

Natural Disasters

Lecture 7

Ch 10 –Tornadoes, Lightning, Heat, and Cold

Text Source Today:

Chapter 10 (p. 254, 261-264, 274-278)

10.2: Ch. 10 – Tornadoes, Lightning, Heat, and Cold

● **Lightning:** can occur in any type of thunderstorm, but occurs most frequently in storms with the strongest updrafts and downdrafts. There are multiple theories about how lightning forms, as scientists are **still uncertain** of the exact mechanism!

◆ However, it is generally accepted that **positive** charges dominate in the **upper** cloud, and **negative** charges dominate the **lower** cloud. This **charge separation** is achieved through collisions of ice crystals and supercooled water drops. The **negative** charges in the **lower** cloud induce a **positive** charge at the Earth's surface, which stays under the cloud as the cloud moves overhead.

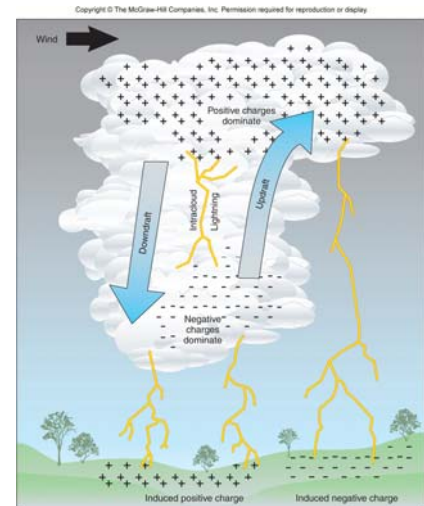
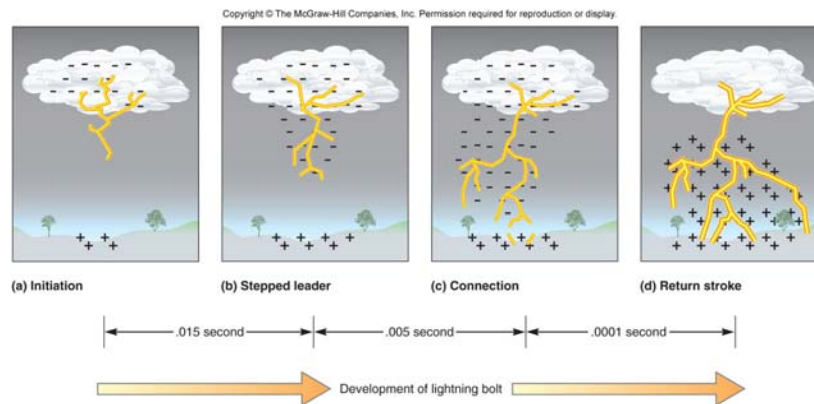


Fig. 10.41

◆ **How cloud-to-ground lightning forms (Fig 10.43):**



(a) as the charge differential between cloud and ground strengthens, a **stepped leader** of **negatively** charged electrons start to reach downward from the cloud; (b) the **stepped leader**

moves in small (20-50 m) steps; (c) as the **stepped leader** gets close enough to the ground, it attracts streamers of **positive** charge and makes a connection about 50 m above the ground to form a channel of ionized air; (d) a rapid movement of charges creates the very bright **return stroke**, which can travel at up to 100,000 km/sec ($\frac{1}{3}$ the speed of light); and, (e) subsequent **dart leaders** and **return strokes** cause the visible “**flickering**” effect.

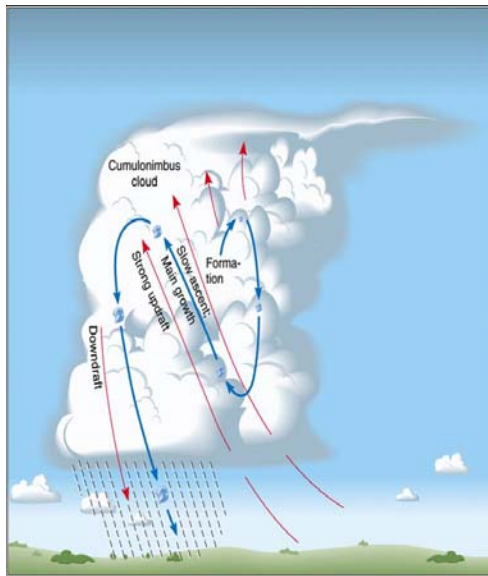
♦ **Thunder** is directly caused by lightning. As the intense current of ions moves down the lightning channel, the air in and around the channel is heated extremely rapidly up to $\sim 30,000^{\circ}\text{C}$ ($\sim 55,000^{\circ}\text{F}$), which is **3-4 times** the temperature of the **Sun**! The intense heating causes a **rapid expansion** of the column, which in turn creates a **pressure shock wave**. This shock wave is similar to a sonic boom and causes the **thunder** that we hear.

♦ **How close is the lightning?** From the instant you see lightning, start counting seconds until you hear thunder. Sound takes about **five seconds to travel one mile**, the number of seconds can be converted to an approximate distance from you.

♦ **Lightning Safety:** is common sense if a few simple rules are followed. Lightning can develop extremely rapidly and can strike up to **10 miles away** from a storm, so decisive actions are essential (visit www.lightningsafety.noaa.gov for more information):

- Keep away from **wired** electrical equipment and phones
- **Get indoors** at the first sign of thunder **or** lightning
- Stay inside for at least **30 minutes** after last thunder
- If stuck outside, **avoid** open areas and isolated tall objects; find a low-lying spot; assume “catcher’s position”
- Simply put, **“When Thunder Roars, Go Indoors!”**

♦ **Hail:** are **layered balls of ice** which fall from within a thunderstorm. Most hail is pea- or dime-sized, but many hailstones have been measured at greater diameters! (Photo of record holder, **8"**, **1.93 pounds**, **Vivian, SD** on 7/23/2010)



♦ **How hail forms:** The upper part of a thunderstorm is often **below freezing**, which causes some of the cloud particles aloft to **freeze**. Liquid droplets ascending in the updraft can **“stick” and freeze** onto the ice particles through **accretion**. To get a large hailstone, the ice ball must **accrete** in a strong updraft for a significant amount of time (in some cases **up to 10 minutes**).

♦ Because **hail** requires long-lived thunderstorms with **strong updrafts** and **cold temperatures aloft**, hail occurs most often in the U.S. in the **central and southern Plains**. Although **Florida** has the most thunderstorms, the air aloft there is much **warmer** and thus less conducive to hail formation.

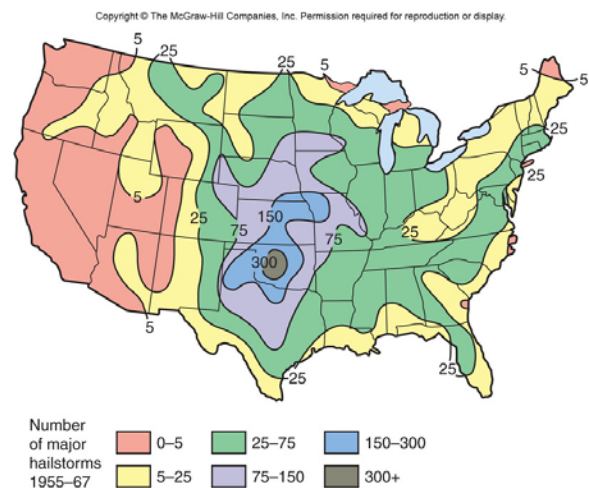
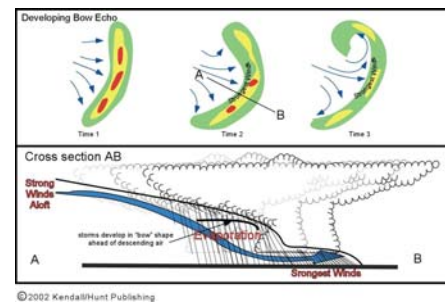


Fig. 10.20

♦ **Severe Thunderstorm Winds: Downdrafts**, as discussed in last lecture, develop as rapidly **descending winds** in a thunderstorm due to **evaporative cooling** and **precipitation drag**. Occasionally, the **downdraft** becomes especially strong, reaches the ground, and spreads out in all directions, forming a **downburst**. The spreading horizontal winds in a **downburst** can reach speeds of **240 km/hr (~150 mph)**.

♦ **Downbursts** (and their associated high winds) are very dangerous, both to people and structures on the ground as well as to **airplanes**. The risk to **airplanes** is especially severe during **takeoff and landing, as pilots** have little time to react to the quick change in **lift**.

♦ **Derecho** is a long-lived **squall line** which usually lasts more than 3 hours, travels for upwards of 400 km (~250 miles), and causes sustained winds of **93 km/hr (~58 mph)** or greater along its path. Though **derechos** most often form in the **north-central U.S.**, they can also be found in **Bangladesh, India, Germany, Argentina, and South Africa**. Also, referred to as a **“bow echo.”**



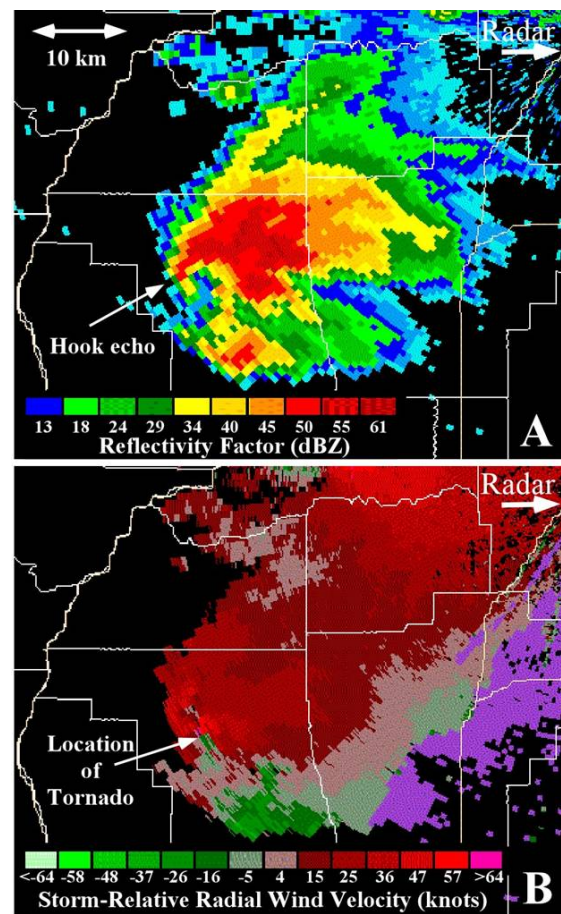
● Many of the most intense **derechos** form **overnight**, so the risk to drivers and travelers is lessened, but **exposed people** are less aware of the risks. On **15 July 1995**, a **severe derecho** moved through **upstate New York** and had a **160 km (~100 mile)** wide swath of winds **>130 km/hr (80 mph)**. The **five** people killed by this storm were **camping in the Adirondacks** and had no idea the **derecho** was on its way.

(Refer to p. 254, In Greater Depth: Doppler Radar)

♦ **Doppler Radar:** The primary tool used to detect thunderstorms. (**Radar** itself is an acronym for **R**adio **D**etection **A**nd **R**anging). All radars operate by emitting a pulse of **microwave energy at a specific frequency** into the atmosphere and then “listening” for the signal to **bounce off a particle** in the distance. There are two main aspects of Doppler Radar: **reflectivity** and **radial velocity**.

♦ **Reflectivity** measures the amount of energy which returns to the radar from **bouncing off a particle**. The **reflectivity** is determined by the **size and type** of the particle; a larger water or ice droplet will **reflect more energy** back to the radar. Thus, heavy (large) rain and ice would have a **higher reflectivity**.

♦ **Radial velocity** uses the Doppler effect. The Doppler effect relates the **change in frequency** of a beam of energy before and after reflection off a moving particle, to the **speed the particle is moving**. However, particle speed can only be determined in the direction **parallel** to the beam. Thus, the only **velocity** that can be determined by a radar is either **directly toward (green) or away (red)** from the radar (hence the name **radial velocity**).



♦ **The Storm Prediction Center (SPC):** is responsible for forecasting **severe weather** over the U.S. The **SPC** has developed a three-tiered system for notifying the public about impending **severe weather**:

- **advisory** is published when an event **becomes likely** over the next 24-72 hours.
- **watch** (either severe thunderstorm or tornado) is the next step, and is sent out if development of severe weather **is expected within the next several hours**; go about your normal business.
- **warning** (again, severe thunderstorm or tornado) is issued if **severe weather is imminent or occurring**; take appropriate action to protect life and property.

Sample SPC Watch/Warning Map:

<http://www.spc.noaa.gov/products/wwa/>