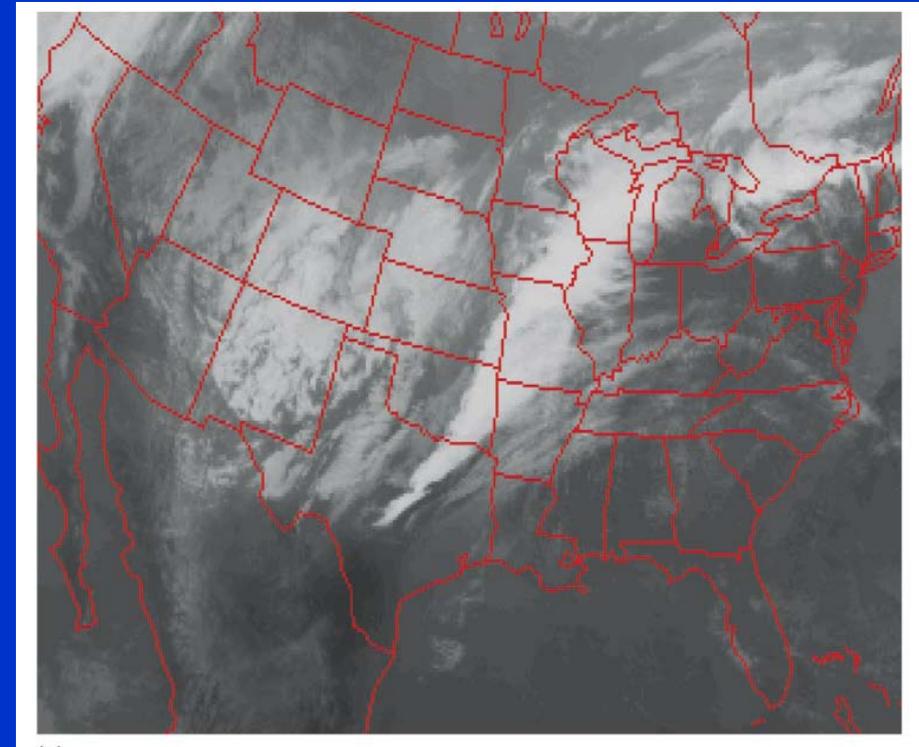


Radar/Satellite Views of Warm Fronts

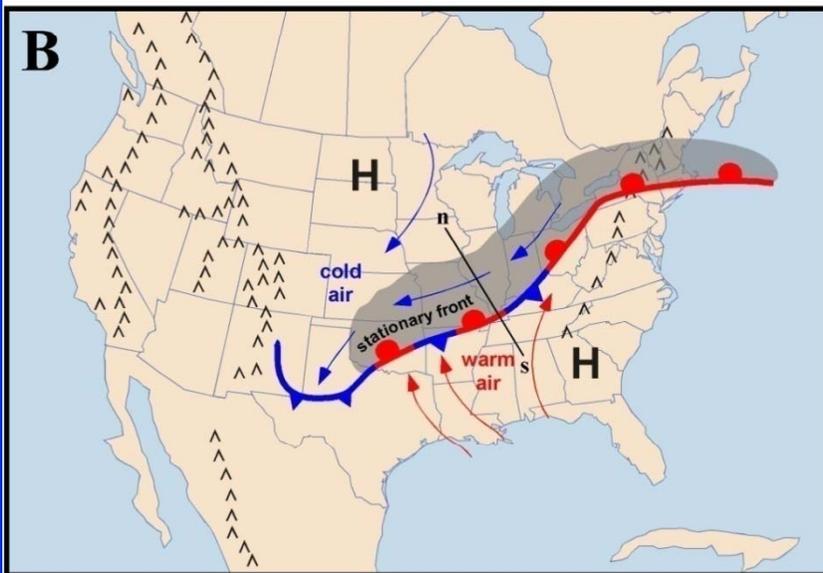
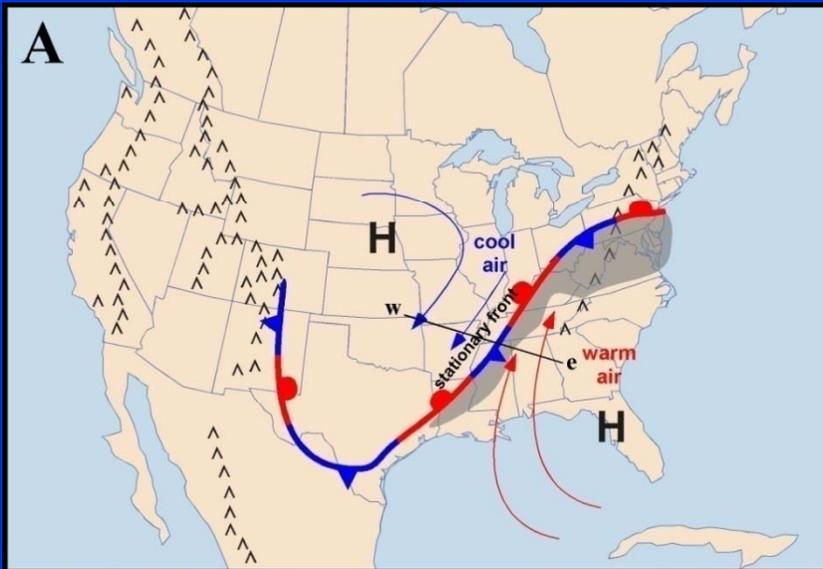
Radar Picture



Satellite Picture



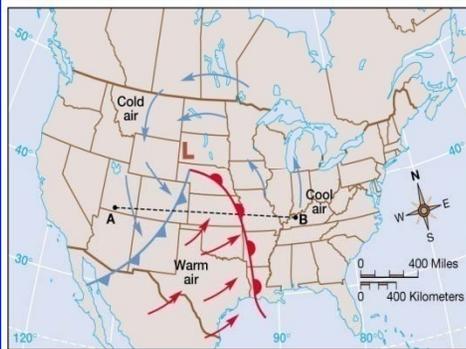
Stationary Fronts



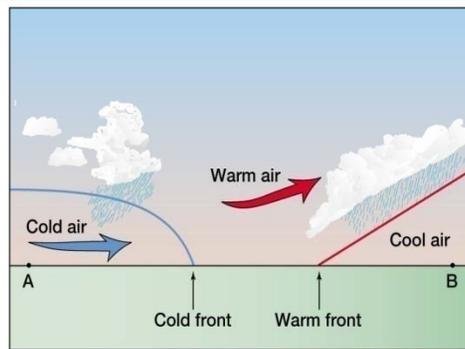
- When two unlike air masses remain side by side, with neither encroaching upon the other, a stationary front exists.
- The cold air on the north side of the front is moving parallel to the front, while the warm air to the south moving toward the front and get lifted along the frontal boundary.
- If the warm air is conditionally unstable, a line of showers and thunderstorms may develop in the warm side of the front.
- If the warm air is stable, widespread layered clouds may form over the front, with rain falling on the cold side of the front.



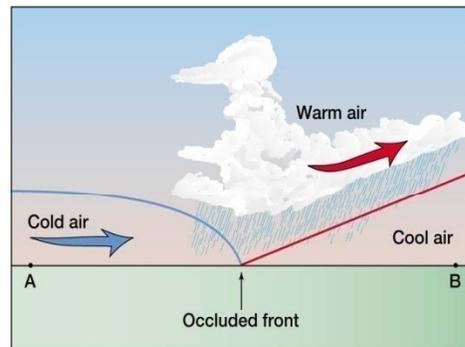
Occluded Fronts



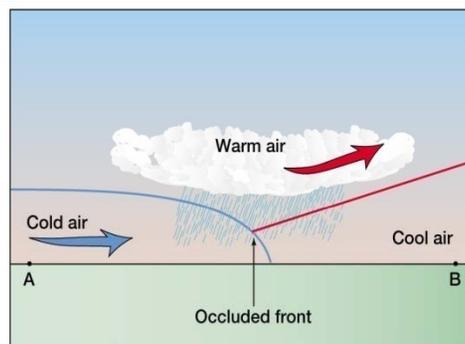
(a) Mature wave cyclone



(b) Partially occluded wave cyclone



(c) Occluded wave cyclone

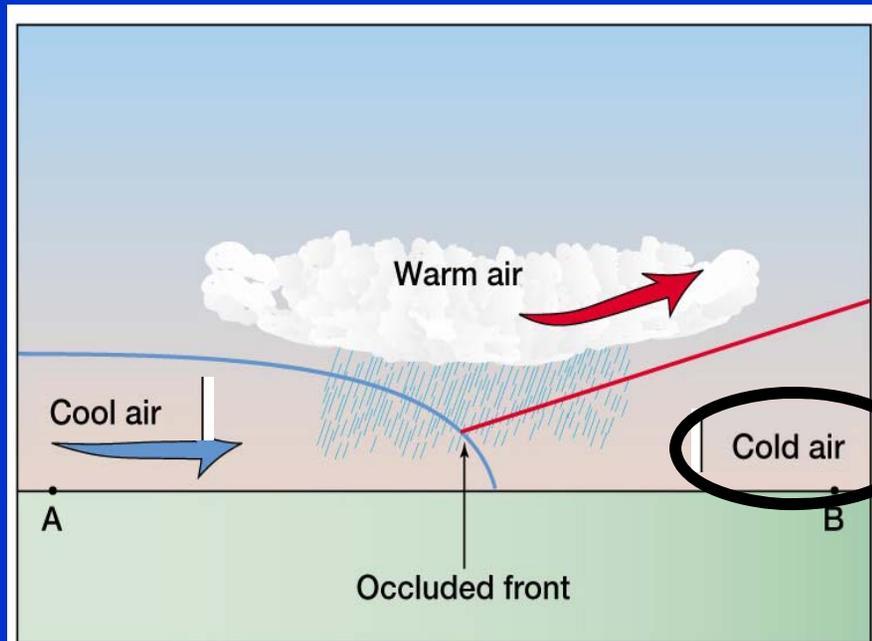


- Occlusion: the warm air is cut off from the surface by the meeting of two fronts.
- Usually, a fast-moving cold front catches a slow-moving warm front.
- A *cold-type occlusion*: eastern half of the continent where a cold front associated with cP air meets a warm front with mP air ahead.
- A *warm-type occlusion*: western edges of continents where the cold front, associated with mP air, invades an area in which colder cP air is entrenched.

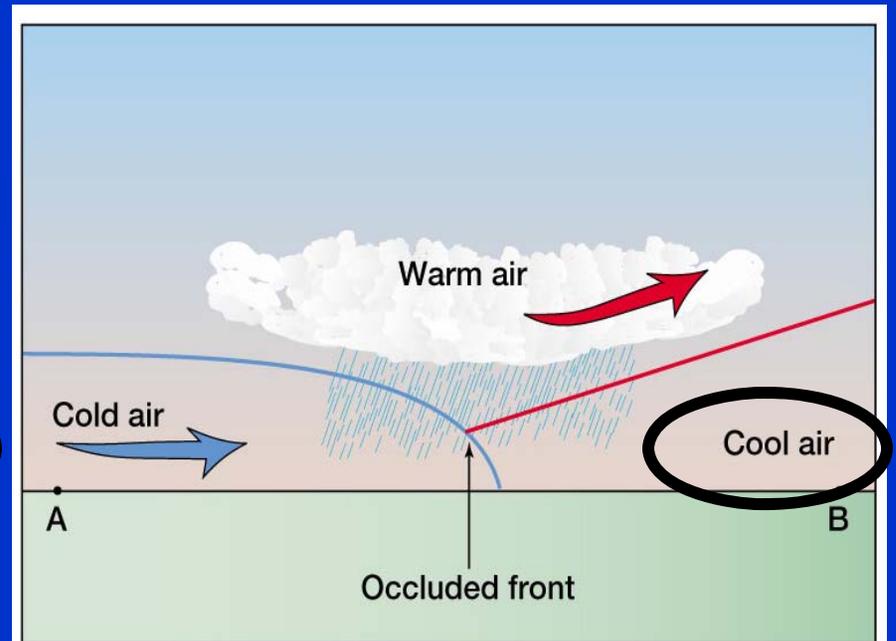


Warm- and Cold-Type Occlusion Fronts

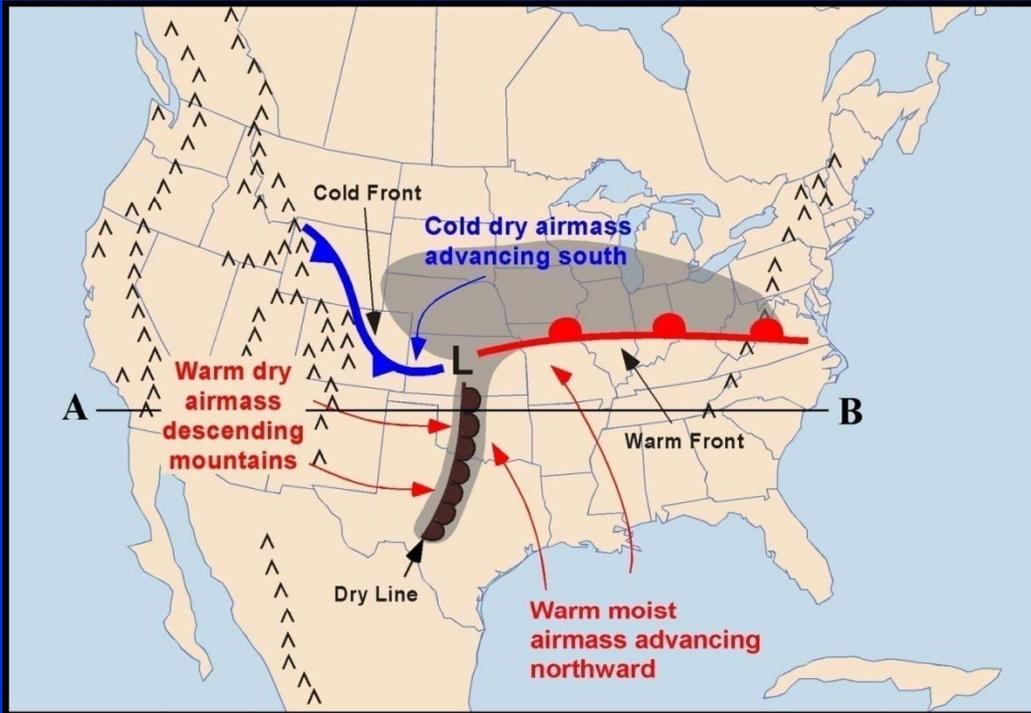
warm-type



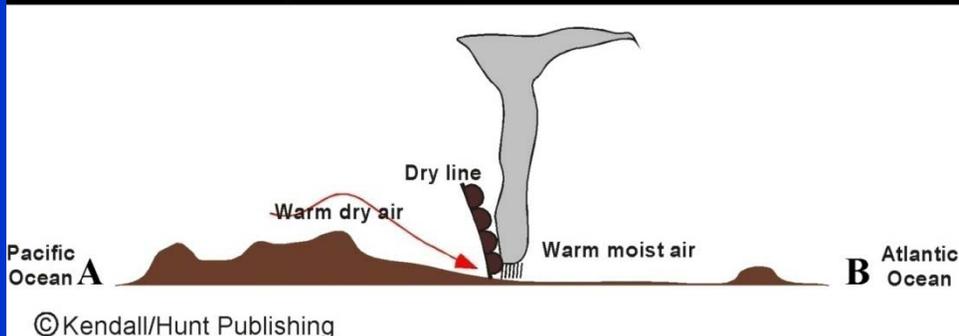
cold-type



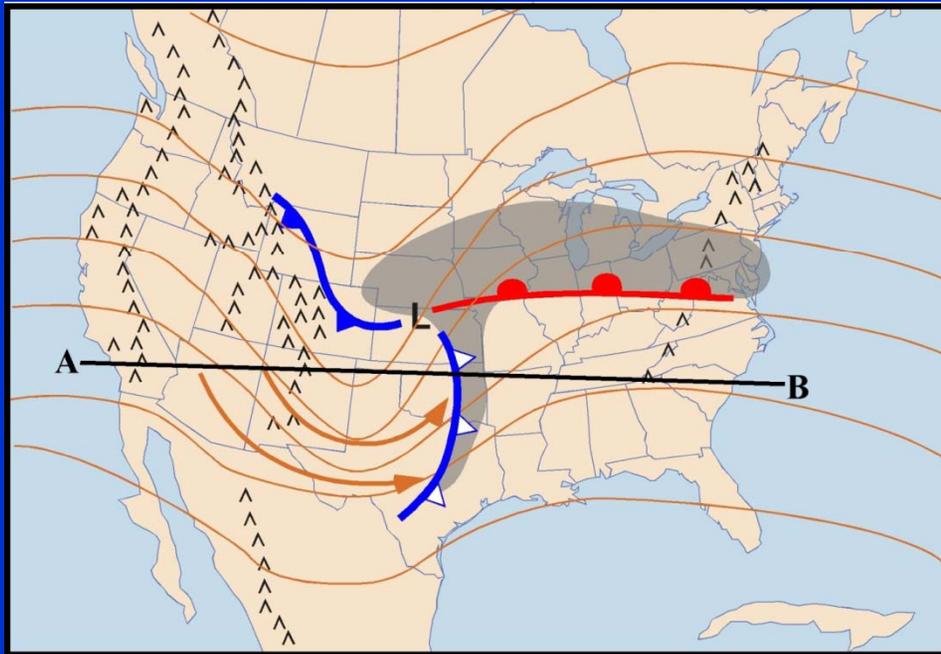
Dry Line



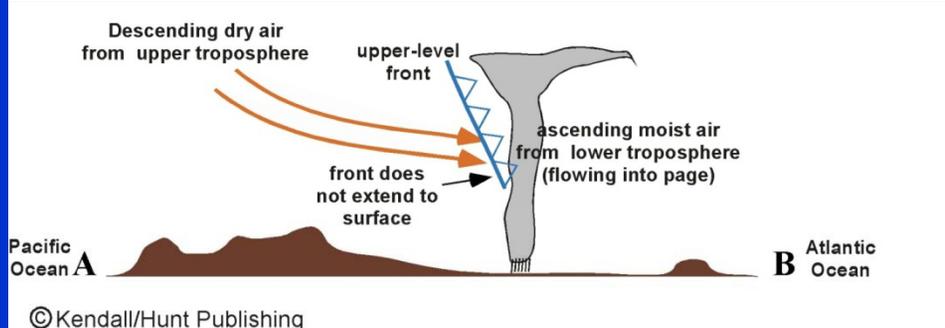
- In the south-central US (Texas, Oklahoma, Kansas region) and northern Mexico, a dry lines can develop between the dry air flowing eastward from the high desert plateau regions of Arizona, Colorado, New Mexico and Mexico encounters the moist air flowing northward from the Gulf of Mexico.
- The moist air will rise over the dry air.
- If the moist air is conditionally unstable, thunderstorm will develop along the dry line.



Upper-Level Front



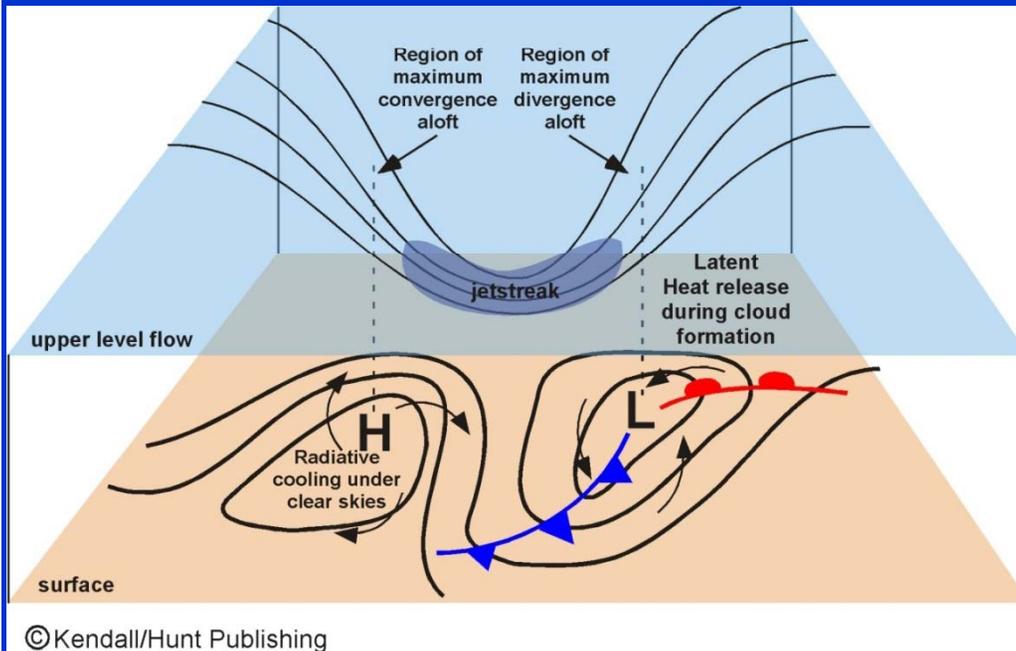
- Air masses do not necessarily extend to the surface of the Earth.
- Air masses can be “stacked” in the vertical, so that an air mass boundary (i.e., front) can be present aloft.
- This type of front is called “cold front aloft” or “upper-level front”.
- Upper-level fronts are common feature within cyclones that form east of the Rockies.



- Upper-level fronts develop when the air from the west of the trough (which goes through adiabatically descending) meets the air from the east of the trough (which goes through moist adiabatically ascending).



Developments of Low- and High-Pressure Centers



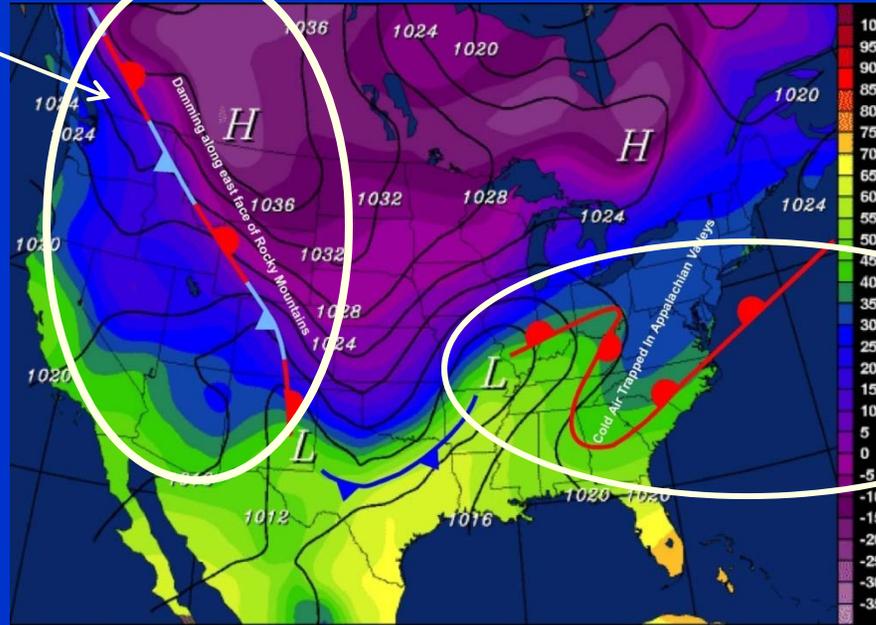
- **Dynamic Effects**: Combined curvature and jetstreak effects produce upper-level convergence on the west side of the trough to the north of the jetsreak, which add air mass into the vertical air column and tend to produce a surface high-pressure center. The same combined effects produce a upper-level divergence on the east side of the trough and favors the formation of a low-level low-pressure center.

- **Thermodynamic Effect**: heating → surface low pressure; cooling → surface high pressure.
- **Frictional Effect**: Surface friction will cause convergence into the surface low-pressure center after it is produced by upper-level dynamic effects, which adds air mass into the low center to “fill” and weaken the low center (increase the pressure)
- **Low Pressure**: The evolution of a low center depends on the relative strengths of the upper-level development and low-level friction damping.
- **High Pressure**: The development of a high center is controlled more by the convergence of surface cooling than by the upper-level dynamic effects. Surface friction again tends to destroy the surface high center.



Finding Fronts on Weather Maps

Not a boundary
between air masses,
but boundary between
air coming from
Canada and the
Rockies.
→ Cold air damming.

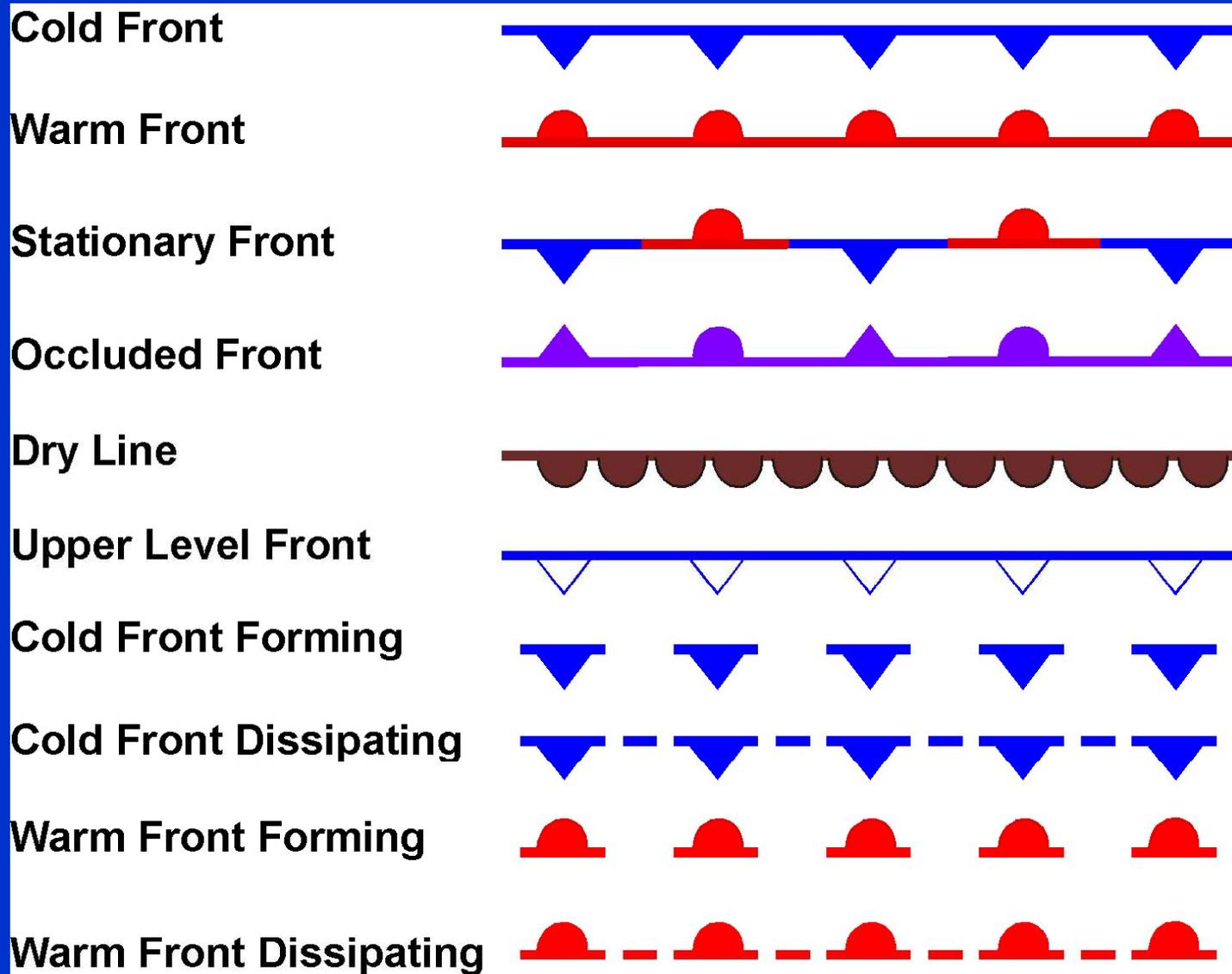


Courtesy of the Department of Atmospheric Sciences
University of Illinois at Urbana-Champaign

- A warm, cold, and stationary front will be located on the warm edge of a shape temperature gradient.
- Lower dewpoint temperatures can sometime be found on the cold air side of a cold, warm, or stationary front.
- If the wind on the cold side blows toward the front, a cold front; away from the front, a warm front; along the front, a stationary front; sharp wind shift, a occluded front.



Figure 9A



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