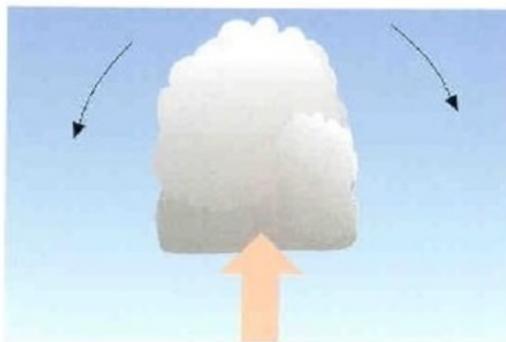


Chapter Nine

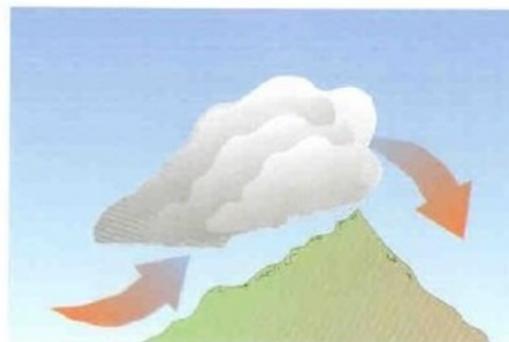
Thunderstorms

General Characteristics

- A thunderstorm is a storm that produces thunder and lightning.
- In a thunderstorm, updrafts can easily exceed 80 km/hr., and have been observed at over 125 km/hr.
- Thunderstorms require some lifting mechanism to start the initial upward motion. This mechanism can be any one of the four lifting mechanisms that we discussed earlier:
 - Convective lifting
 - Orographic lifting
 - Convergence
 - Frontal wedging



5 km
Convection
(a)



150 km
Topography
(b)



500 km
Convergence of air
(c)

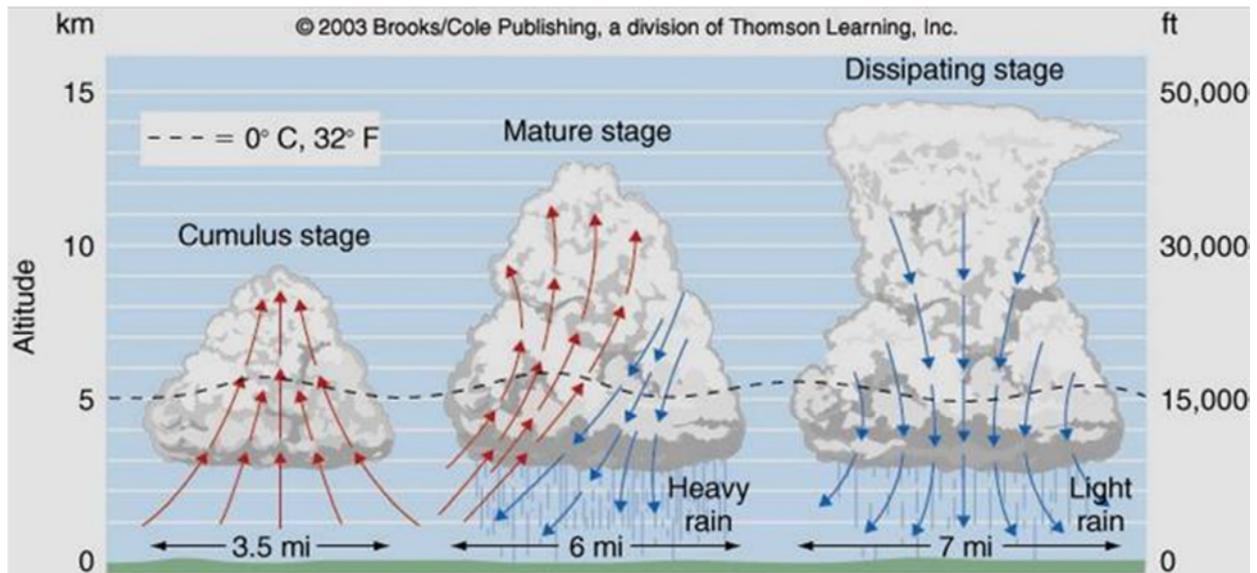


1500 km
Lifting along weather fronts
(d)

- On average there are about 45,000 thunderstorms around the world every day.
- Most thunderstorms occur over land, and in the Tropics.

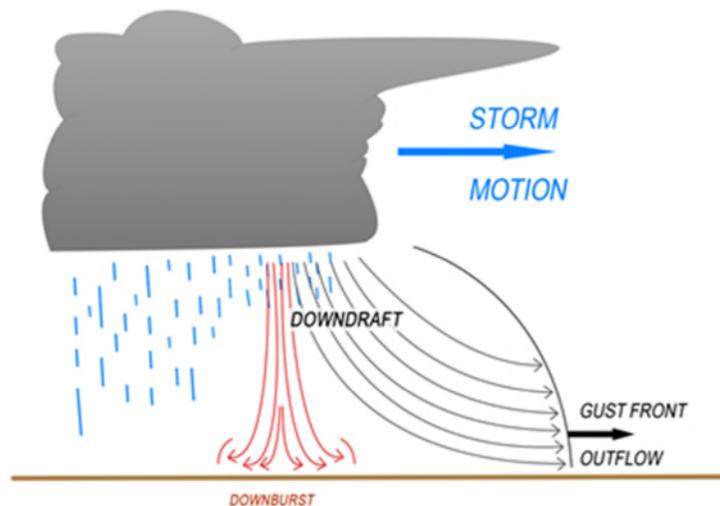
Air Mass Thunderstorms

- Air mass thunderstorms are associated with mT air.
- Stages of development of air mass thunderstorms are:
 - ✓ **Cumulus stage:** Strong updrafts.
 - ✓ **Mature stage:** Precipitation begins and downdrafts form from both the frictional drag of the precipitation, and due to entrainment of dryer air and evaporation of precipitation.
 - ✓ **Dissipating stage:** Downdrafts have shut off the updrafts that feed the storm. Clouds evaporate as the storm dissipates.
- Air mass thunderstorms are more likely to occur over mountains or hills, due to differential heating and orographic lifting.



Gust Fronts and Downbursts

- Thunderstorm downdrafts are cool because of two factors:
 - Entrainment of unsaturated, cooler air from outside of the thunderstorm.
 - Evaporation of precipitation into the air.
- As the cool downdraft hits the ground it spreads out.
- The leading edge of the downdraft acts like a miniature cold front, and is called the gust front. As the gust front passes the wind become gusty, and the temperature drops.
- The lifting of warm, moist air along the gust front can trigger new thunderstorm development.
- If the downdraft is very strong it is called a downburst.
 - Downbursts can be quite damaging to trees, building, power lines, and airplanes.
 - They are often mistaken for tornadoes by people who experience them.
 - A very narrow downburst is sometimes called a microburst.



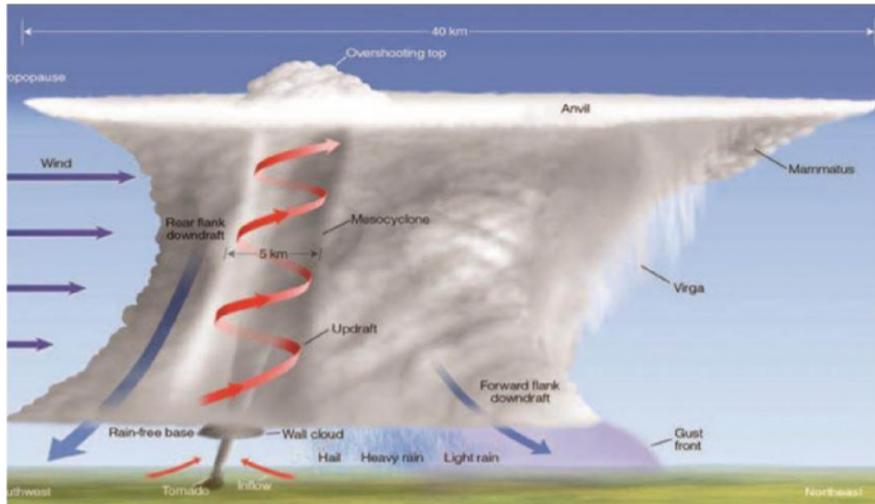


Severe Thunderstorms

- A thunderstorm is classified as severe if any one of the following conditions are met:
 - It produces winds in excess of 50 knots (59 km/hr.).
 - It produces hail larger than one inch (2.5 cm) in diameter.
 - It produces a tornado.

Supercell Thunderstorms

- Thunderstorms are also classified according to the number and strength of the updrafts, or cells.
 - **Single-cell:** In a single-cell thunderstorm there is only one main updraft and downdraft. Most air mass thunderstorms are of this variety.
 - **Multi-cell:** Multi-cell thunderstorms have more than one updraft.
 - **Supercell:** These have a single, rotating updraft.
- The type of thunderstorm produced is largely determined by the type of vertical wind shear present.
- Although the updraft in most supercell thunderstorms rotates cyclonically, they can also rotate anticyclonically.
 - The rotating updraft is called a *mesocyclone* if it is rotating counterclockwise, and a *meso-anticyclone* if it is rotating clockwise.



Thunderstorms and the Global Electrical Circuit

- The upper atmosphere is a good conductor of electricity because there are a lot of ions present.
- The troposphere is a poor conductor of electricity, because there are not many ions.
- The earth normally has a negative charge, and the upper atmosphere normally has a positive charge.
- There is a constant leakage current through the atmosphere that could neutralize the earth-atmosphere charge imbalance in about 10 minutes.
- Thunderstorms provide the mechanism for pumping positive charges into the upper atmosphere. They can therefore be thought of as the electromotive force for the global electrical circuit.

Observed Electrical Properties of a Thunderstorm

- The top of a thunderstorm (cumulonimbus) cloud becomes positively charged.
- The bottom of the cloud becomes predominantly negatively charged, although there are often smaller pockets of positive charge near the bottom as well.
- The negative charge at the bottom of the cloud induces a positive charge at the ground.
- Lightning is a discharge of electricity between the oppositely charged centers, either from the cloud to the ground, or within the cloud.
- Globally there are on the order of 50 to 100 lightning flashes every second.