

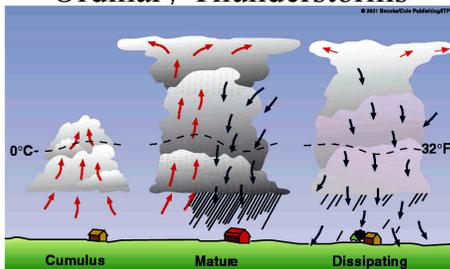
Chapter 15, Part 1

Thunderstorms

What are thunderstorms?

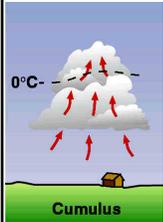
- Thunderstorms are simply storms containing thunder and lightning.
- Sometimes also gusty winds, heavy rain, or hail.
- Categorized as
 - Ordinary – short lived, rarely produce strong winds or hail
 - Severe – high winds, flash floods, damaging hail, and even tornadoes

Ordinary Thunderstorms



- There are three stages of an ordinary thunderstorm: cumulus, mature, dissipating.

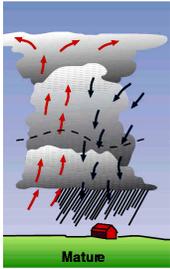
Cumulus Stage



- Warm humid air rises, cools, and condenses into cumulus cloud(s)
- Sometimes cloud evaporates in dry air, but then a new cloud grows higher.
- Condensing water releases latent heat making cloud warmer than air around it.
- Insufficient time for precipitation to form.
- Updrafts keep water droplets and ice crystals suspended.

Mature Thunderstorm

Anvil shape at stable region.



- Entrainment – dryer colder air drawn in. Sometimes rain drops evaporate further cooling air.
- Creates downdraft.
- Cell = updraft + downdraft.
- Most storms several cells (~1hr).
- Storm most intense with heavy rain and sometimes small hail.
- Cold air at onset of precipitation.
- Top reaching stable region leads to anvil shape.

Picture of Mature Thunderstorm



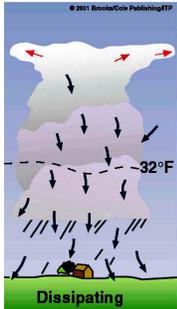
- Note anvil top.

Overshoot



- Updrafts can be so strong that the cloud rises into the stable region of the atmosphere.

Dissipating Stage



- Updrafts weaken and downdrafts dominate.
- Light precipitation, weaker winds.
- Down drafts can feed other updrafts, creating multicell storms (common).
- At end of storm surface temperature can be much cooler (10-20°F), but rain evaporating increases moisture.

Dissipating Thunderstorm



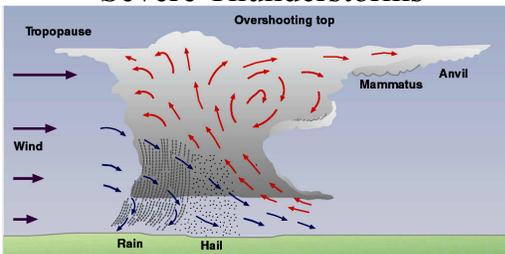
- Most of the lower half of cloud has evaporated leaving only cirrus anvil top.

A Multicell Storm



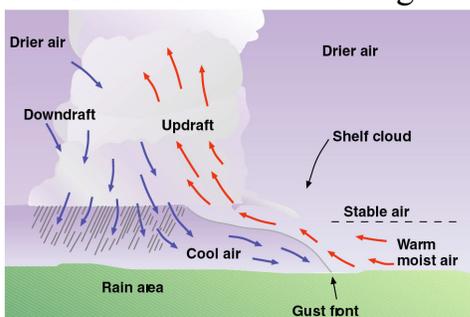
- Middle cell is mature stage, right cell in cumulus stage, and left cell is almost mature.

Severe Thunderstorms



- Also form as warm moist air rises; however, winds cause the cloud to tilt so that updrafts can move up and over downdrafts and remain strong for longer.
- Can get same effect with rotation.

Gust Front and Mesohigh



- Strong cold downdraft can cause a cold (gust) front and mesohigh which enhances updraft.

Shelf Cloud



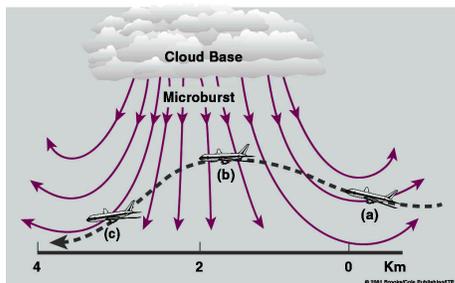
- As warm, moist air rises along a gust front a shelf cloud may form. <http://www.australiaseverweather.com>

Downbursts



- Beneath a severe thunderstorm, localized downdrafts create a burst of wind. A microburst is $< 4\text{km}$ and a macroburst is $> 4\text{km}$.

Microbursts and Wind Shear

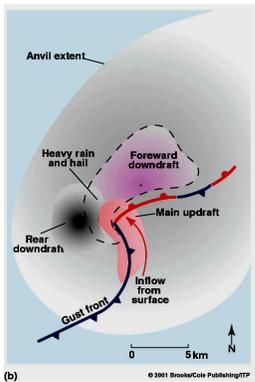


- Wind shear = rapid change in wind speed and direction
- (a) additional lift, (b) downdraft, (c) headwind and reduced lift. Dangerous.

Supercell Storm

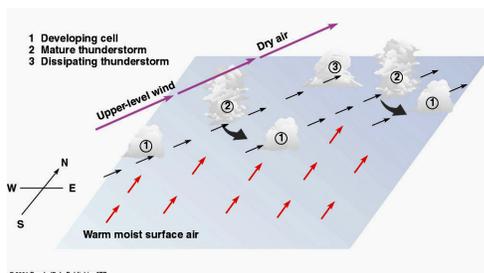
- Enormous rotating thunderstorm whose updrafts and downdrafts are organized so that it is able to maintain itself for hours.
 - HP supercell – high precipitation
 - LP supercell – low precipitation
- Most are right movers (move to the right of winds aloft). Allows for new updrafts on right side of storm.

Air Flow in a Supercell Storm



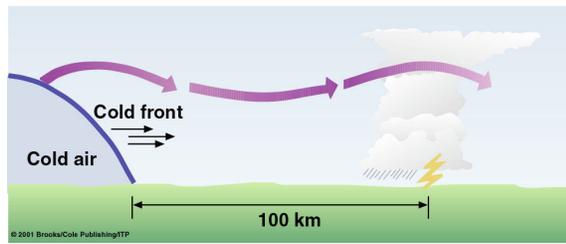
- Main updraft
- Rear and forward downdrafts
- Heavy precipitation
- Anvil extent

Motion of a Multicell Thunderstorm



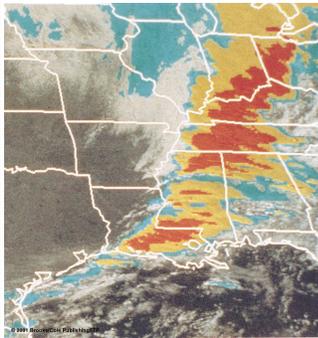
- Individual cells move with the upper level winds, but the entire storm moves to the right of the upper level wind because of the formation of new cells.

Squall Line



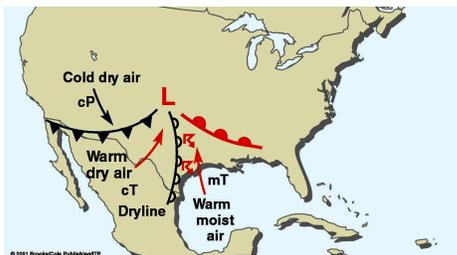
- A line of thunderstorms either right along a cold front or in a warm air 100-300km out ahead (pre-frontal squall line thunderstorms). The later are larger and more severe.

Infrared Image of Pre-frontal Squall Line



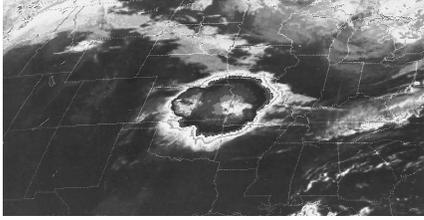
- Note the enormous size of this storm.

Dryline



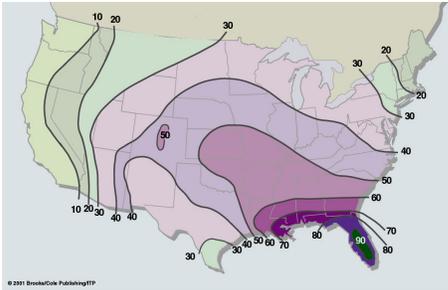
- Narrow zone where sharp horizontal change in moisture.
- Rain does not occur along cold front since no moisture.
- Convergence along dryline may result in thunderstorms.

Mesoscale Convective Complexes



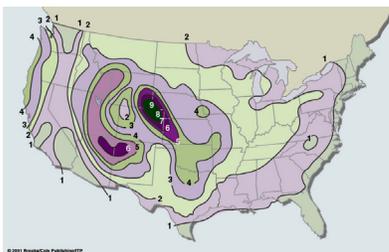
- A number of individual thunderstorms may grow in size and organize into a large (1000 km²) convective weather system.
- Tend to form in summer when upper-level winds are weak.

Distribution of Thunderstorms



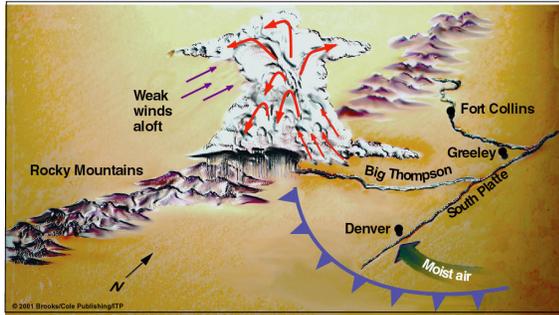
- Number of days each year in which thunderstorms occur. Note maximum (90) in Florida.

Distribution of Hail Storms



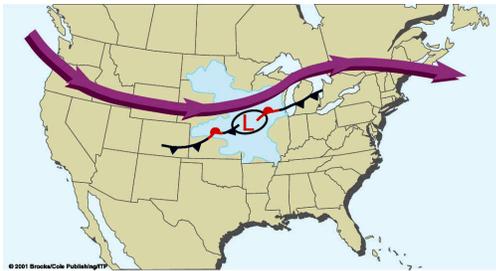
- Number of days per year in which hail is observed.
- Note maximum in western Great Plains (9). Warm surface air inhibits hail in Florida.

Flash Floods



- Intense thunderstorms that rise rapidly with little or no warning can lead to flash floods.

Floods



- Flooding can arise when thunderstorms move slowly or stall. Floods can also be created when storms repeatedly pass over a given area (training).

Summary

- Thunderstorms are storms containing thunder and lightning.
- They can be either ordinary or severe depending on precipitation and wind speeds.
- A cell is a pair of updraft and downdraft winds. Most thunderstorms consist of multiple cells.
- Some consequences of thunderstorms are heavy rain or hail, flooding, strong winds, wind shear, and cooling temperatures.
