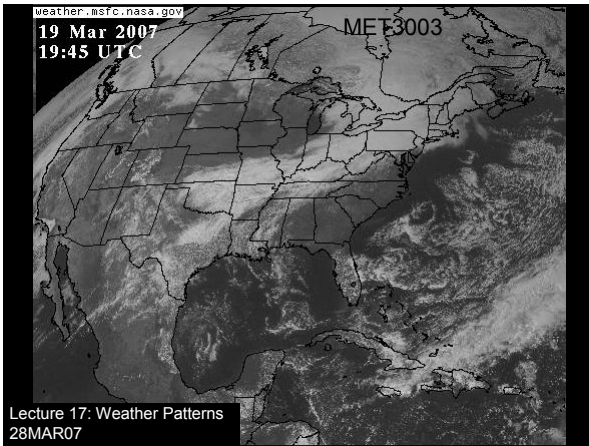


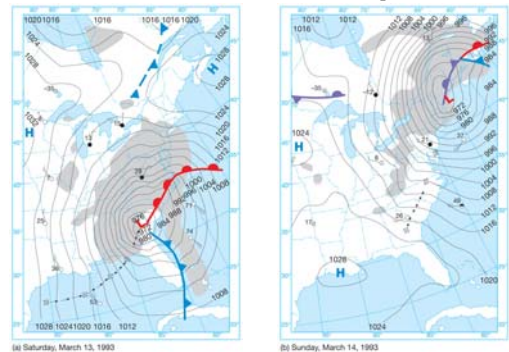


Blizzard of 1993

- March 13 & 14
- Record low temperatures & barometric pressures. Record high snowfalls
- Killed 270 people
- Three million in the dark
- Caused 27 tornadoes in Florida
- “Storm of the Century”



On Weather Maps



Middle Latitude Cyclones

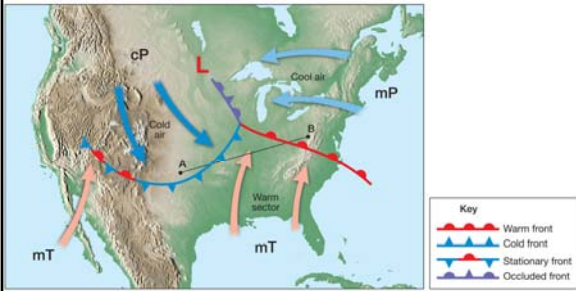
- Generally between 30-60° Latitude
- Also called **Mid-Latitude** or **Frontal Cyclones**
 - Low pressure systems
 - Generally > 1000 km across
 - Travel west-to-east
 - Usually have a cold front and a warm front extending out from their centers
- Remember that a **Front** is a sharp boundary between air masses

The Norwegian School

- Cyclones as traveling low pressure systems had been known since Torricelli (1644) and Franklin (1743)
- World-War I shut down weather communications
- Norwegians established a dense local observing network
- Observed middle-latitude cyclones in great detail
- Revealing discontinuous temperature contrasts
- And that they formed on the Polar Front
- Wilhelm Bjerknes →
 - Helped by Jacob B., Halvor Solberg & Tor Bergeron

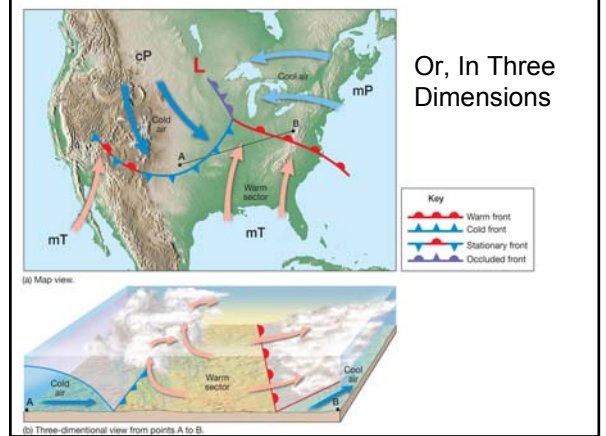


Frontal Cyclone in North America

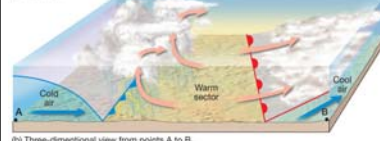


(a) Map view.

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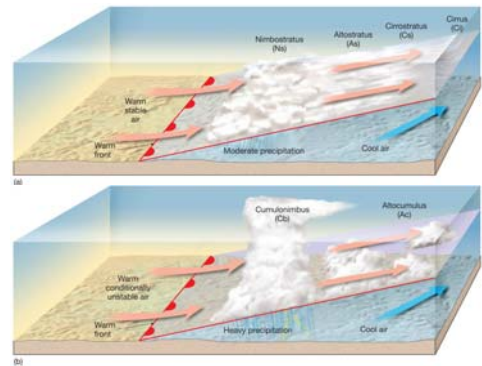
(a) Map view.



All About Fronts

- Boundaries between air masses
 - Frontal “zone” 15-200 km wide
 - Compared with > 1000 km extent of Air Mass
 - Limited mixing across the boundary
- Boundary always slopes
- Warm (OK, less dense) air always overlies cold (more dense) air
- Air behind the front catches up with air ahead
 - **Wedging:** Cold air runs under warm (underrunning)
 - **Overtaking:** Warm air glides up over cold

Warm Fronts

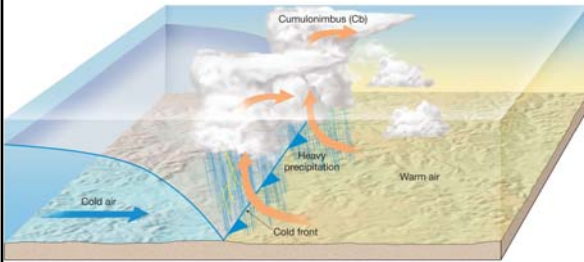


Warm Front Properties

- Surface front slowed by friction
 - Causes a gradual slope
 - Broad frontal zone at surface
- Rising motion due to overrunning
 - Stratiform rain in cool-season stable stratification
 - Convective rain only in warm-season, conditionally unstable air
 - Generally, gradual moderate to light rain
- Sequence of clouds: Ci, Cc, Cs, As or Ac, Ns
 - Can have Cb's with unstable warm air
- Winds:
 - East to South ahead of front
 - Southwest after frontal passage
- Barometer falls slowly ahead of the front, then steady after passage



Cold Fronts

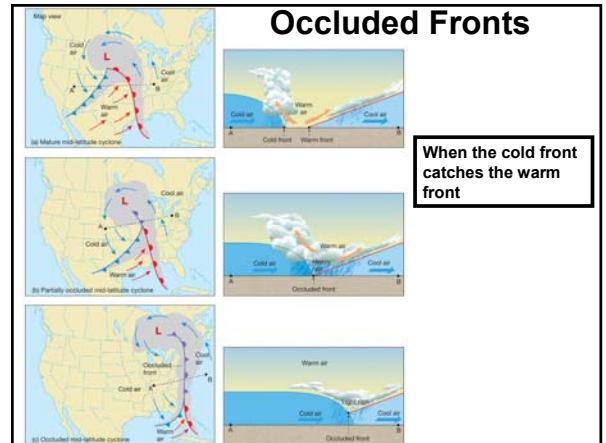


Cold Front Properties

- Surface front slowed by friction
 - Causes steep slope
 - Narrow frontal zone at surface
- Rising motion due to wedging
 - Convective rain in nearly all seasons
 - Dry cold fronts happen in arid southwest
- Abrupt arrival of Cb's then clearing
- Winds go from Southwest to North or Northwest
- Barometer steady or falling slowly then rising.
- Pronounced temperature drop

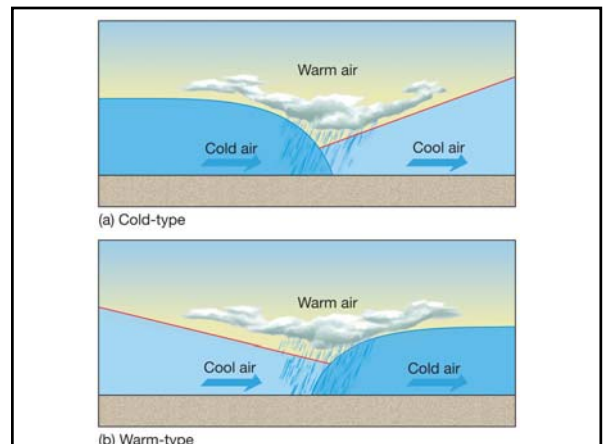


Occluded Fronts

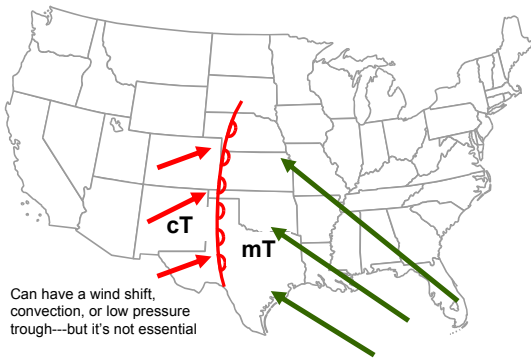


Occluded Front Properties

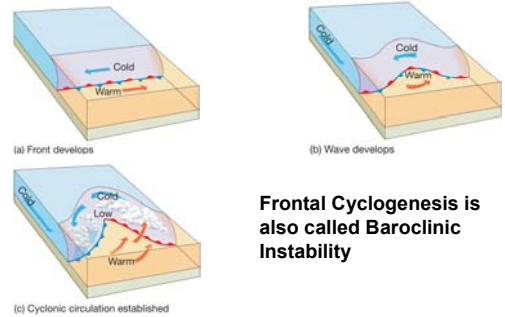
- Cold front overtakes the warm front
- Complicated weather
- When the air mass behind the front is colder (cP catches mP, East Coast)
 - Cold-front type occlusion & weather
 - Often behind the surface front
- When the air mass behind the front is warmer (mP catches cP, West Coast)
 - Warm-front type occlusion & weather
 - Often ahead the surface front



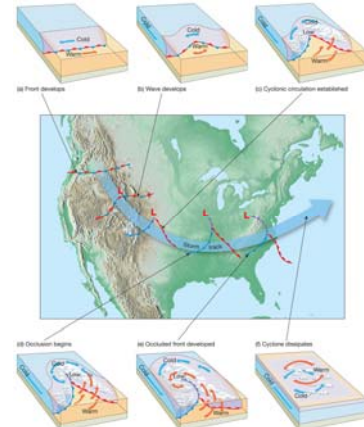
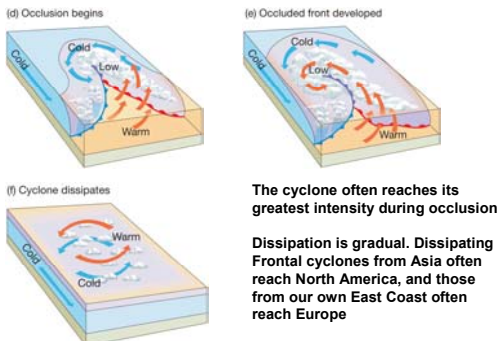
DRYLINE



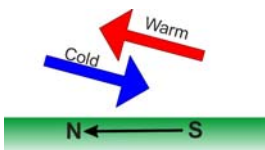
Frontal Cyclone Development



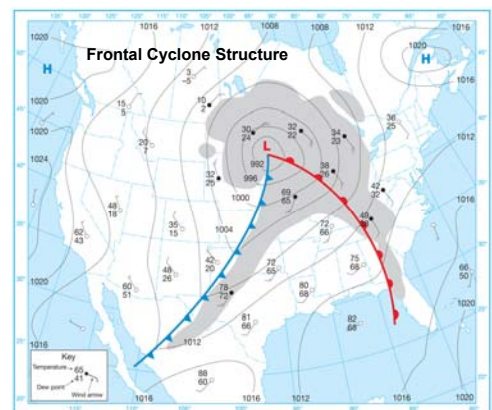
Frontal Cyclone Maturity and Dissipation



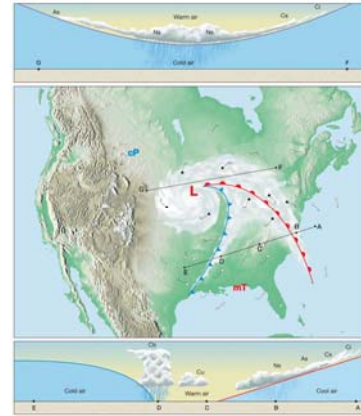
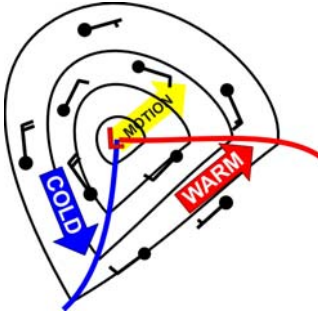
Cyclogenesis or Baroclinic Instability



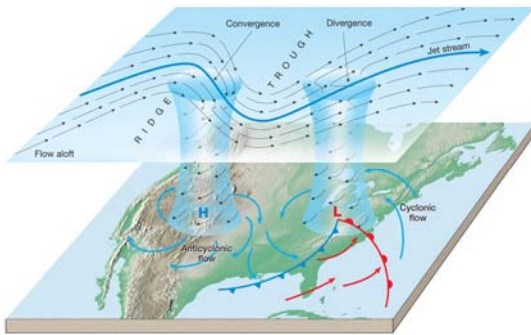
- Slantwise motion
- Cold air pushes south and sinks
- Warm air pushes north and rises
- The net effect is to turn energy stored in the N-S temperature gradient into energy of the baroclinic waves



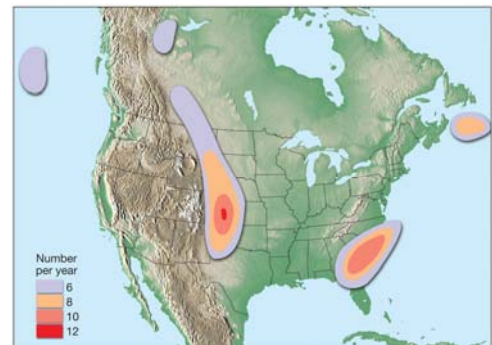
Baroclinic instability moves both heat and westerly momentum poleward



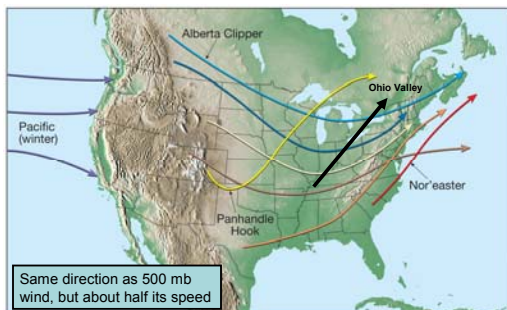
Vertical Structure of Frontal Cyclones



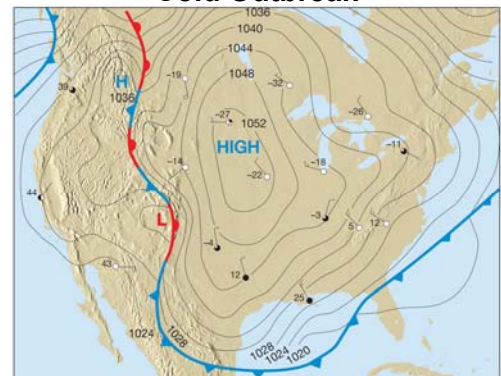
Frontal Cyclone Formation

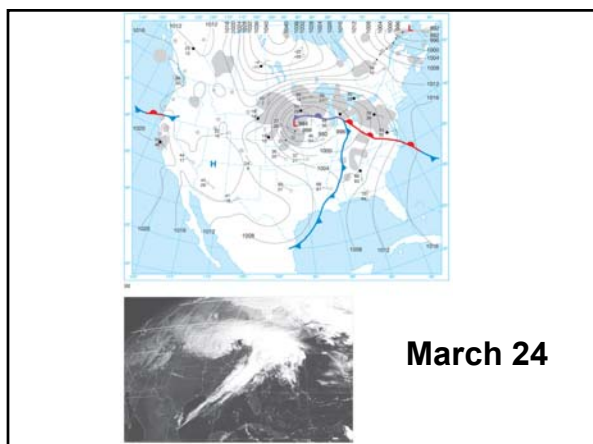
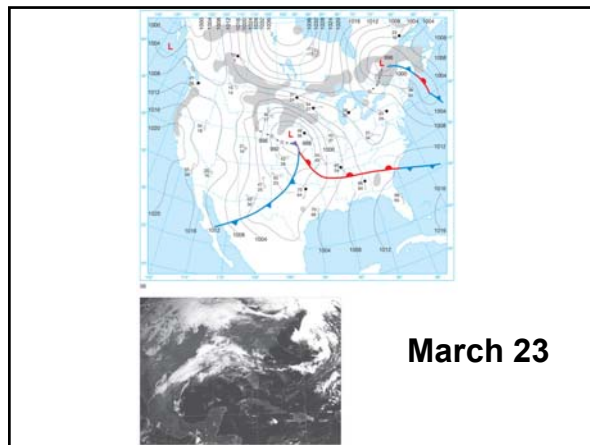


Frontal Cyclone Motion



Cold Outbreak





Summary

- Know the properties of **Frontal** or **Mid-Latitude Cyclones**.
- Be able to draw and explain the structure and dynamics of **Warm Fronts**, **Cold Fronts**, **Stationary Fronts**, and **Occluded Fronts**, including typical weather
- Know the definitions of **Cyclogenesis** and **Baroclinic Instability**, **Blocking High**, **Nor'Easter**, **Alberta Clipper**, and **Polar Outbreak**
- Be able to draw and explain the structure of an open wave middle-latitude cyclone and an occluded cyclone
- Be able to draw and explain the life cycle of a typical frontal cyclone over North America
- Be able to relate frontal cyclone motion to the mid-level (500 mb) wind
- For Next Time: **Read Chapter 10**