Chapter 10
Thunderstorms and Tornados

Thunderstorms

- Can produce intense rain, hail, wind, lightning
- Can make tornadoes
- Formed by rising air from
  - Uneven surface heating
- Uplift along a frontal boundary
- Topographical uplift

Definitions

- *Supercell thunderstorms* – large updraft storms that can produce flash floods, severe weather, tornadoes
- *Severe Thunderstorm* – has to have one of following:
  - Hail greater than or equal to 2 cm
  - A tornado
  - Wind gusts 80 km/hr

Ordinary Cell Thunderstorms

- Form in region of low wind shear
- Can form due to surface air convergence

Cumulus stage (growth stage) – due to rising warm, humid air condensing into cumulus cloud

- Latent heat release keeps cloud warm and unstable
- Grows quickly to towering cumulus
- Usually no precipitation because of updrafts
- No lightning or thunder

Mature stage – marked by considerable downdrafts

- Cloud particles grow larger, and begin to fall
- Entrainment - Dry air is sucked into cloud, causing evaporation and cooling
- Heavier and cooler air descends…downdrafts
- Formation of updraft and downdraft cells
- Most intense time of thunderstorm
- Storm may grow as high as stratosphere (anvil)
- Heavy rain, lightning, small hail
- May have overshooting top
- Downdraft reaches ground and spreads along surface as a gust front

- Sometimes rain may not reach ground, but cold air does

Dissipating stage – thunderstorm weakens

- Updrafts begin to weaken after 15 to 30 min.
- Gust front moves too far from the storm, so updrafts have to weaken
- Light precipitation falls
- Only anvil remains
- All three stages in less than an hour

Severe Thunderstorms and the Supercell

- So ordinary cell storms weaken because the updraft weakens
- What if the updraft doesn't weaken quickly?
  - If moderate wind shear pushes downdraft downwind, updraft is not cut off
  - If downdraft then undercuts updraft, a multicell storm forms

Multicell storms

- Cells of varying age co-mingling
- Top of cloud well into stratosphere
- Updrafts allow hail to grow large

Supercells

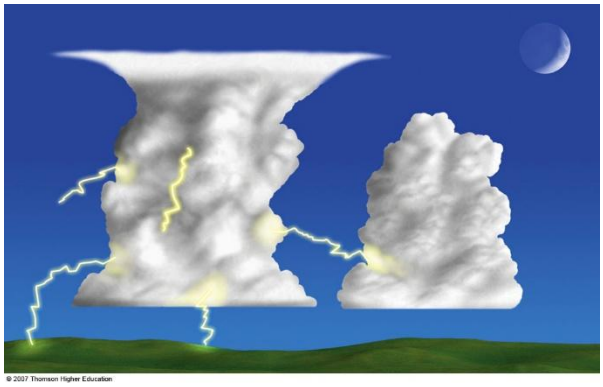
- If wind shear is strong and changes direction with height, downdraft may not undercut updraft
- Updraft remains strong for long time (> 1 hour)
- One rotating vertical column
- Can create tornadoes
- Hail size of grapefruit

Squall line – line of multicell t-storms extending many kilometers

Mesoscale convective complex- cluster of storms in one spot

Lightning and Thunder

- Lightning – simply a discharge of electricity, usually in mature thunderstorms
  - Heats air up to 30,000 ºC (5 times hotter than the surface of sun)
- Thunder – the explosive expansion of the hot air creates a sound wave that travels in all direction
- Light travels faster than sound, so we see the lightning before we hear the thunder
  - Sound takes 3 seconds to travel 1 kilometer
  - So if we hear thunder 3 seconds after we see the lightning, the stroke was 1 kilometer away

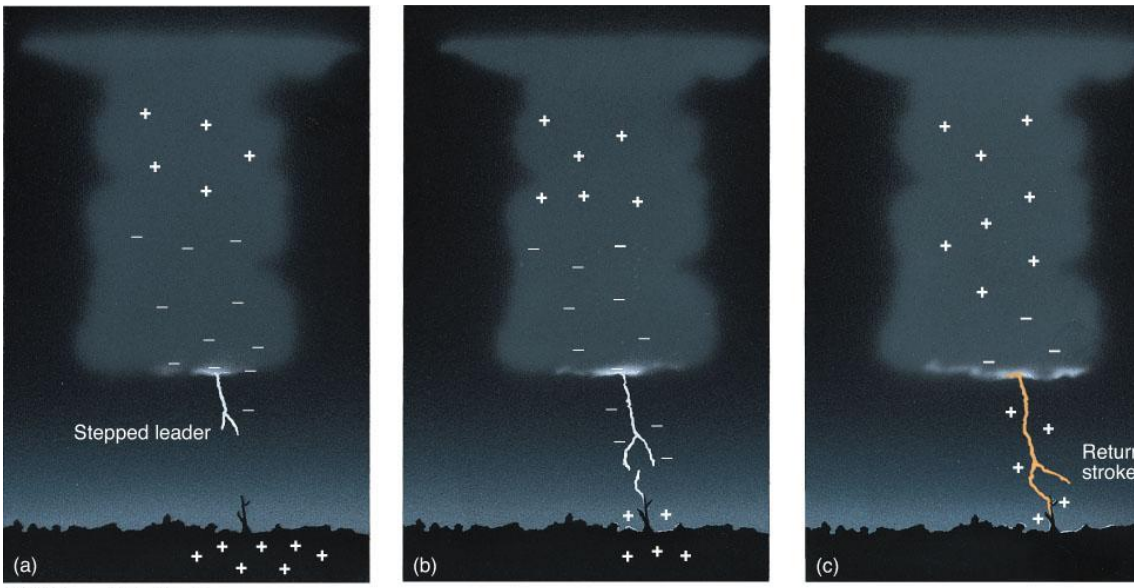


Electrification of Clouds

- Must have charging of the cloud to have lightning
- Electrification of clouds not fully understood
- **Theory 1:** Supercooled droplets fall through cloud and collide with warm hailstone. Latent heat is released (warm or cold?)
- Net transfer of positive ions from warm to cold object
- Falling hailstone is negatively charged, falls to bottom of cloud
- Light positively charge particle is lifted to top of cloud
- Small area of positively charge particles near melting level
- **Theory 2:** When precipitation forms, it has a -ve in the upper portion and +ve charge in the lower
- As droplets collide, the large droplets become -ve and fall
- The small droplets are lifted by updrafts and rise

The Lightning Stroke

- Basics of lightning
  - Opposite charges attract
  - Positive charges on ground follow negative charges at base of cloud
  - Electrical current will not flow because air is good insulator
  - Charge must be large (< 1million volts per meter) to create a lightning bolt
- Cloud-to-ground lightning
  - Discharge of electrons from cloud to ground as a stepped leader (many times)
  - Positive charges race back up from elevated object as a return stroke



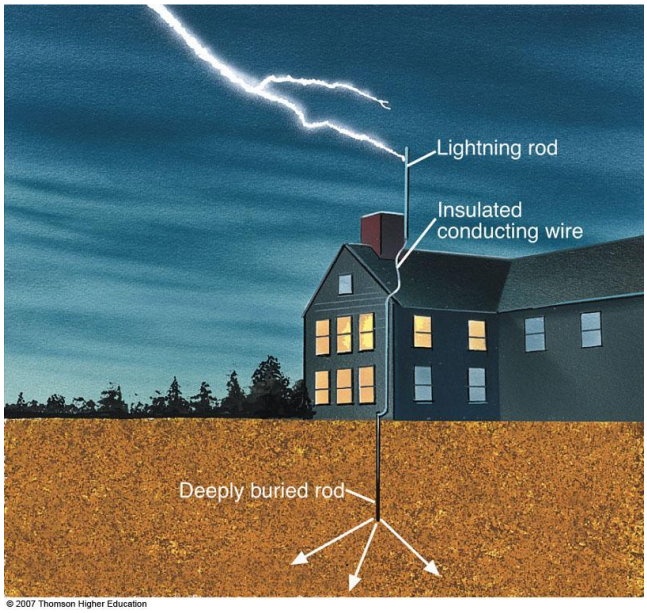
- Cloud-to-ground lightning
  - Many electrons flow to ground and a stronger return stoke follows (this is what you see)
  - 1/10,000 of a second so it looks like one continuous flash
- Dart leader – subsequent initial stroke that follows same path as initial stepped leader
  - Causes the multiple flash of the lightning

Types of Lightning

- Forked lightning – dart leader takes different path than stepped leader
- Ribbon lightning – wind blows charges into ribbon-like lightning
- Dry lightning – lightning that occurs in a dry thunderstorm
- Heat lightning – lightning that is seen by not heard (can be orange)
- St. Elmo's Fire – luminous green or blue halo around the top of pointed objects (antennas, masts of ships). Lightning may occur after this is seen

Lightning Detection and Suppression

- Lightning direction-finder



Tornados

- Tornado – rotating column of air blowing around a small low pressure that reaches the ground

Tornado Life Cycles

- Funnel cloud
  - Tornado that hasn't reached the ground
- Dust-whirl stage
  - Swirling dust at the ground marks the tornadoes circulation
- Mature stage
  - Funnel at greatest width, most intense damage. Often vertical

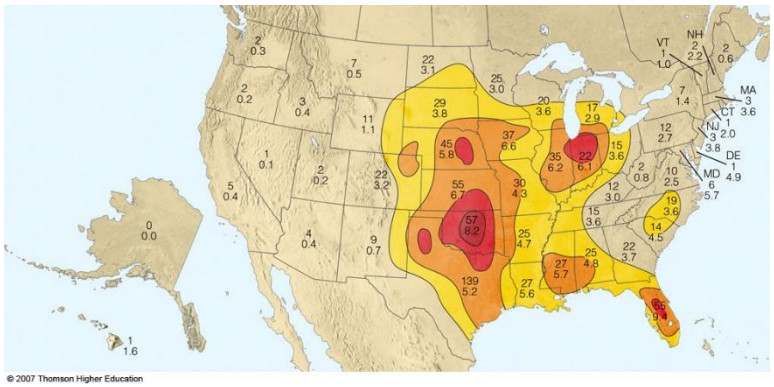
- Decay stage
  - Funnel shrinks, damage becomes less, tornado

Tornado Outbreaks

- Tornado families – tornadoes spawned by the same thunderstorms
- Tornado outbreaks – many tornadoes that form over same region

Tornado Occurrence

- Tornado alley – part of the Central Plains from Texas through Nebraska
- Time of day – most often in the afternoon
- Times of year – most often in Spring, lease often in Winter



Tornado Winds

- Multi-vortex tornadoes
  - A single tornado with multiple rotating columns within it
- Suction vortices
  - The small rotating columns within multi-vortex tornadoes