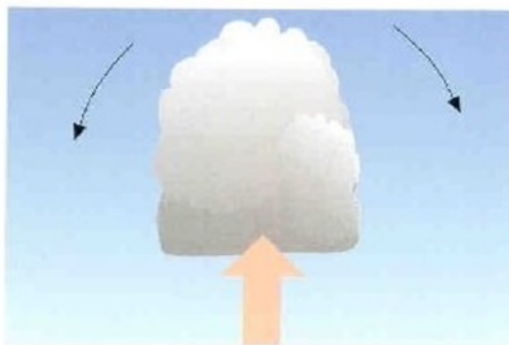


# Chapter Nine

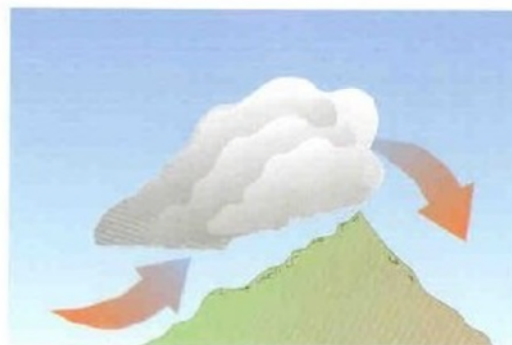
## Thunderstorms

### 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)

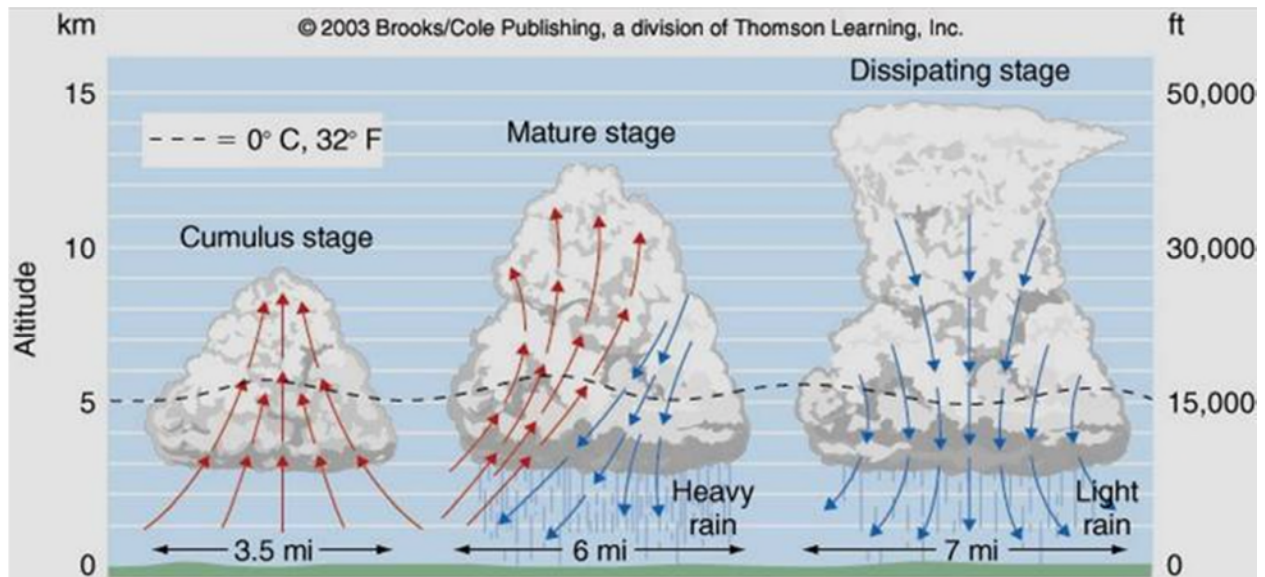


1500 km  
Lifting along weather fronts  
(d)

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

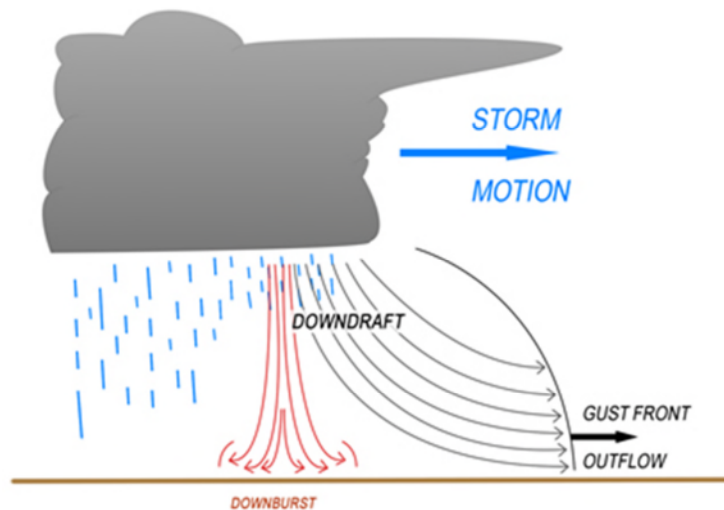
## Air Mass Thunderstorms

- 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.



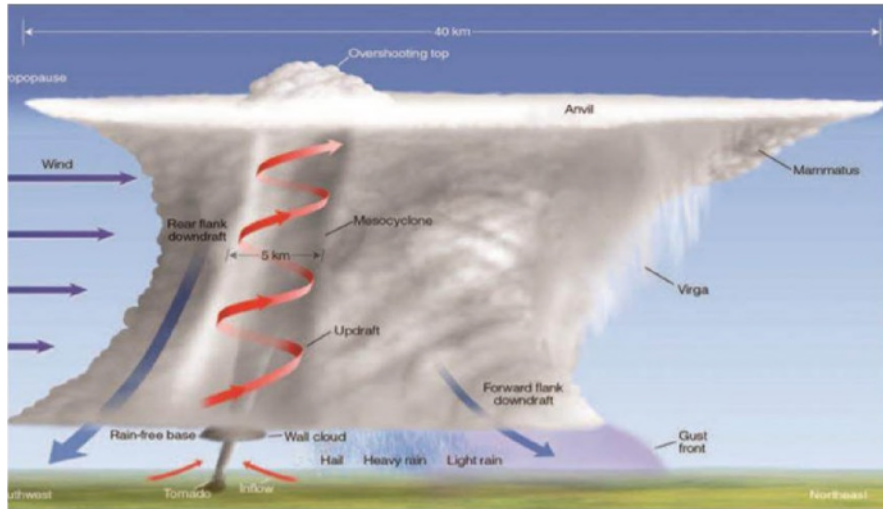


## Severe Thunderstorms

- 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.