MET 4300/5355

Lecture 9:
Air Masses & Fronts (CH9)

Airmasses

- An airmass is a large body of air with relatively uniform thermal and moisture characteristics.

- Airmasses cover large regions of the earth, typically several hundred thousand square kilometers.

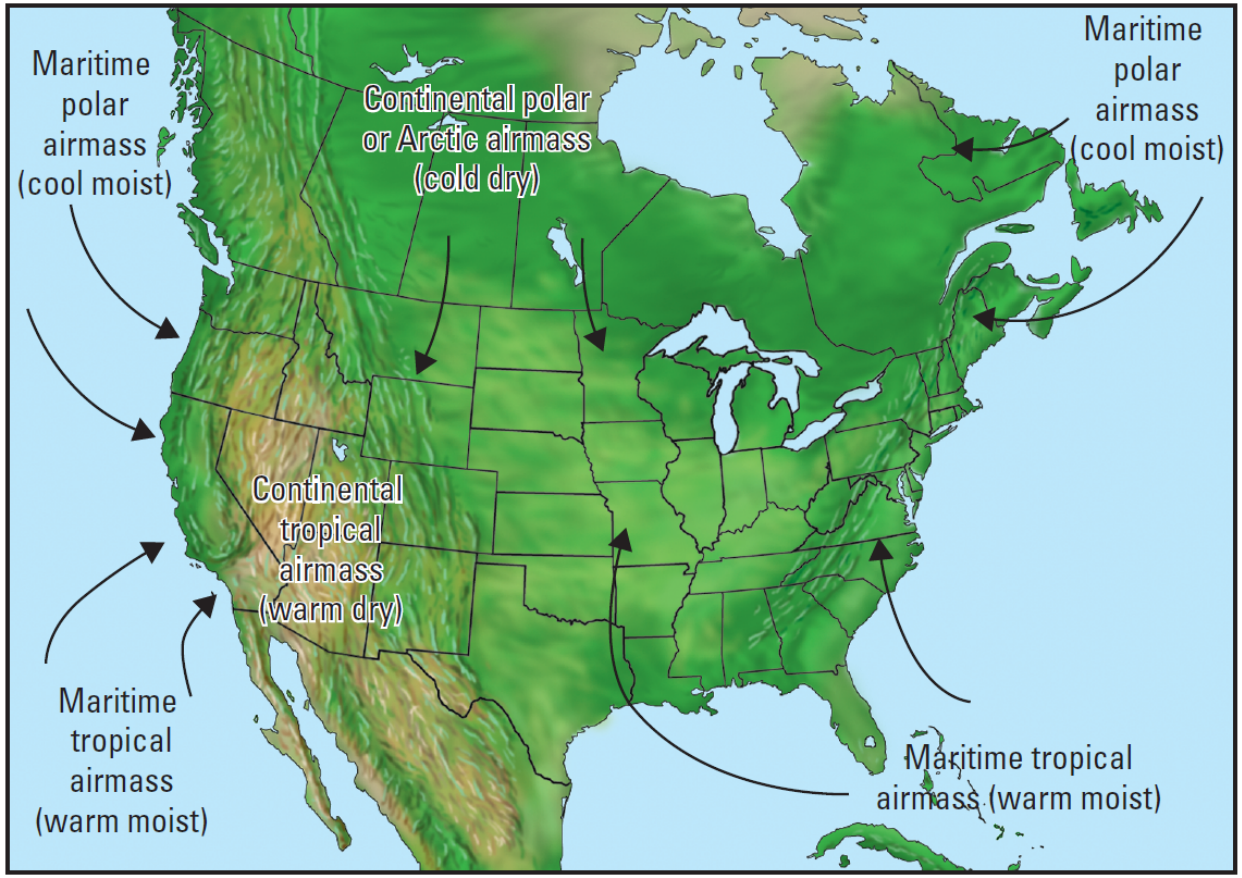
- Airmasses can be as deep as the depth of the troposphere or as shallow as 1 to 2 km.

- Airmasses form when air remains over a relatively flat region of the earth* with homogeneous surface characteristics for an extended period of time.

(* Canadian and Siberian plains, cool oceanic regions such as the North Atlantic and Pacific, deserts, such as the Sahara and the American southwest, and tropical oceanic regions including the equatorial Atlantic and Pacific, and smaller water bodies such as the Caribbean Sea and the Gulf of Mexico).

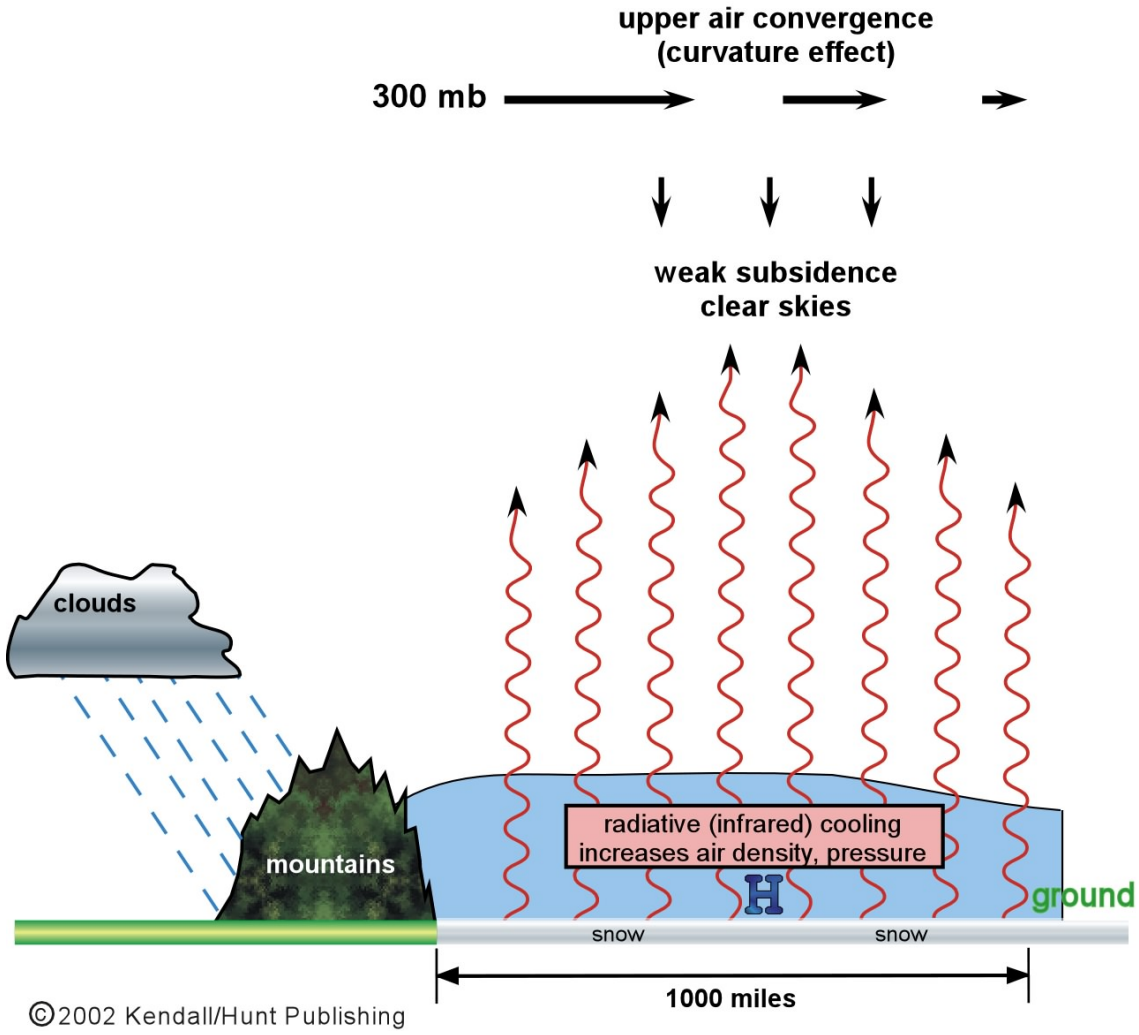
Sources of North American Airmasses

- ***Continental Arctic*** (cA): Ice cap or frozen sea
- ***Continental Polar*** (cP): High-latitude land mass
- ***Maritime Polar*** (mP): High-latitude sea
- ***Maritime Tropical*** (mT): Tropical (Trade-Wind) sea
- ***Continental tropical*** (cT): Desert
- ***Air-Mass Modification*** takes place outside source region
- North American weather is dominated by alternation of cP and mT air

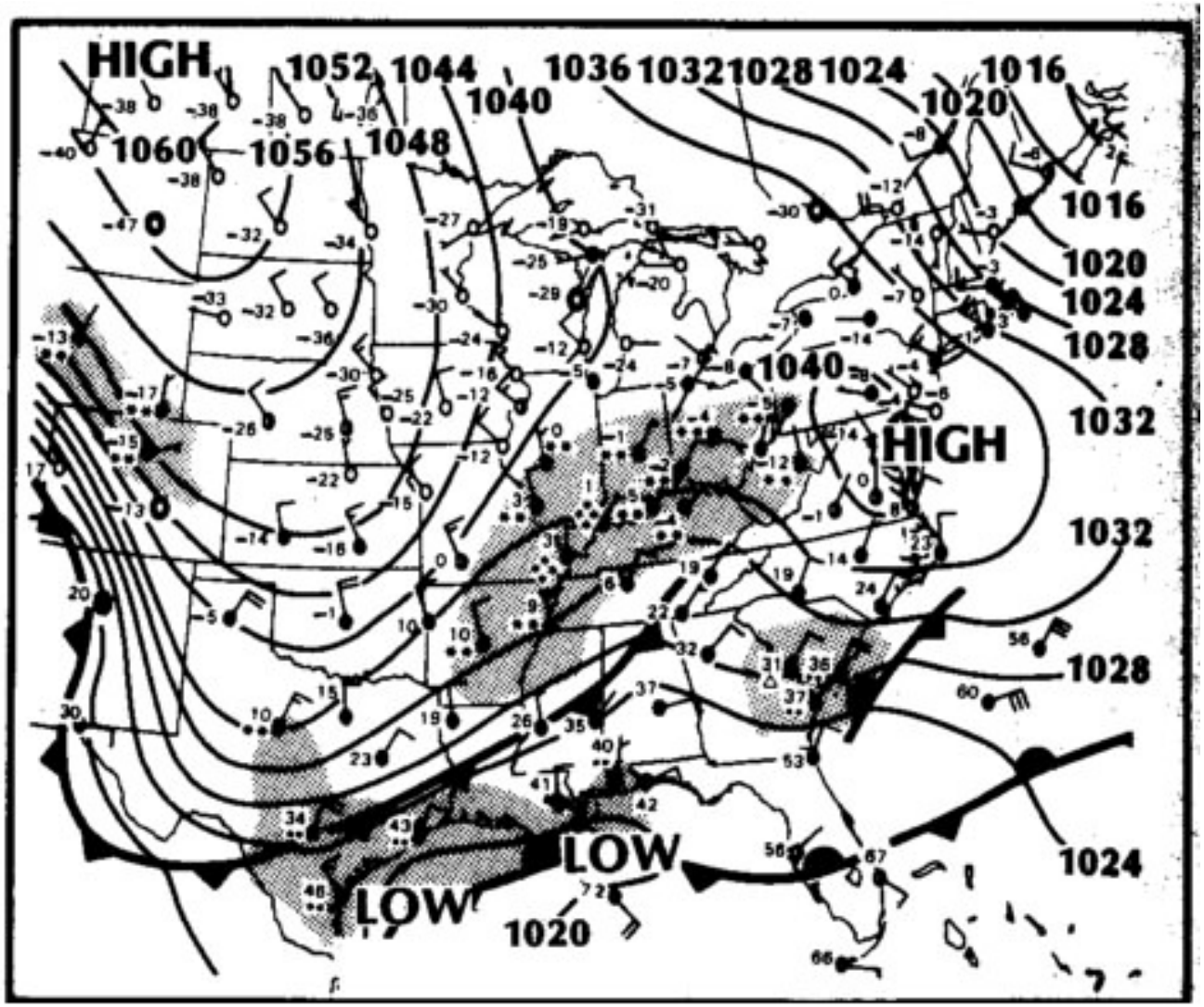


Key features of an airmass on weather maps:

The centers of cold airmasses are associated with high pressure on surface weather maps. High pressure develops in response to cooling.

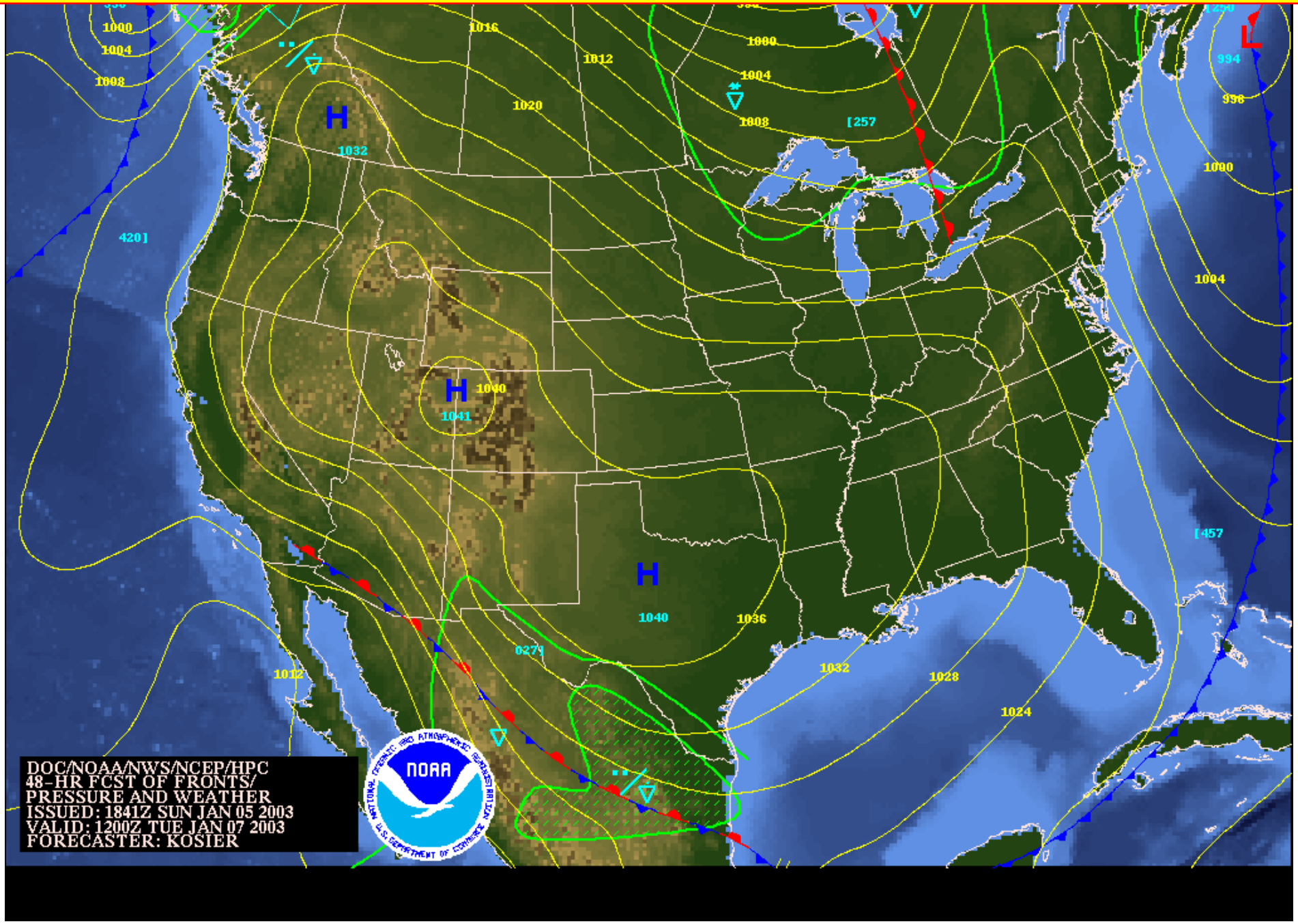


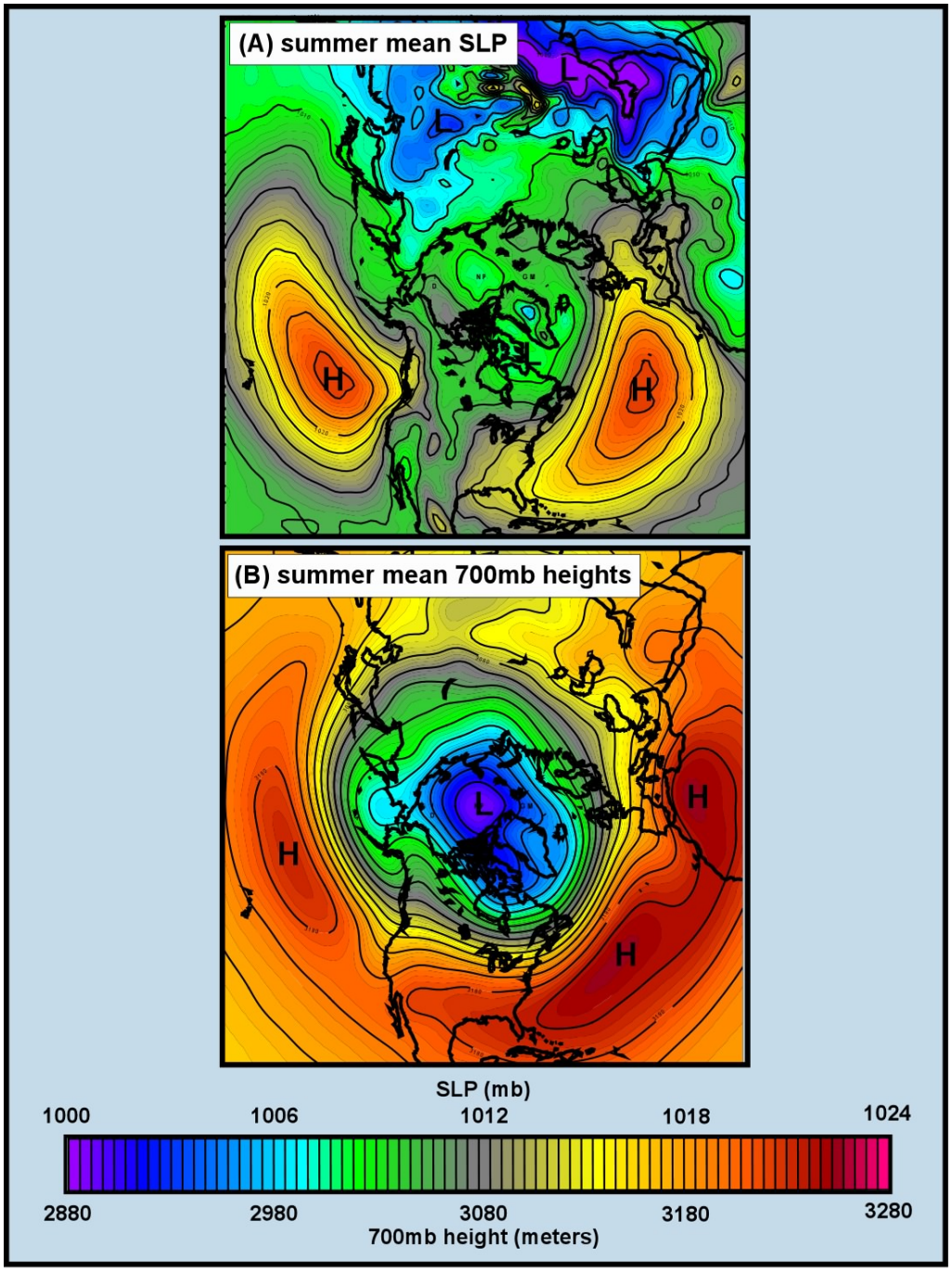
In winter, high-pressure centers form and are the dominant feature over the northern parts of the continents of Asia and North America.



Courtesy of the American Meteorological Society

Example of a high pressure system that moved southward into the central US in winter





In summer, when the oceans are cooler than the landmasses, large high-pressure centers are the dominant feature of the atmosphere over the North Atlantic and Pacific Oceans.

The high-pressure center over the Atlantic is called the "Bermuda High" because it is centered near Bermuda, while its Pacific counterpart is called the "Pacific High"

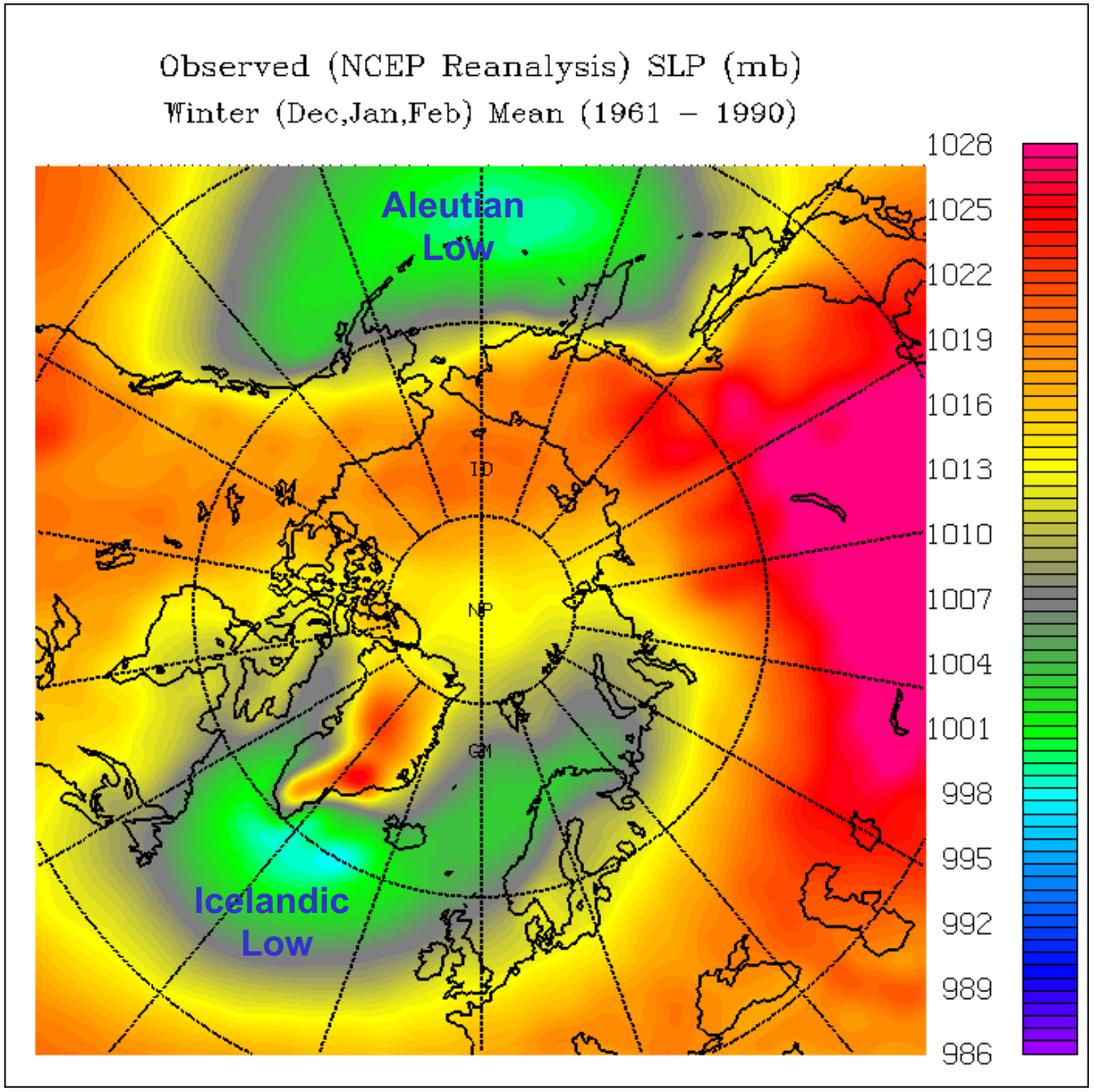
The centers of very warm airmasses appear as semi-permanent regions of low surface pressure.

Examples:

1) Monsoon Low in summer over S.E. Asia
2) North American Monsoon Low over Deserts of the U.S. southwest
3) Equatorial low pressure belt
4) Icelandic Low over the N. Atlantic
5) Aleutian Low over the N. Pacific in winter.

Note: Semi-permanent low-pressure centers differ substantially from migrating tropical and extratropical low-pressure centers associated with cyclones and hurricanes.

The Aleutian Low and the Icelandic Low are associated with airmasses that are warm relative to the surrounding continental airmasses in winter.



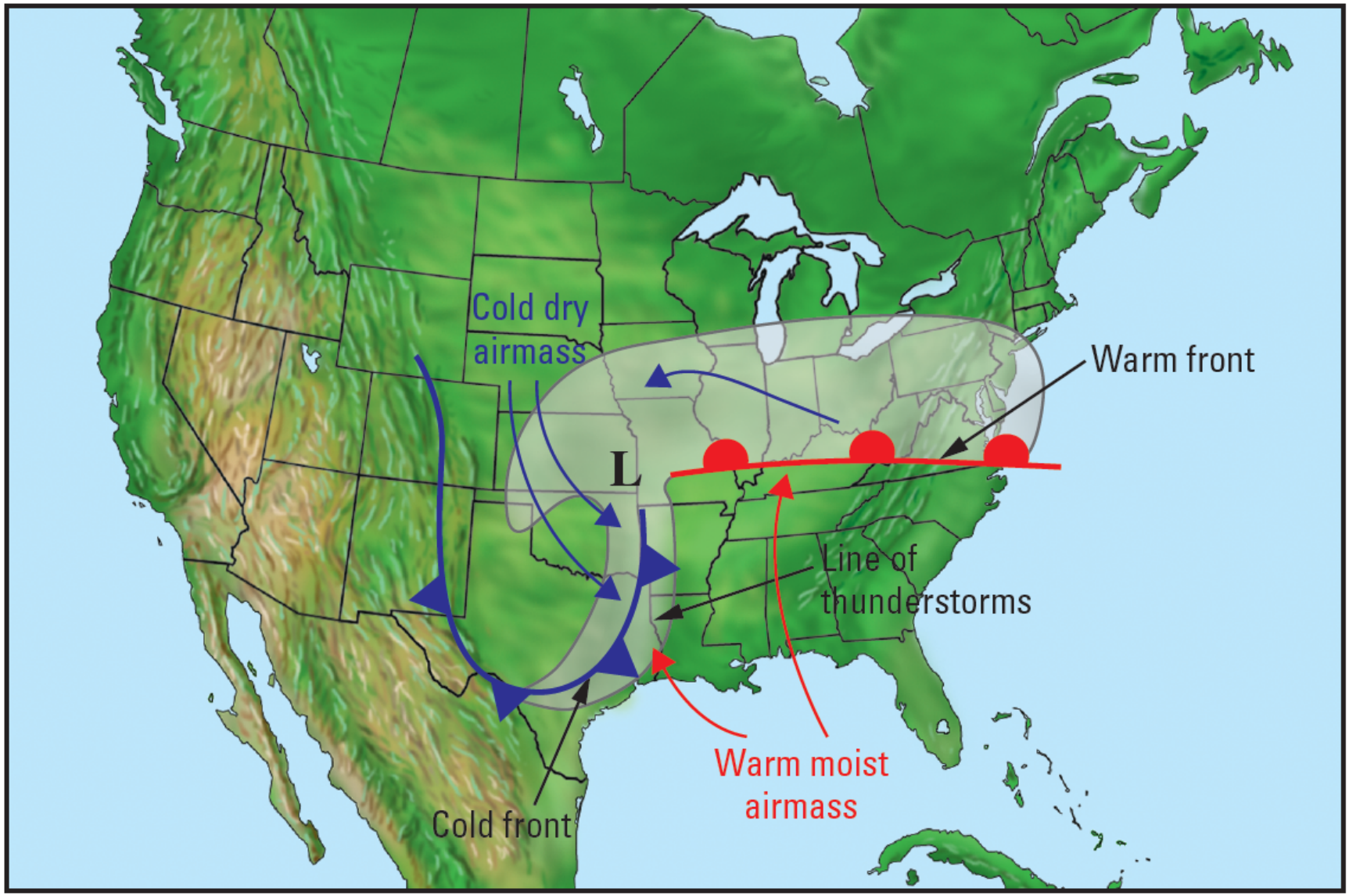
http://zubov.atmos.uiuc.edu/FINGERPRINT/obs.slp.html

Fronts

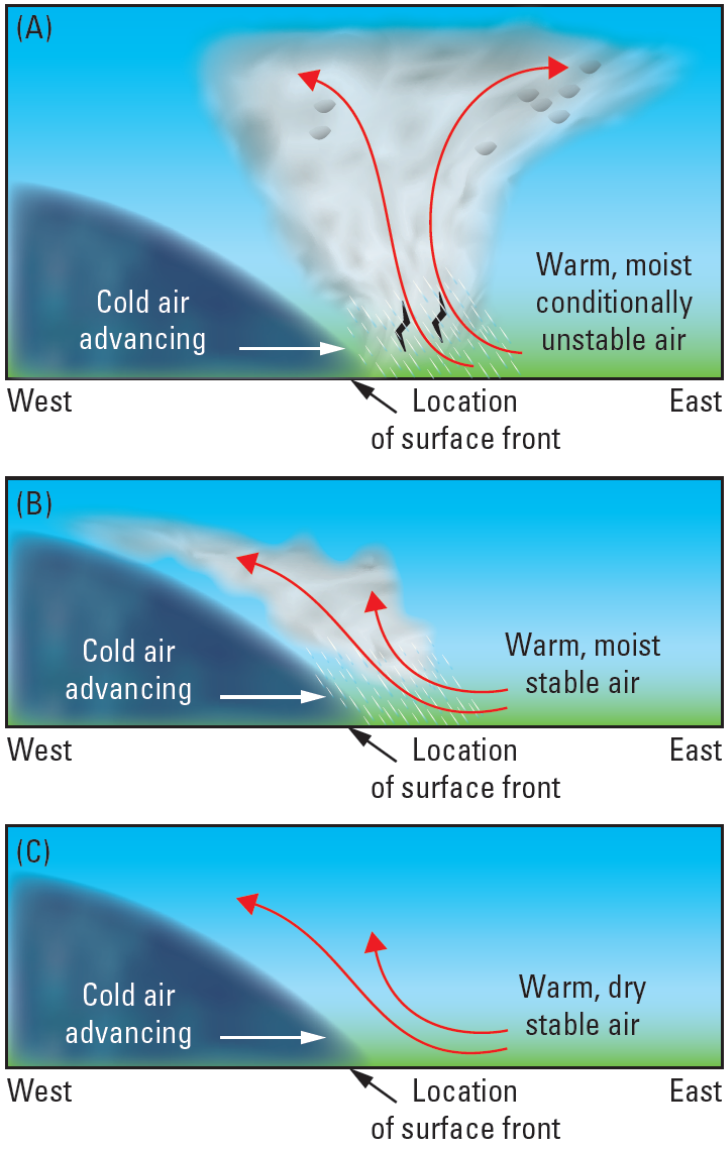
- Front---A sharp, almost discontinuous, boundary between two airmasses
  - Fronts generally move and cause disturbed weather as they pass in addition to changes of temperature and humidity

- **Meteorologists classify fronts based on:**
  - **a) the thermal and moisture characteristics of the airmasses**
  - **b) the direction of movement of the airmasses**
  - **c) whether the boundary between the airmasses is in contact with the ground (a surface front), or can only be found aloft (an "upper level front").**

Fronts in a Middle-Latitude Cyclone

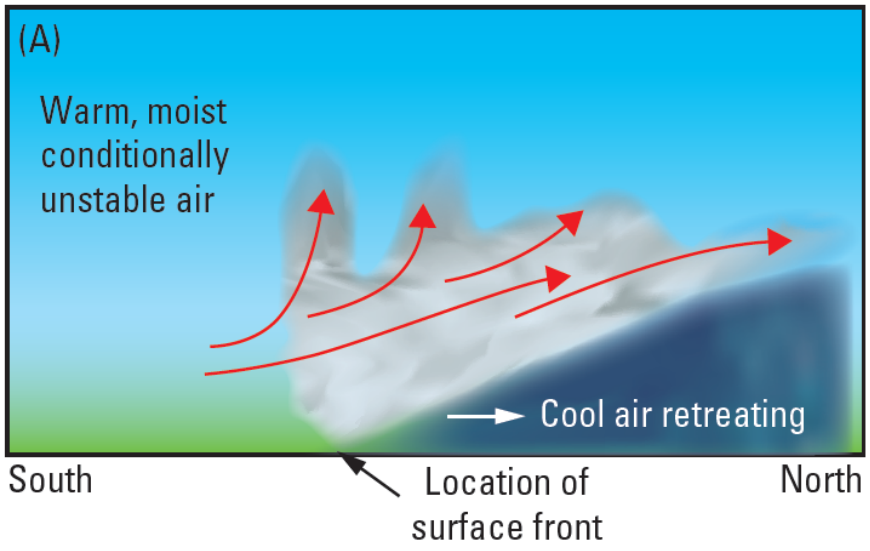


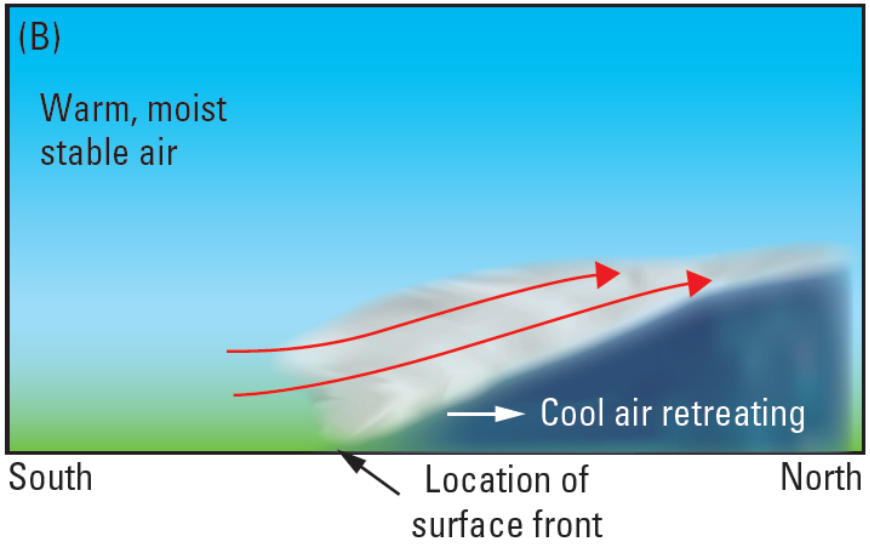
Cold Front: Cold air is advancing forward, lifting the warm air



- Warm (less dense) air ahead of the front overlies cold air
- Slope is typically 1/100
- Move faster than other kinds of fronts
- Abrupt cooling and veering of the wind from SW to N when the front passes
- Convection depends on stability and humidity of the warm air ahead of the front

Warm Front: Cold air is retreating and the warm air is advacning

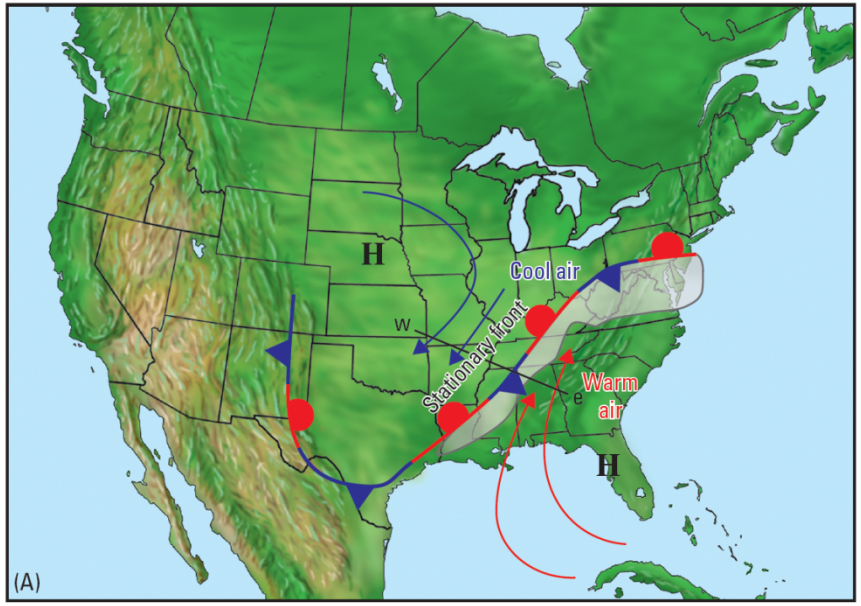


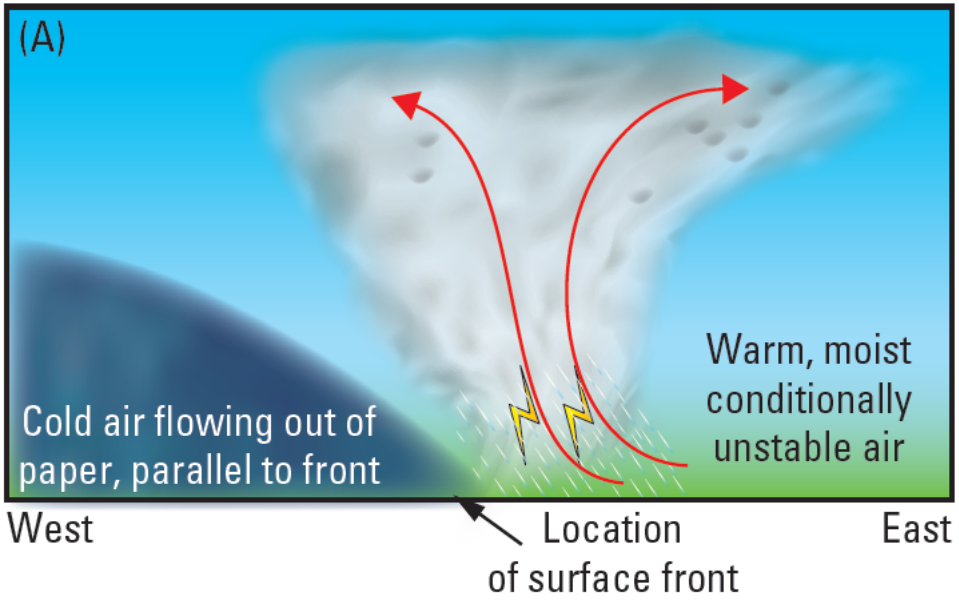


- Warm air <u>behind</u> the front overlies cold air
- Slope is typically < 1/200
- Move slower than cold fronts
- Gradual warming and veering of the wind from the S to SW when the front passes
- Convection depends on stability and humidity of the warm air behind of the front
  - Unstable: Thunderstorms
  - Stable: clouds will be layered. If below freezing, snow or freezing rain may occur
  - Clouds are deepest just north of the frontal boundary and become thinner and higher toward north.

Stationary Fronts: cold air is neither advancing or retreating

Stationary Front: Front does not move; Cold air does not advance or retreat, just flowing parallel to the front; Warm air flows toward the front

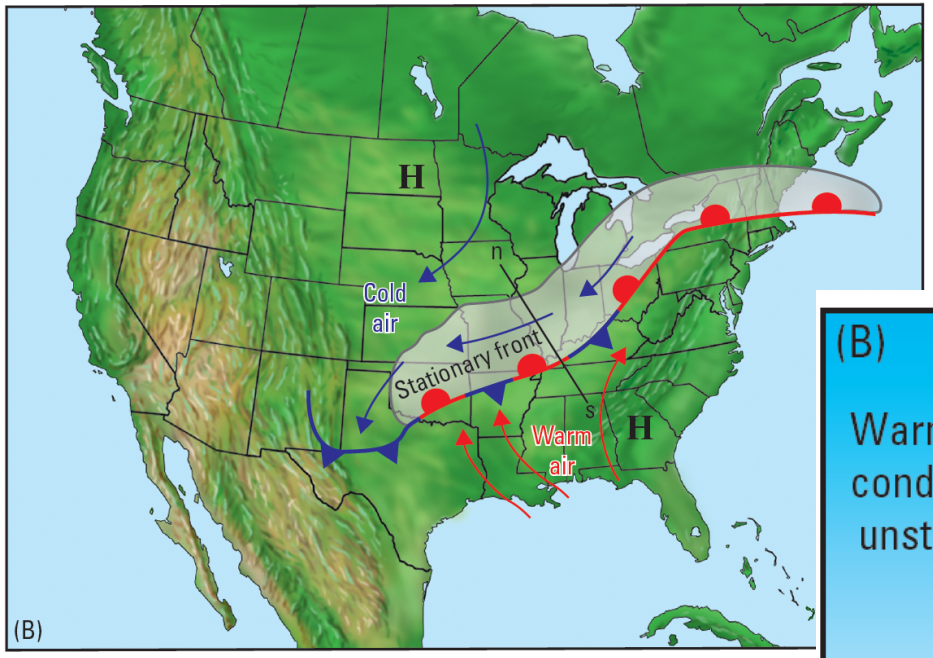


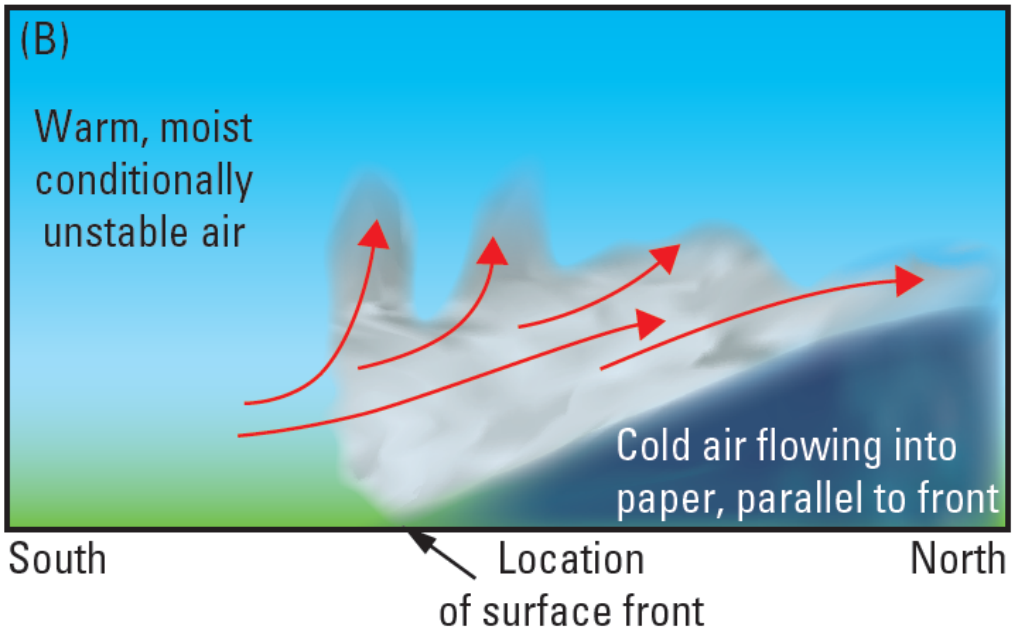


Unstable Stationary Front: Warm air is conditionally unstable; Convection triggers in the warm air S and E of the frontal boundary; Precipitation falls in the warm air

Stable Stationary Fronts

Warm air is stable
Warm air glides up the frontal surface producing stratiform rain
Rain falls through the frontal surface into the cold air N & W of the front

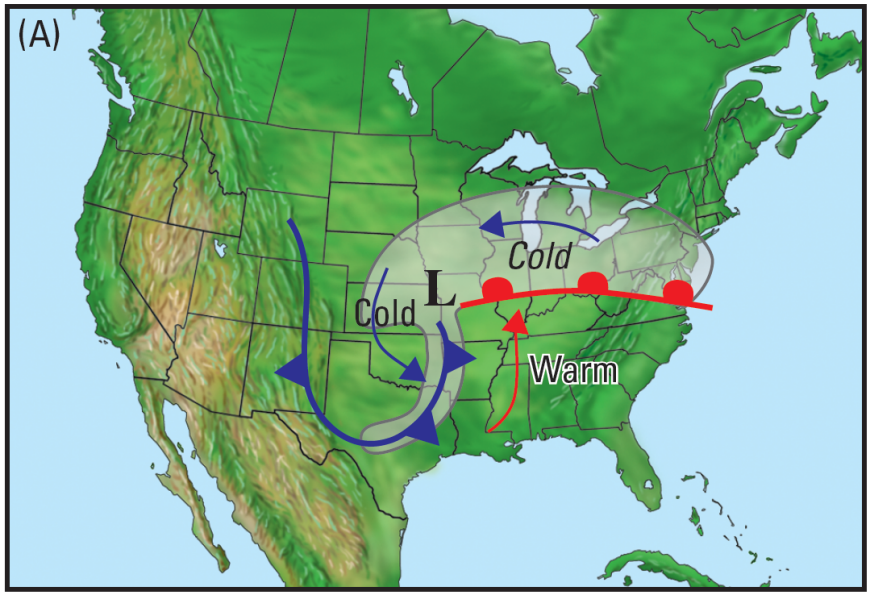


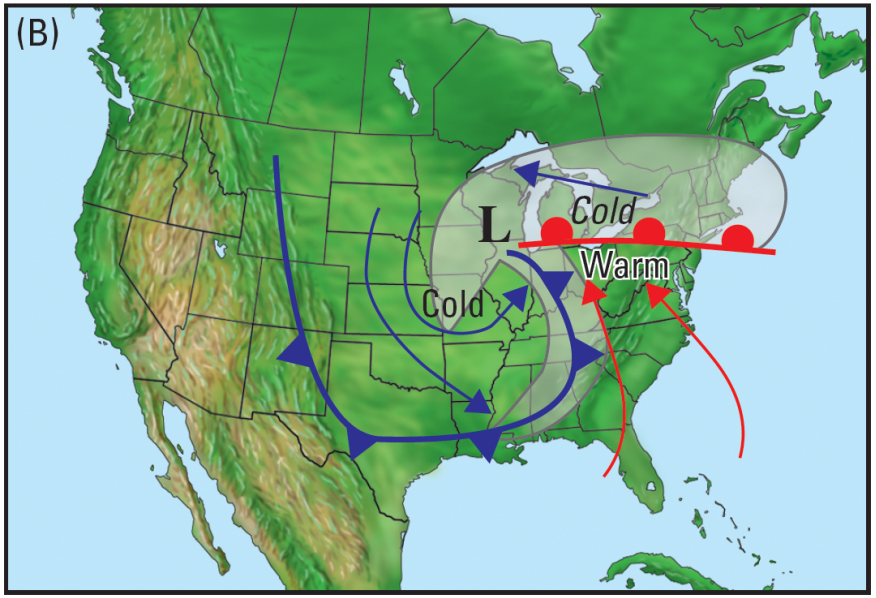


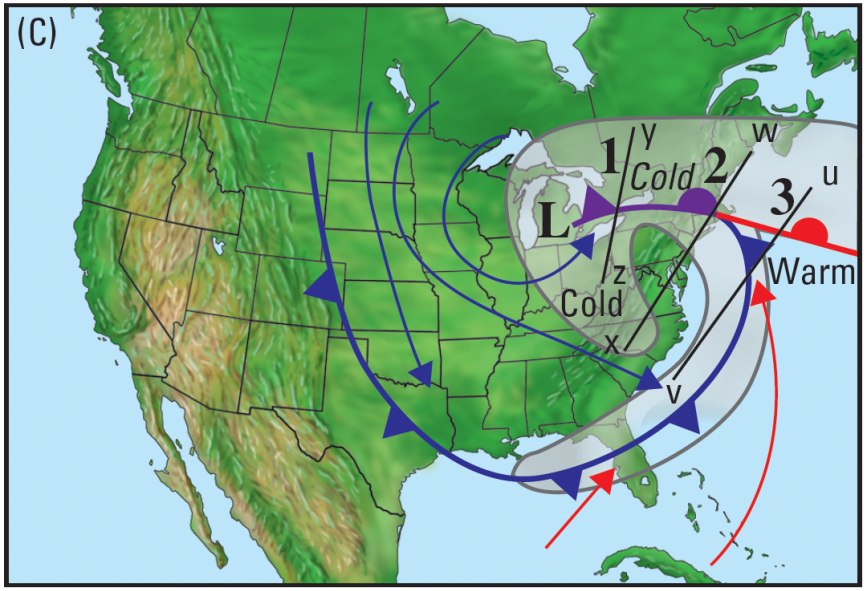
Occluded Fronts

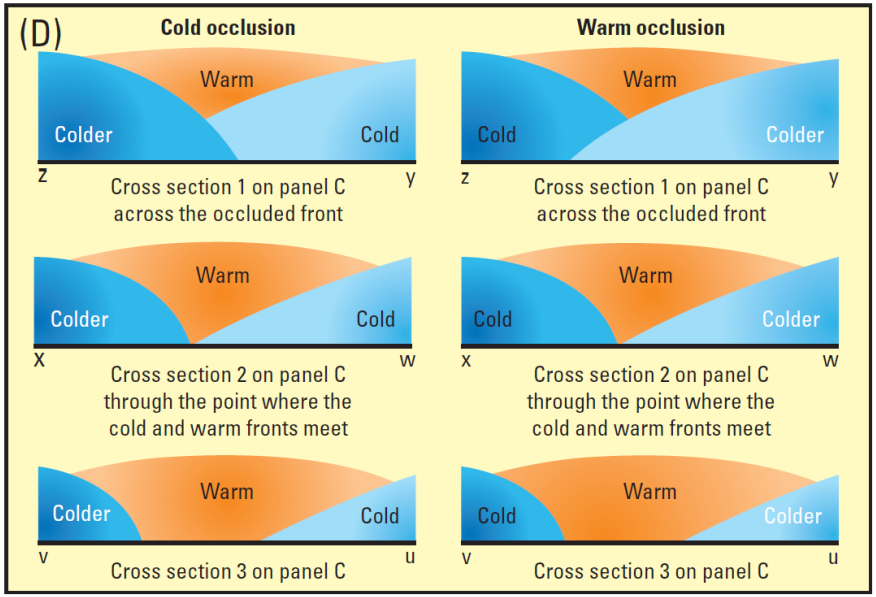
- As cyclones develop, the cold front can catch up and wrap into the warm front.
- The cold (behind/west of the cold front) air comes in direct contact with the cold air north of the warm from.
- The boundary between the two cold airmasses is called **an occluded front.**
- Occluded fronts develop during mature and dissipating stages of cyclones
- Cold occlusion: the cold air behind the cold front is colder.
- Warm occlusion: the cold air north of the warm front is colder; more common.

Occluded Fronts (produce widespread cloudiness and rain or snowfall)

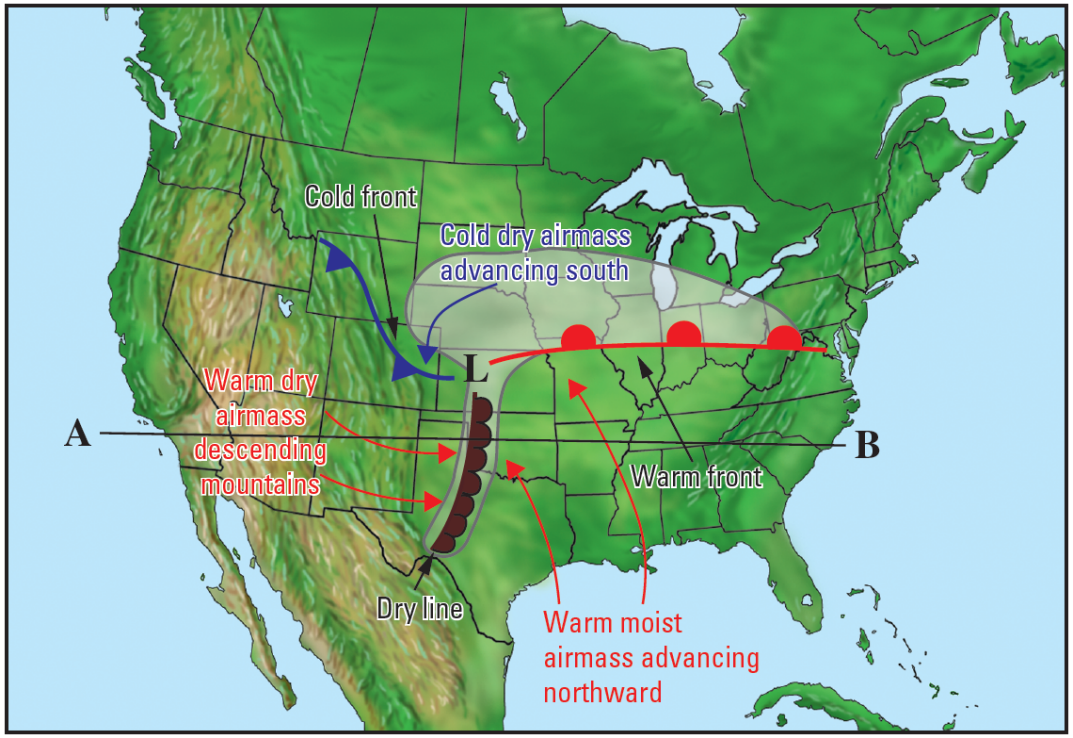


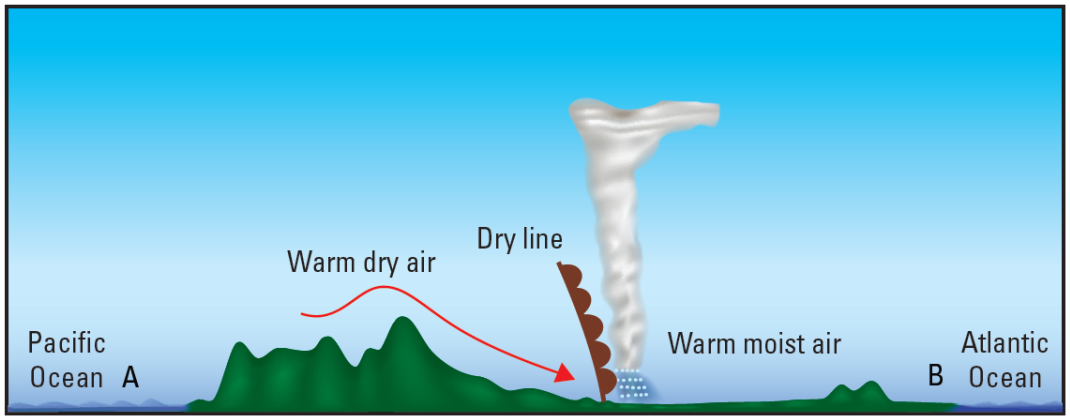






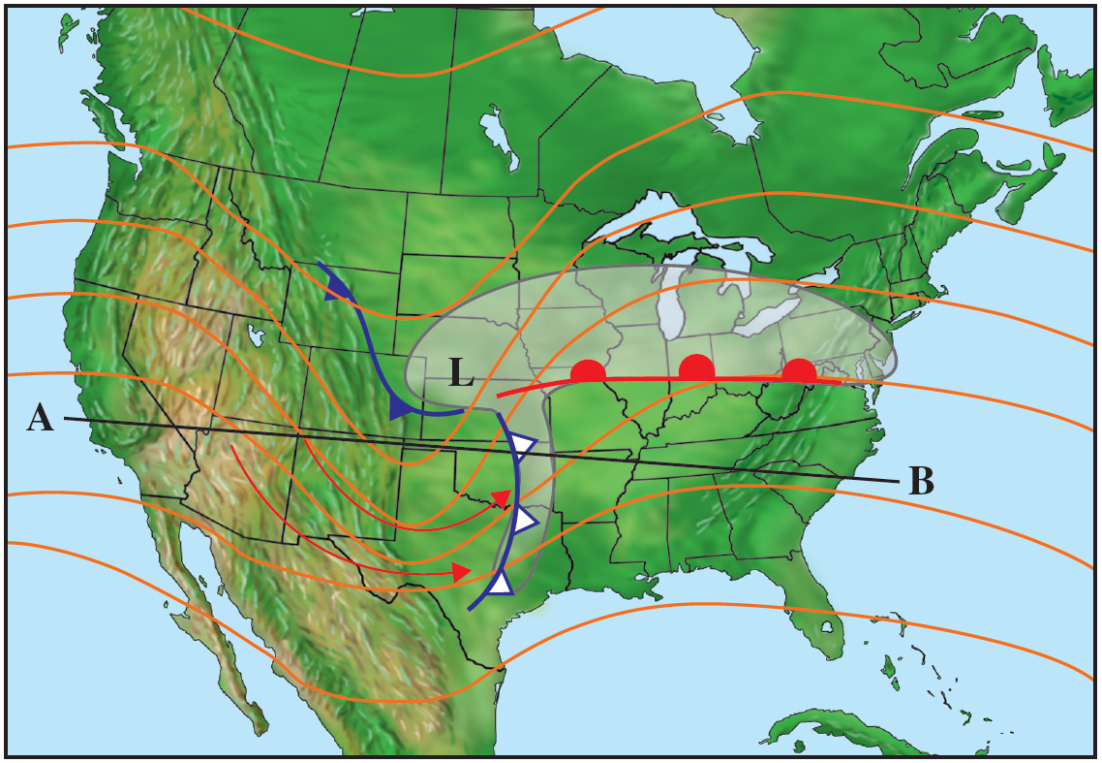
Dry Lines

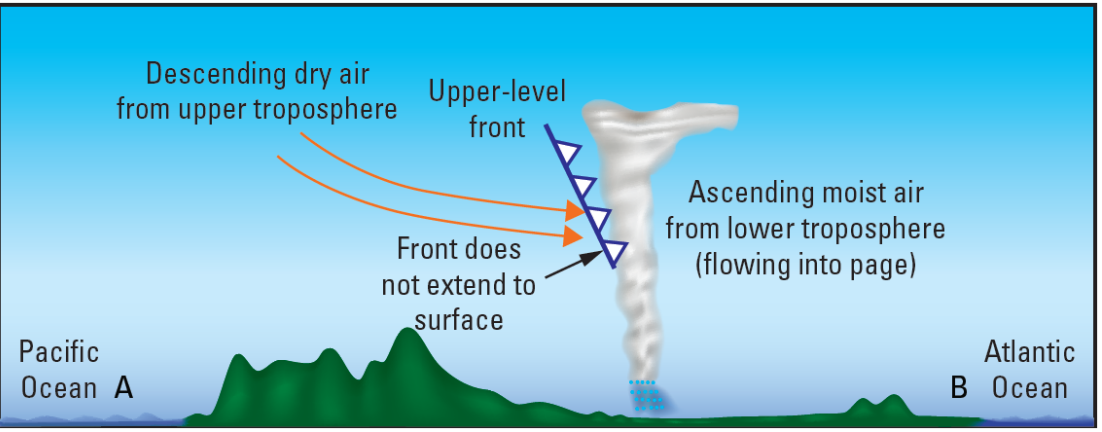




- Surface boundary between dry air from the deserts and plateaus to the west (even warmer & drier when descending down to the Plains) and moist air to the east
- Contrast in dew point, but generally not in temperature
- Dry air is denser (molecular weight higher) and runs under the moist air, triggering convection E of the dry line
- Afternoon thunderstorms are common in the moist air

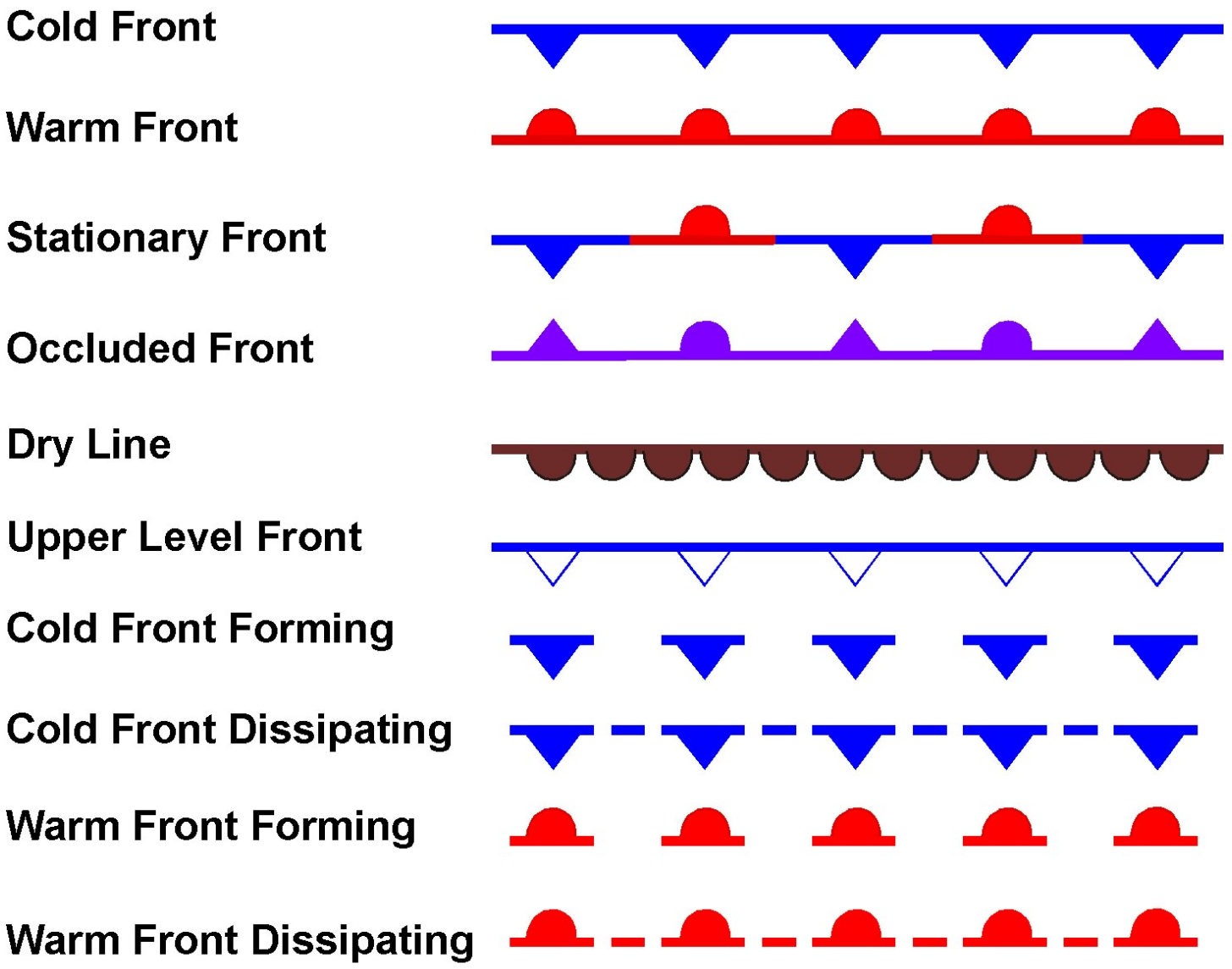
Upper Fronts





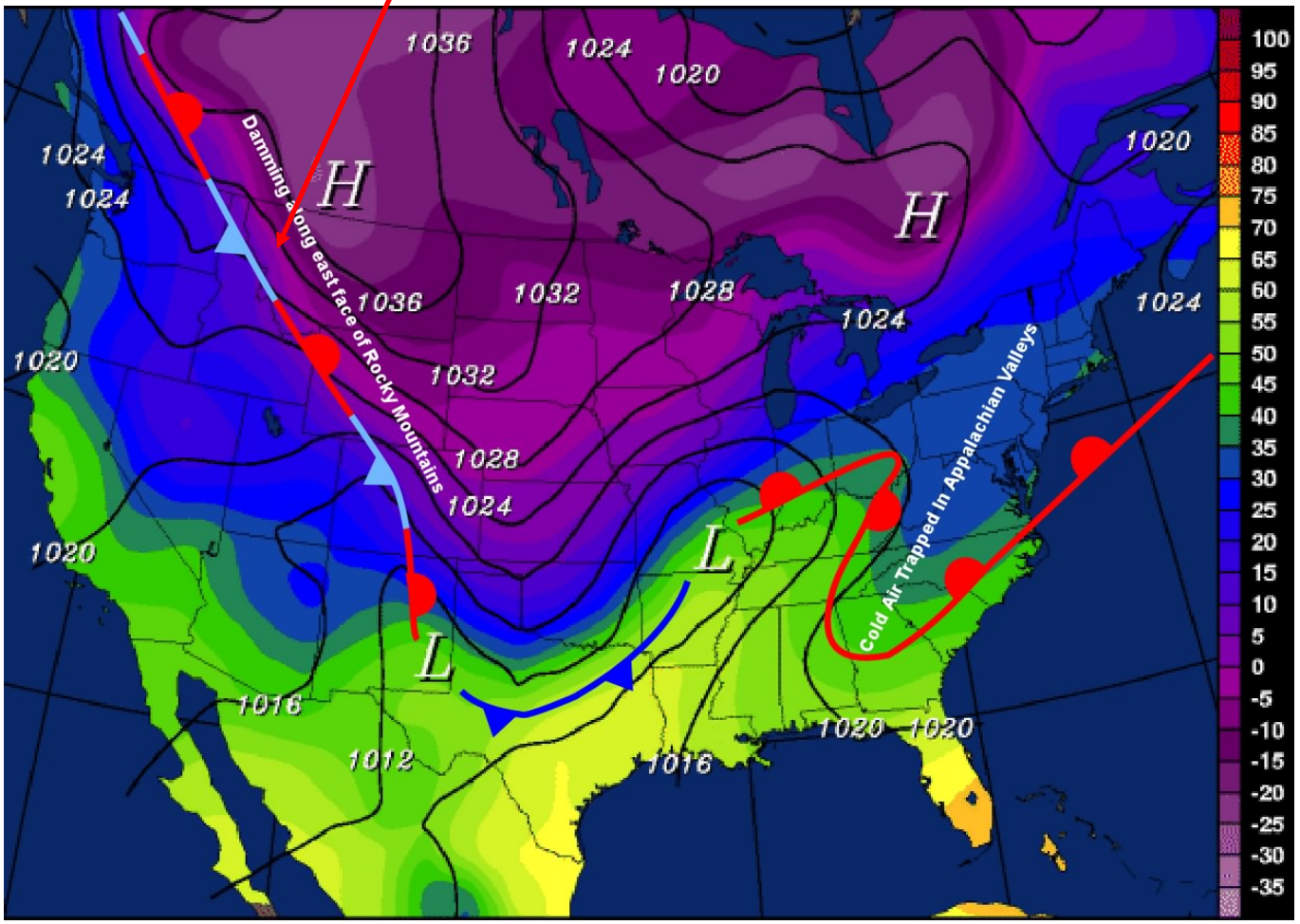
- Upper level boundary between descending dry air from upper troposphere and lower stratosphere and ascending moist air from the Mississippi Valley
- Sinking air starts out very cold in the upper troposphere (from the convergent zone west of the trough)and warms dry adiabatically
- Rising air starts out warm near the surface (from the divergent zone east of the trough) and cools moist adiabatically
- Sharp upper contrast in humidity, but weak temperature contrast
- Often causes a sharp line of showers (with clear air to the west of the line) with no surface temperature contrast

Frontal Symbols on Weather Maps



Topography and Fronts

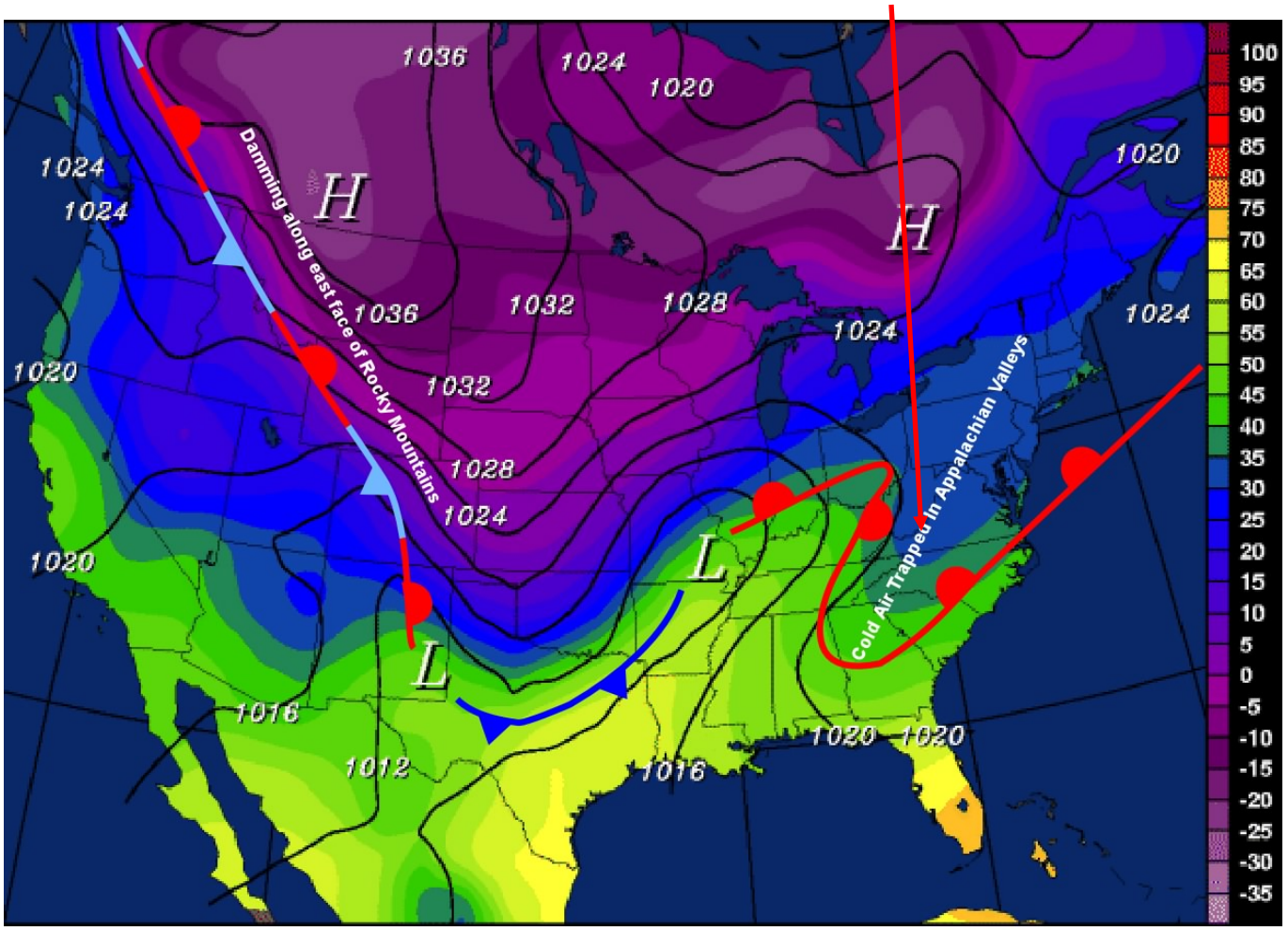
Cold air dammed along the Colorado Rockies is often analyzed as a stationary front. It is a boundary between air and rock.



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

Topography and Fronts

Cold air trapped in Appalachian valleys is often analyzed as a distorted warm front



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

Finding Fronts on Weather Maps

- Cold, warm, stationary fronts: on the warm edge of a sharp temperature gradient; sometime a sharp dewpoint gradient; a sharp shift in wind direction
- Fronts typically align with troughs in the surface pressure field
- A line of showers or thunderstorms; a transition from a clear to cloudy sky
- Cold front: wind on cold side blows toward the front
- Warm front: wind on cold side blows away the front
- Stationary front: wind on cold side blows along the front
- Occluded front: sharp wind shift, widespread clouds, light to moderate precipitation
- Dry line: sharp gradient in dewpoint; common in south-central US east of Rockies; Daytime: weak temperature gradient; Nighttime: more like cold fronts
- Upper Front: pressure trough in surface data; may have wind shift; lines of showers and precipitation.

Summary

- Air Masses: Bodies of air with well-defined temperature and humidity derived from a source region
- Fronts: Boundaries between air masses
- Kind of front (Cold or Warm) is defined by the temperature of the air that arrives with it
- Cold fronts are steeper and move faster than warm fronts
- Stationary Front: Flow is mostly parallel with the front
- Stability of warm air to S & E controls rainfall
  - Unstable: Convection in warm air
  - Stable: Stratiform rain falls through frontal surface into cold air
- Dry line: Surface humidity boundary
- Upper Front: Boundary between rising, moist cold air & and sinking, dry, somewhat colder air
- Occluded Front: Cold front catches up to warm front wedging a layer of moist air upward