Funding provided by NOAA
Sectoral Applications Research Project

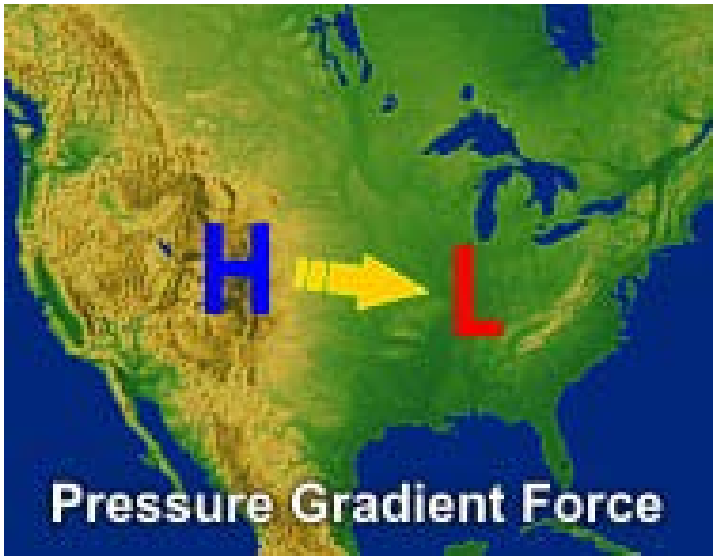
PRESSURE SYSTEMS, AIR MASSES & FRONTS

Basic Climatology
Colorado Climate Center

PRESSURE SYSTEMS

Pressure makes the wind blow

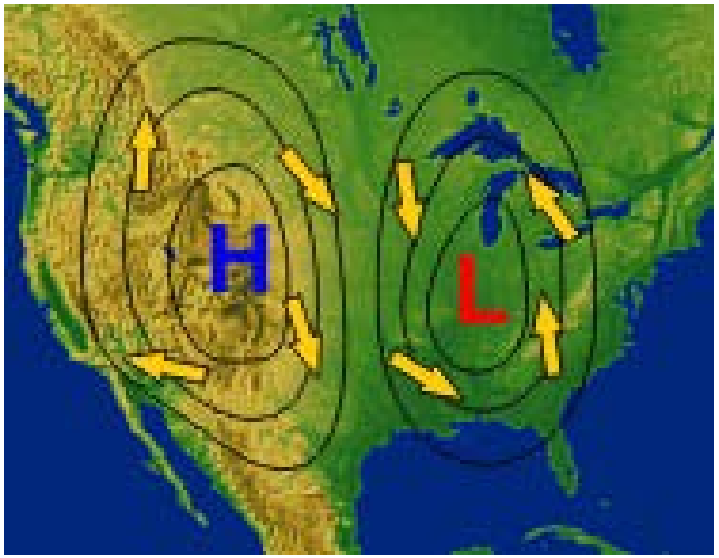
- Wind is simply air molecules in motion
  - We "see" wind through the force of these molecules on objects, such as leaves
- Air moves from areas of high pressure to low pressure
  - Recall *density* – molecules are packed more tightly together when pressure is high, so they want to spread out a bit



Source: NOAA National Weather Service Jetstream

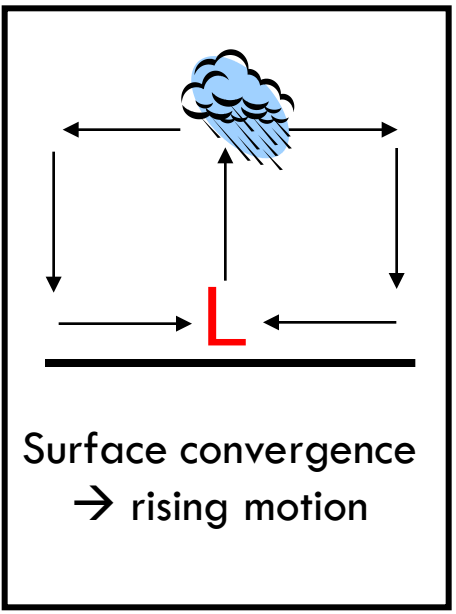
Pressure makes the wind blow

- But remember all that stuff about the Earth's rotation?
  - The *Coriolis force* turns air parcels to the right (in the northern hemisphere)
  - This causes air to 'spin' around the pressure centers
- The air would end up going around in circles around the pressure centers except for *friction*
  - Friction slows wind speeds, lessening the effects of the Coriolis force
- Air moving away from high pressure creates *divergence* at the surface, drawing air downward from aloft
- Air moving toward low pressure creates *convergence* at the surface, forcing air upward near the low's center

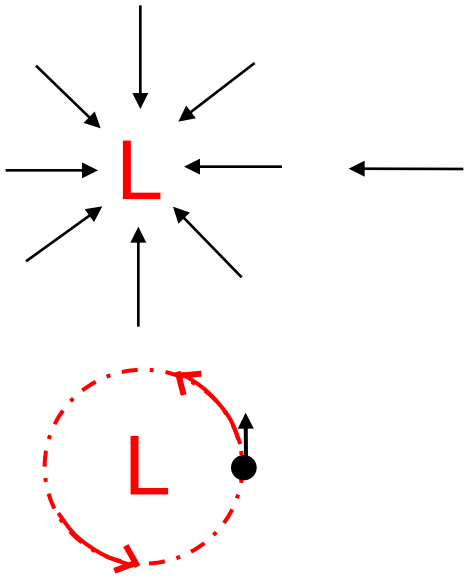


Source: NOAA National Weather Service Jetstream

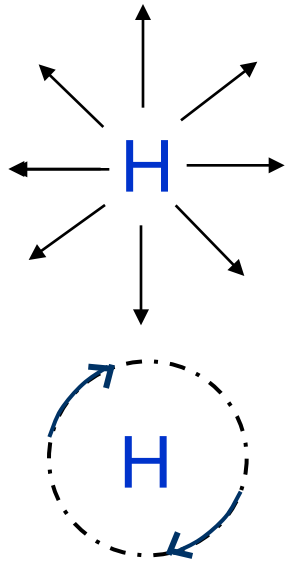
Low vs. High Pressure (N. Hemis.)



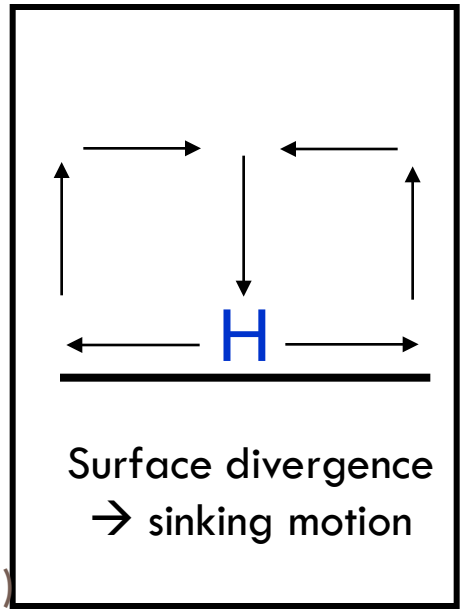
Surface convergence
→ rising motion



Counter-clockwise (cyclonic) flow



Clockwise (anticyclonic) flow



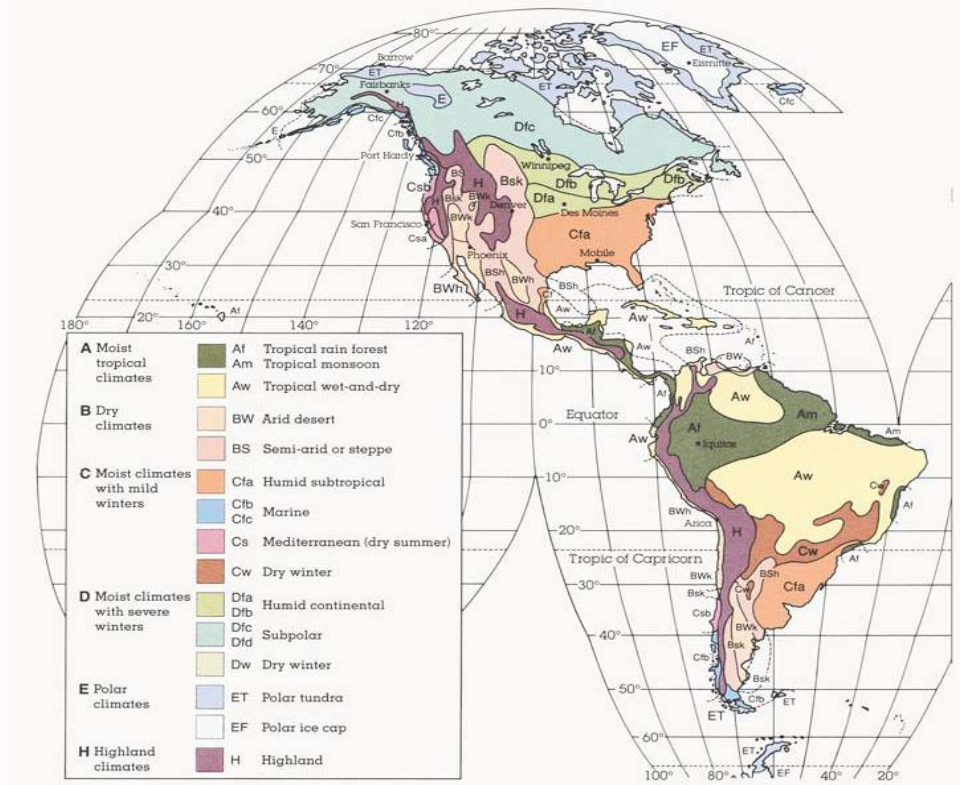
Surface divergence
→ sinking motion

In the Northern Hemisphere, if you stand with your back to the wind, then the lower pressure will be to your left.

AIR MASSES

Remember This?

- Air in motion brings with it characteristics of its source region
- These characteristics are called an *air mass*
- Boundaries between air masses are called *fronts*



Types of Air Masses

- Air masses are distinguished by one of four source characteristics:
  1. Polar (sometimes called Arctic)
  2. Tropical
  3. Continental (land regions)
  4. Maritime (water regions)

- As air masses move, they become *modified* such that they show characteristics of two source regions
  - cP = continental Polar
  - mT = maritime Tropical

Air Masses of North America

(1) cP and cA Continental Polar and Continental Arctic

Cold (very cold in winter) and dry, stable conditions

(2) mP Maritime Polar

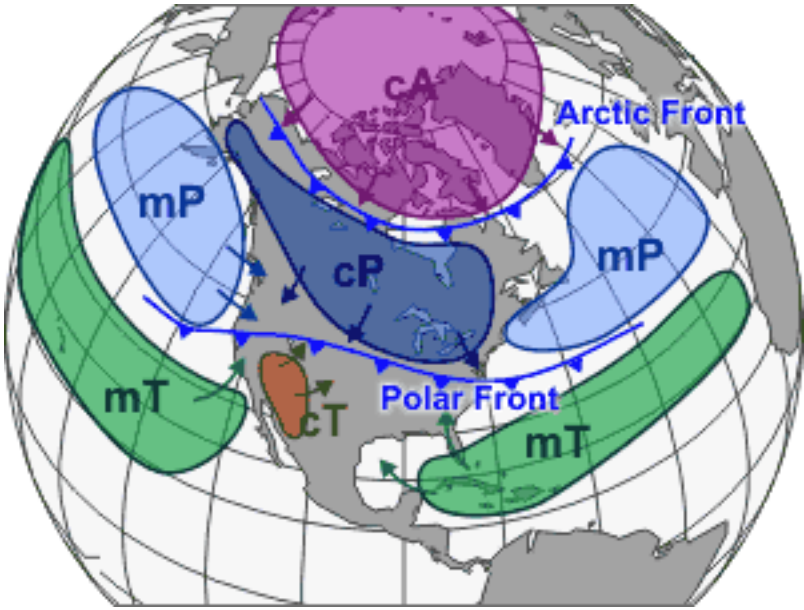
Cool, moist and somewhat unstable. Forms in polar regions, then moves over oceans.

(3) mT Maritime Tropical

Very warm and moist. Forms over the eastern Pacific and the Caribbean sea and Gulf of Mexico.

(4) cT Continental Tropical

Hot, dry and unstable conditions. Forms over northern Mexico and the southwestern U.S. during the summer.

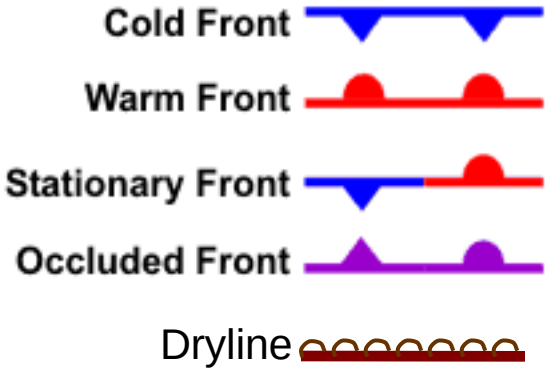


Source: NOAA National Weather Service Jetstream

FRONTS

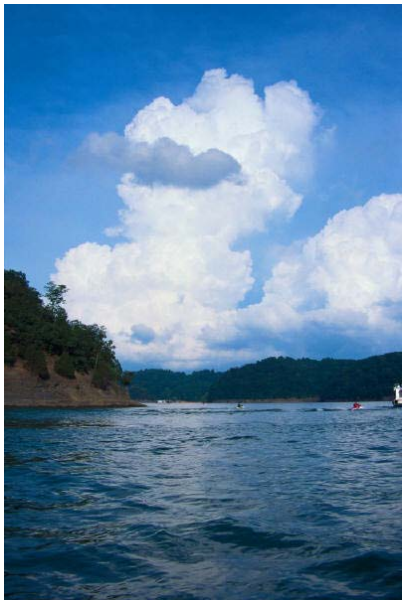
Fronts

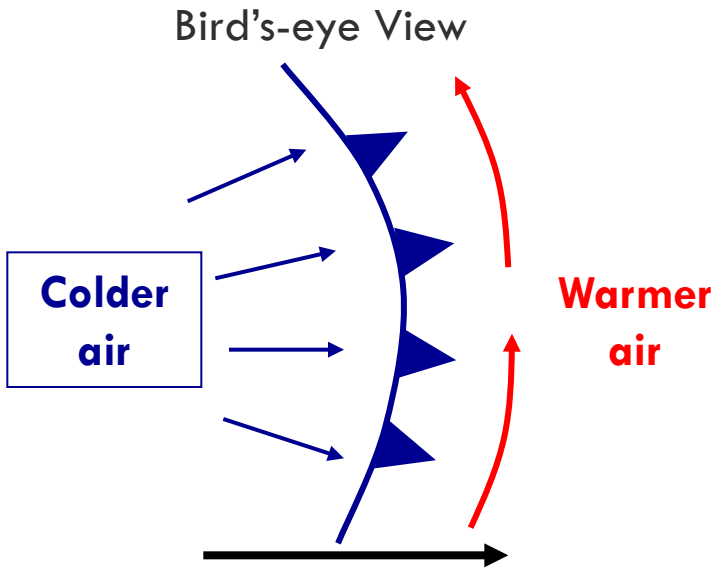
- *Fronts* are the boundaries between air masses
- Fronts are defined by the characteristics of the air mass it is replacing:
  - *Cold front*: colder air is replacing relatively warmer air
  - *Warm front*: warmer air is replacing relatively colder air
  - *Stationary front*: neither air mass is moving
  - *Occluded front*: a cold air mass (cold front) has overtaken a warmer air mass (warm front), lifting the warm layer aloft
  - *Dryline*: like a front, but a sharp contrast in moisture (humidity) more so than temperature
- Fronts are three-dimensional
  - Their slope determines the types of clouds that form along the boundaries

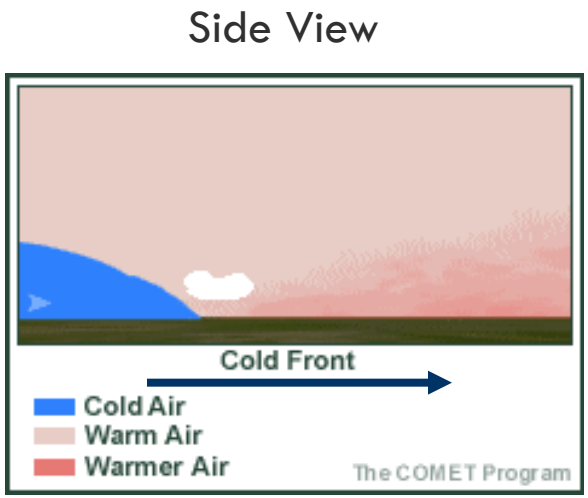


Cold Front

- A cold front is a boundary where a cold air mass is replacing a warm air mass.
- Blue triangles point in the direction of movement.
- Air on the warm side is lifted rapidly over cold air → air rises and cools → condensation begins and clouds form, heavy showers may fall
- *Cumulus clouds* are associated with cold fronts.
- A cold front moves faster than a warm front.

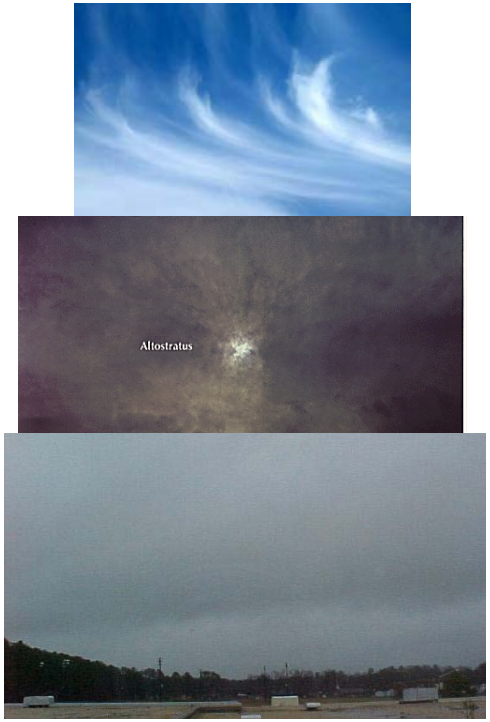




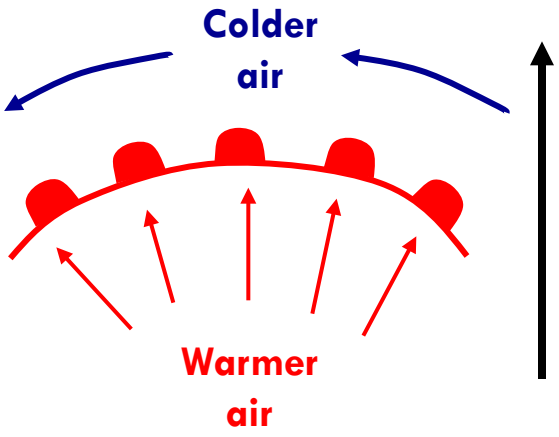


Warm Front

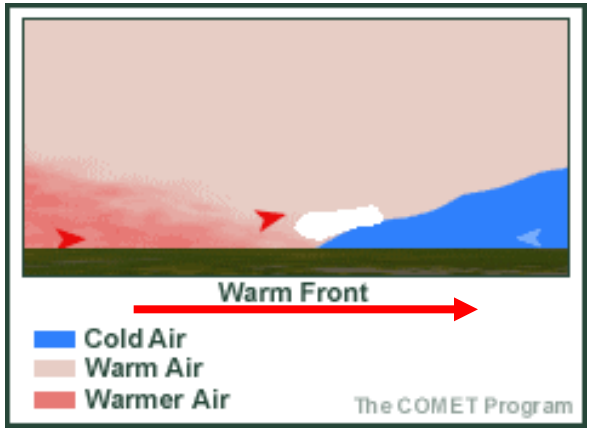
- A warm front is a boundary between an advancing warm air mass and a retreating cold air mass.
- Red half circles point in the direction of motion.
- Warm air rises over cold air at a slant, which leads to gradual lift.
- *Stratus, altostratus, and cirrus* are associated with warm fronts.



Bird's-eye View

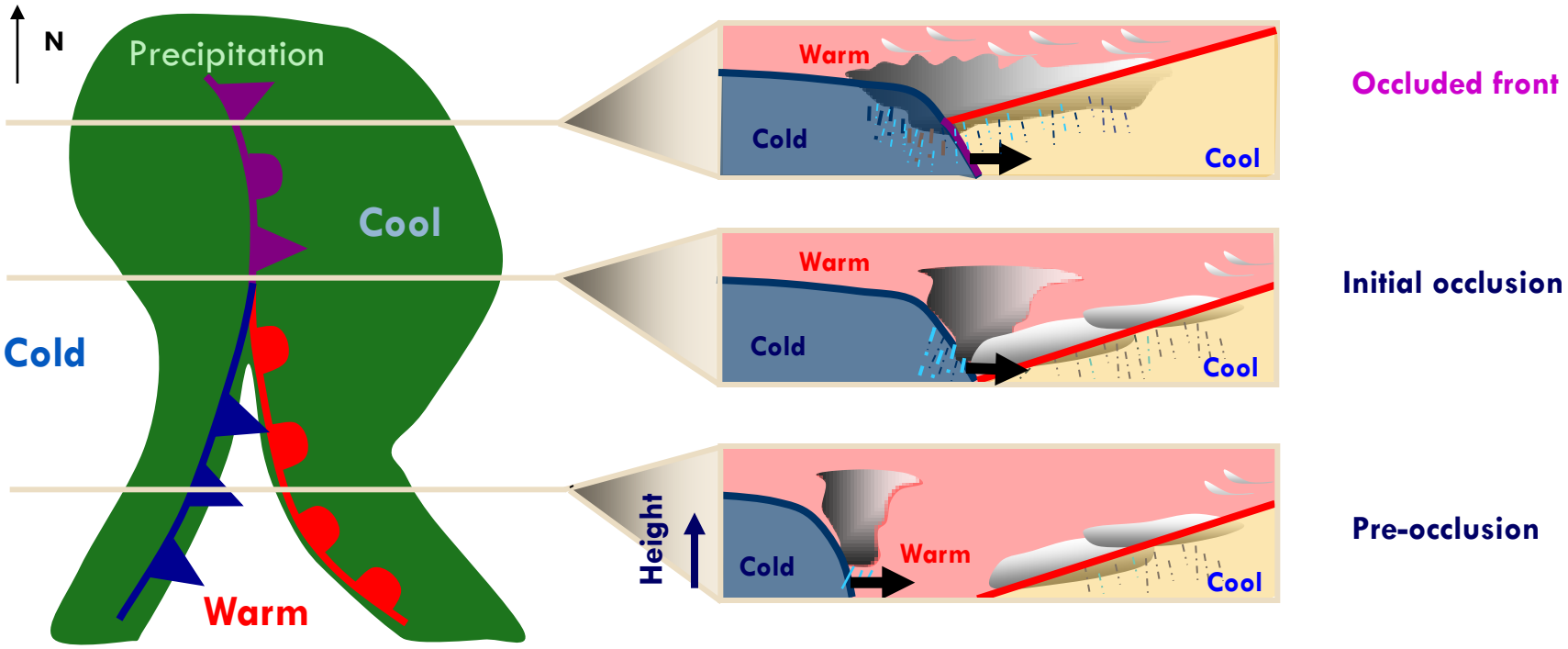


Side View



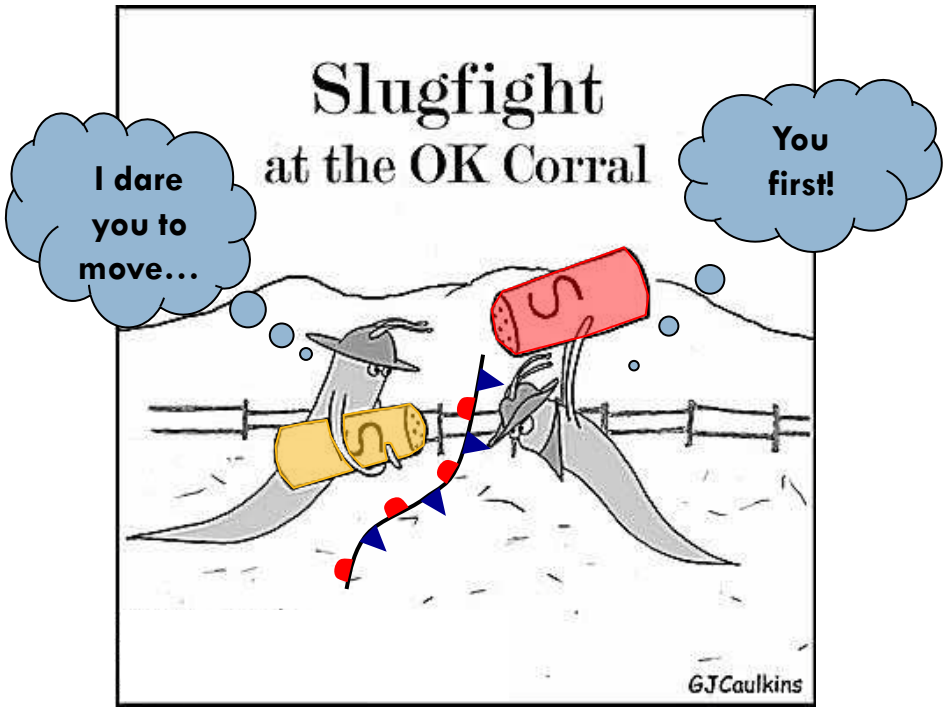
Occluded Front

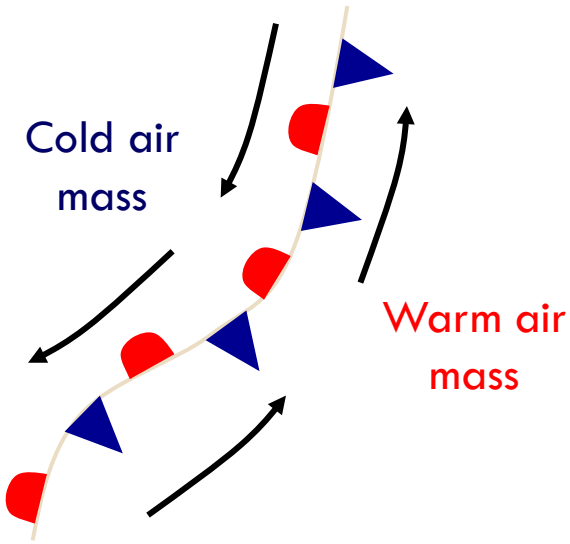
- An occluded front occurs when a cold front catches up to and overtakes a warm front (because the cold front moves faster than the warm front).
- It is shown as a purple line with alternating purple triangles and half circles.
- *Cirrus, altostratus, and stratus* are followed by *cumulus* and possibly heavy showers.



Stationary Front

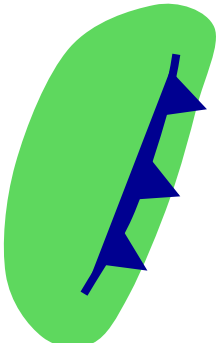
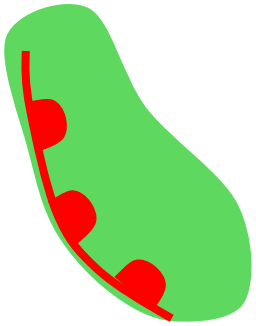
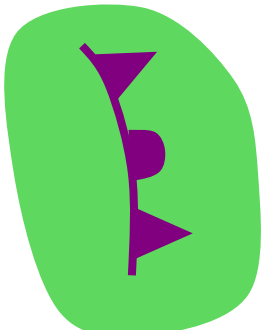
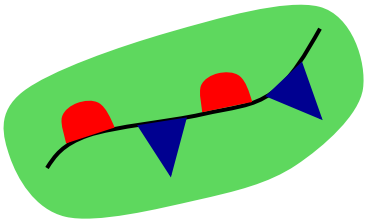
- A stationary front experiences very little to no movement.
- Two air masses are at a "stand-off," waiting for one to make a move.
- The wind blows parallel to the front, but in opposite directions.



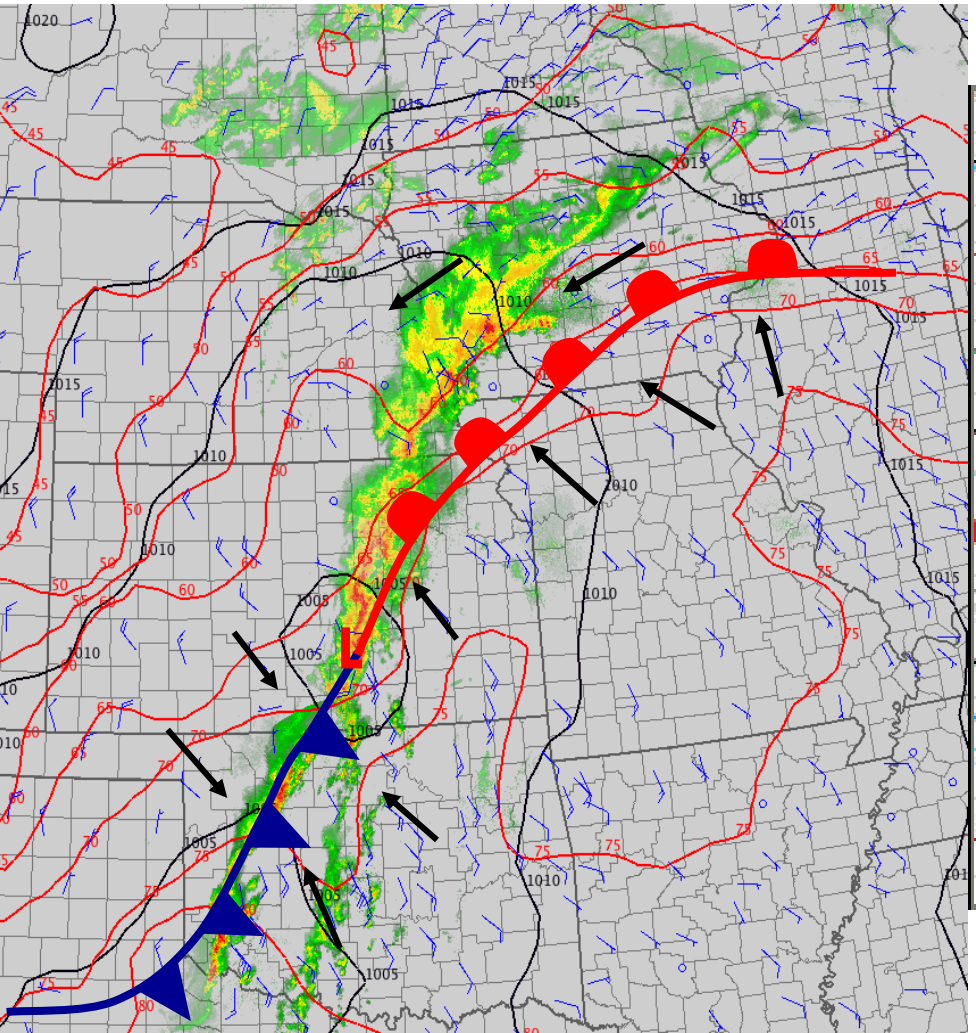


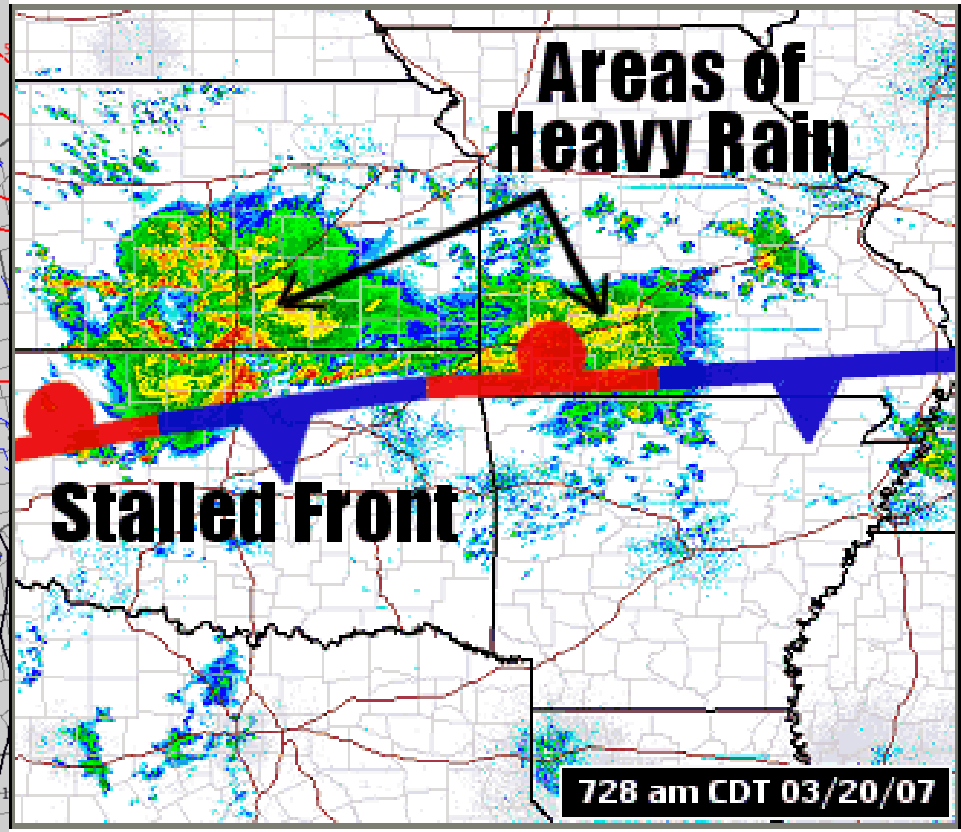
Identifying Fronts

- Now we know the front types…but how do we find them?
  - Radar
  - Weather map
- Fronts on Radar
  - ***Cold front***—Precipitation is mostly behind the front, but there is some before and along the front. There is a convective band (high echo values) with a stratiform band (low echo values).
  - ***Warm front***—Precipitation is mainly before the front, with some along the front. The precipitation is mainly stratiform (low echo values).
  - ***Occluded front***—Precipitation falls before, behind, and along the front.
  - ***Stationary front***—There is no precipitation if both air masses are dry; if there is enough moisture, precipitation can fall over the same area for a while, which can lead to flooding!

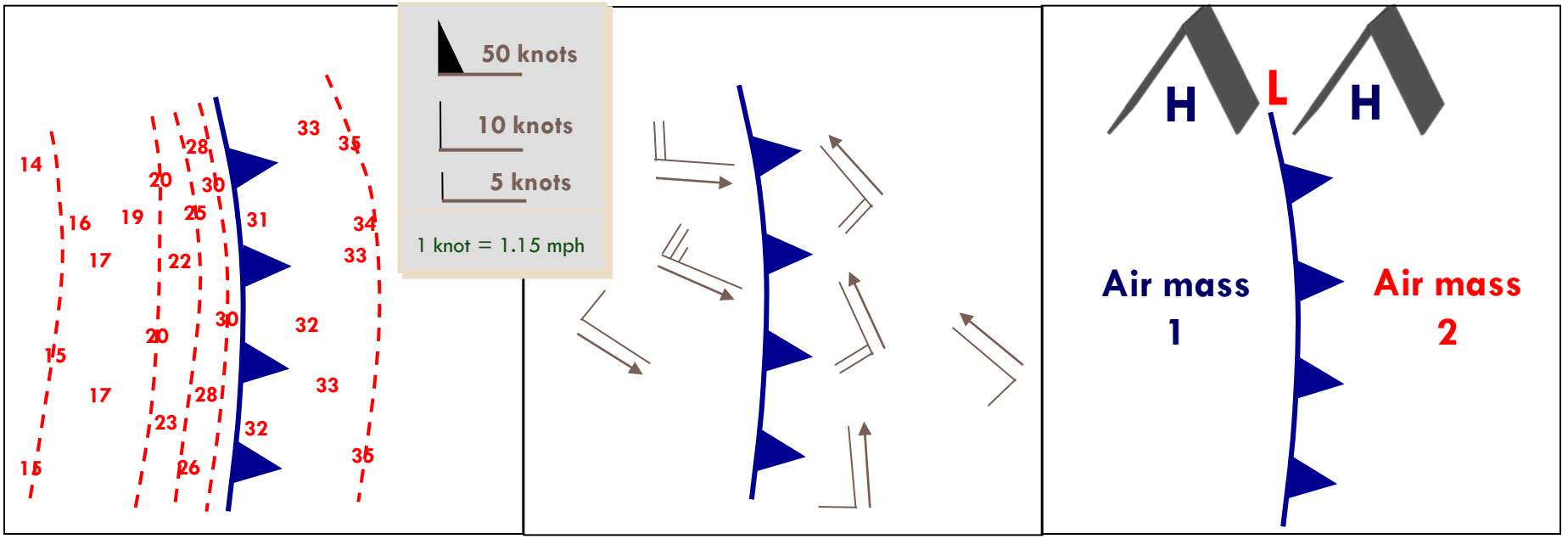
Identifying Fronts on Radar





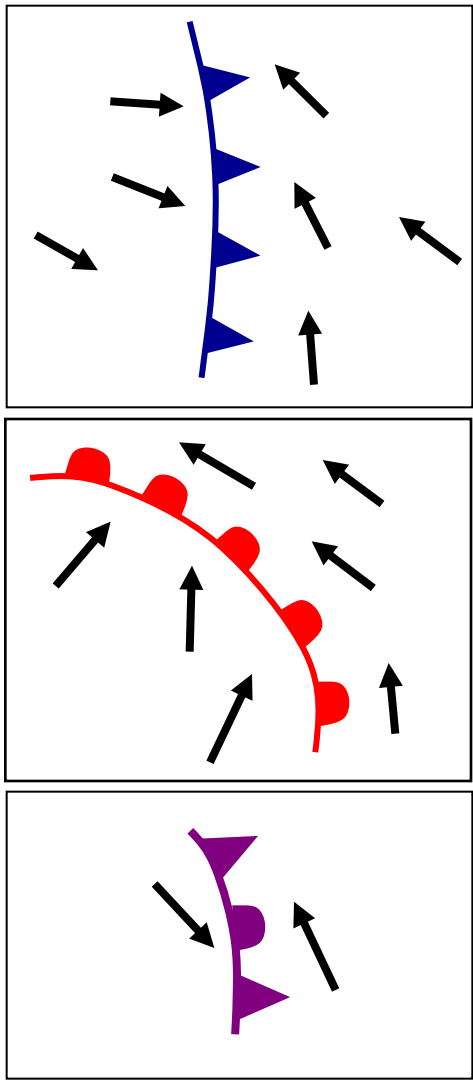
Identifying Fronts on Weather Map

- Sharp temperature changes over relatively short distance
- Changes in moisture content (dew point changes)
- Wind direction shifts
- Pressure and pressure changes
- Clouds and precipitation patterns (seen in radar/satellite)

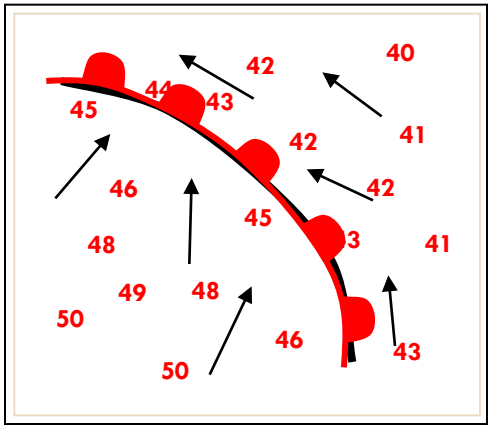


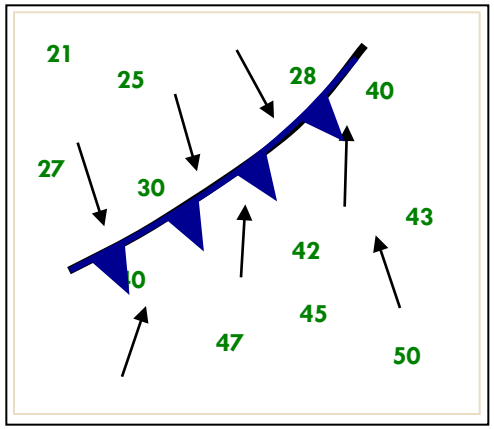
Identifying Fronts on Weather Map

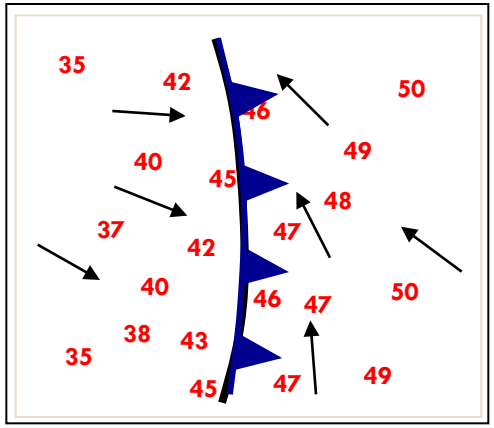
- Cold front
  - Cooler temperatures with frontal passage
  - Lower dewpoint temp. with frontal passage
  - Winds: S/SW before front, W/NW after front
- Warm front
  - Warmer temperatures with frontal passage
  - Higher dewpoint temp. with frontal passage
  - Winds: S/SE before front, S/SW after front
- Occluded front
  - Often cooler temperatures with frontal passage
  - Slightly lower dewpoint temp. with frontal passage
  - Winds: E/SE/S before front, W/NW after front



Identify the Fronts







Dryline

- Smaller scale than other fronts
- Mainly seen in the Plains states, especially in W Texas, OK and KS (spring/early summer)
- Narrow zone where there is a sharp change in moisture (dewpoint temperature)
- Black or brown scalloped line
- Separates warm, dry air and warm, moist air
- Severe thunderstorms (e.g., supercells) can form along the dryline.