

How to "Grow" a Storm

- Upper level **shortwave** passes
- Upper level **divergence** -> sfc low
- **Cold advection** throughout lower troposphere
- **Cold advection intensifies upper low**

Leads to **more upper level divergence**

Temperature advection is key!

Fronts

A Front - is the **boundary between air masses**; normally refers to where this interface intersects the ground (in all cases except stationary fronts, the **symbols are placed pointing to the direction of movement of the interface (front)**)

Warm Front

Cold Front

Stationary Front

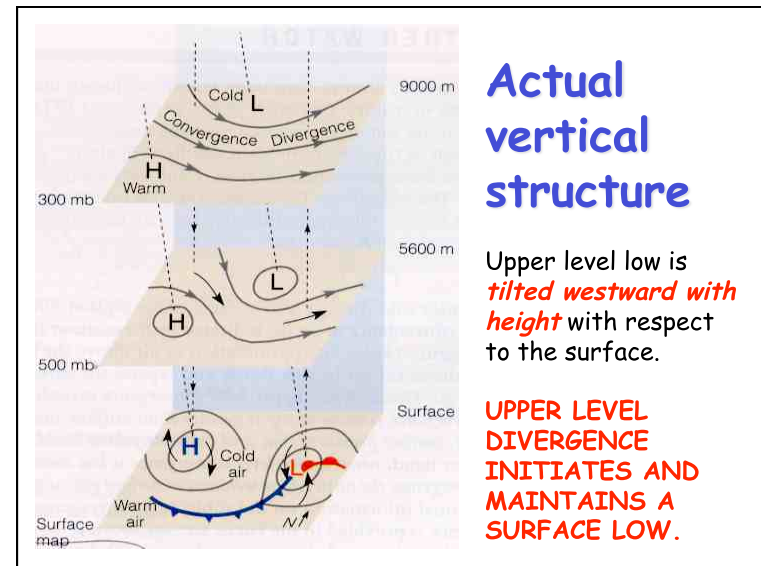
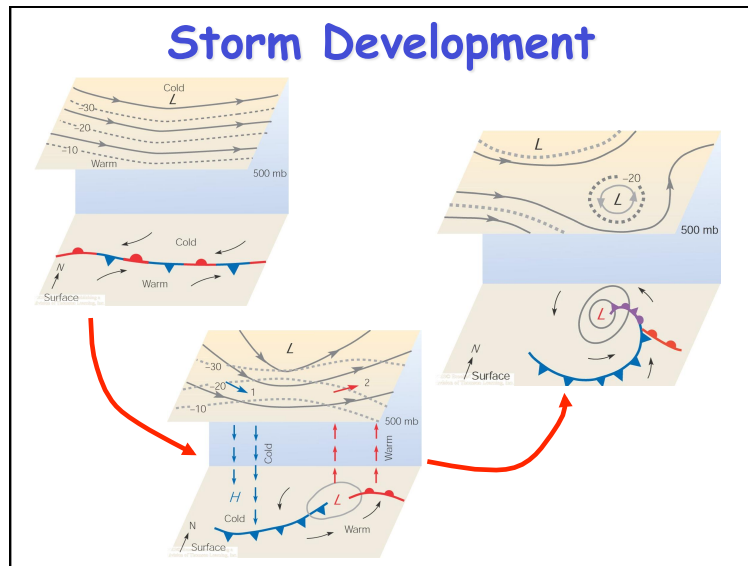
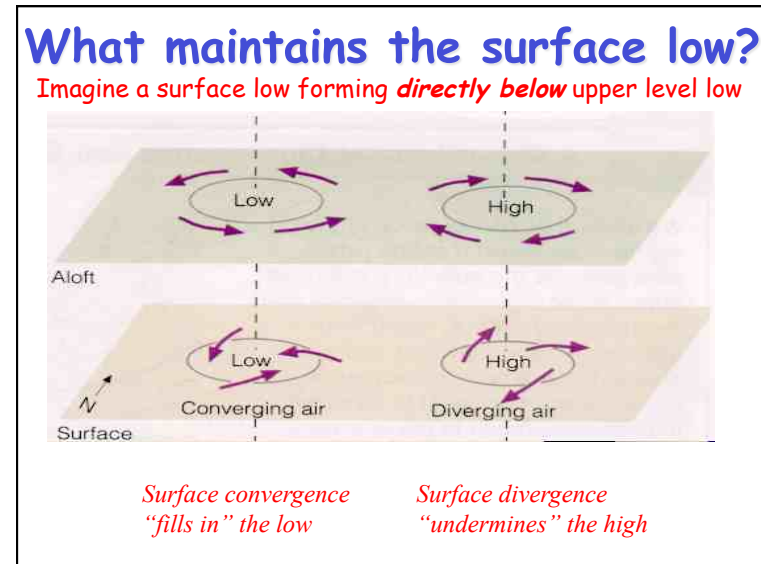
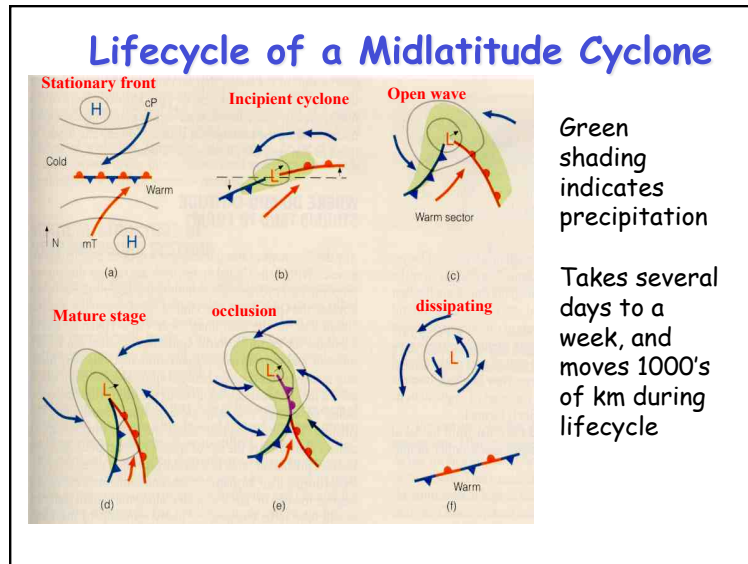
Occluded Front

Characteristics of Fronts

- Across the front - look for one or more of the following:
 - Change of **Temperature**
 - Change of **Moisture**
 - Change of **Wind** Direction
 - Change in direction of **Pressure Gradient**
 - Characteristic **Precipitation** Patterns

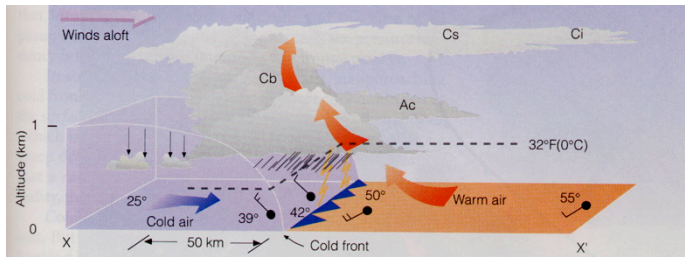
How do we decide what kind of front it is?

- If warm air replaces colder air, the front is a warm front
- If cold air replaces warmer air, the front is a cold front
- If the front does not move, it is a stationary front
- **Occluded fronts do not intersect the ground; the interface between the air masses is aloft**



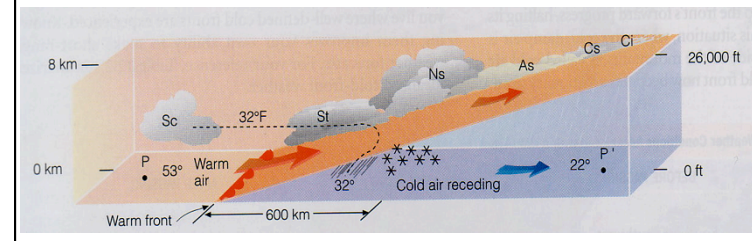
Cold Front Structure

- Cold air replaces warm; leading edge is steeper due to friction at the ground
- Strong **vertical motion and unstable air** forms cumule clouds (thunderstorms!)
- Upper level winds blow ice crystals downwind creating cirrus and cirrostratus

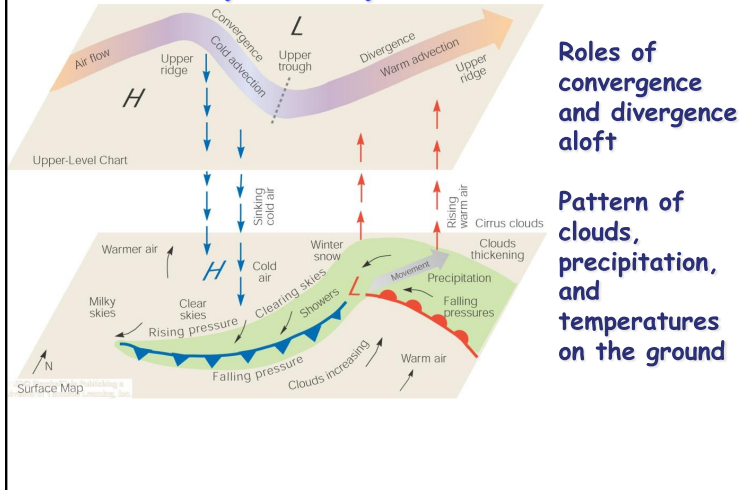


Warm Front Structure

- In an advancing warm front, **warm air rides up over colder air at the surface; slope is not usually very steep**
- Lifting of the warm air produces stratus **clouds and precipitation well in advance of boundary**
- At different points along the warm/cold air interface, the precipitation will experience different temperature histories as it falls to the ground



Summary of Cyclone Weather



Roles of convergence and divergence aloft

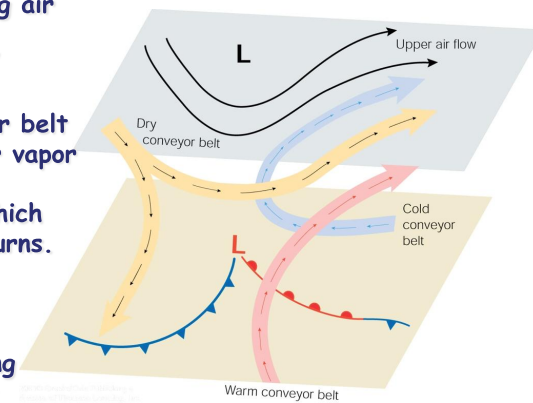
Pattern of clouds, precipitation, and temperatures on the ground

"Conveyor Belts"

This model describes rising and sinking air along **three "conveyor belts"**

A **warm conveyor belt** rises with water vapor above the **cold conveyor belt** which also rises and turns.

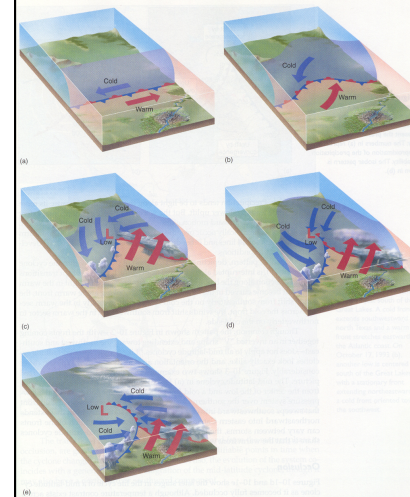
Finally the **dry conveyor belt** descends bringing clearer weather behind the storm.



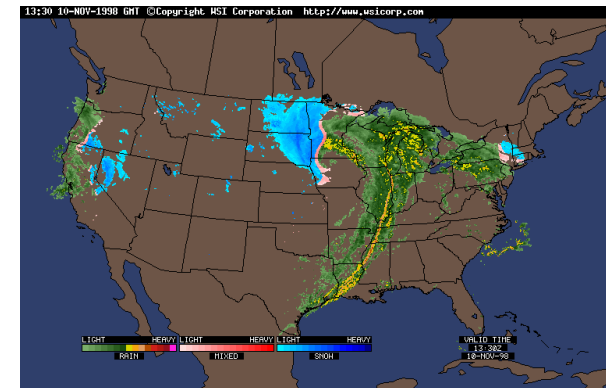
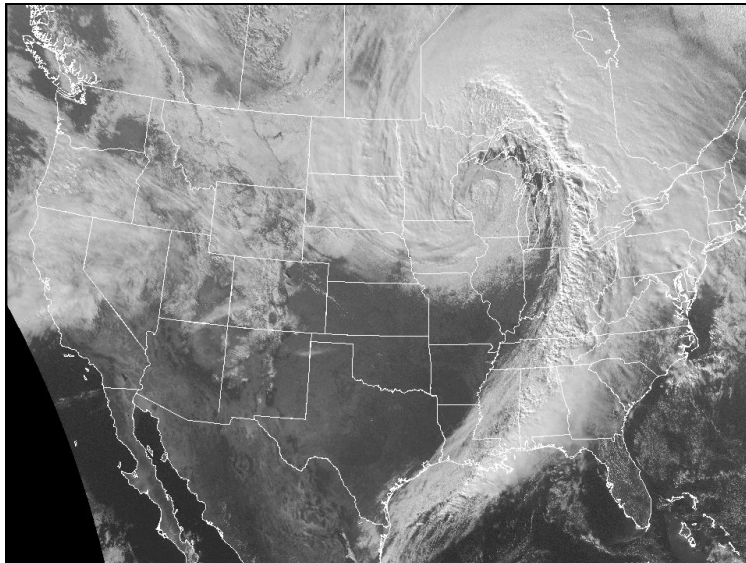
Follow the Energy!

- Midlatitude storms release gravitational potential energy arising from the temperature differences found in the different air masses north and south of the polar front
- **Cold, dense air pushes warmer, less dense air up and out of the way**
- **"Up warm, down cold"**
- These storms let the atmosphere lower its center of mass ... "air falling down"

Lifecycle of a Midlatitude Cyclone



- Pressure surfaces tilt because of N-S temperature contrast
- Passing wave initiates divergence and cyclonic vorticity
- Cold air undercuts warm, and flows south
- Cold air advection undermines upper trough, deepening it
- N-S mixing in cyclone eventually consumes the available potential energy, and cyclone dies



The "Big Picture"

- We've emphasized **horizontal** transport of energy to balance the planetary energy budget:
 - Hadley Cell
 - Subtropical divergence
 - Midlatitude cyclones and conveyor belts
- What about **vertical** motion?
 - "Up-warm, down cold"
 - "Up moist, down-dry"
- Severe weather is all about vertical motion, and represents local release of energy that contributes to planetary energy balance