13. SEVERE WEATHER

Reading Assignment:

- A&B: Ch. 11, 12

Introduction:

Concepts:

Scale, Motion, Thunder and Lightning, Latent heat of vaporization, Spatial and temporal variability, Atmospheric motion, Development and decay, Law of conservation of angular momentum, Formation and decay, Sources of energy, Structure - horizontal and vertical.

Severe thunderstorms, Tornadoes, Hurricanes, etc.

o Thunderstorms	Each have things in common but there are differences
o Tornadoes	
o Hurricanes	

Scale

	Diameter	
Mid latitude cyclone	1600 km +	
Hurricanes	600 km	Smaller & more intense than a mid-latitude cyclone
Tornado	0.25 km	

o Tornado - does not show up on a weather map

Motion

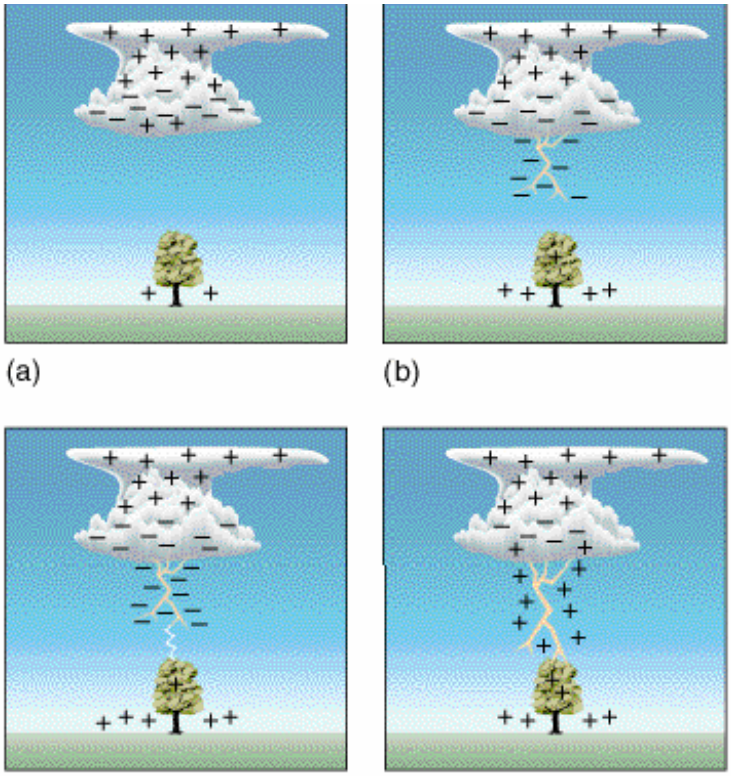
Mid latitude cyclone	Inward, spiral
Hurricanes	Inward, spiral
Tornado	Inward, spiral
Thunderstorms	Strong upward & downward motion Very variable, gusty winds

1. Thunderstorms

- Unlike hurricanes and tornadoes
  - Different air motion
  - Can form:
    - on their 'own'
    - in conjunction with cyclones
      - Frequently form along the cold front of a mid-latitude cyclone
- Rare occasions - tornado may descend from thunderstorm - cumulonimbus tower
- Hurricanes - generate widespread thunderstorm activity

- Thunder and lightning
  - "Thunderstorm" - thunder has to be heard
  - Thunder is produced by lightning therefore lightning also present
  - During the formation of large cumulonimbus cloud separation of charge occurs

- Part of the cloud has an excessive negative charge and another part excessive positive charge
- Lightning - attempt to equalize these electrical differences



  - Negative flow of current from region of excess negative to region of excess positive (or vice versa)
  - Air is a poor conductor electrical potential (charge differences) must be very high before lightining will occur
  - Electrical discharge of lightning heats the air and causes it to expand explosively - expansion produces sound waves - hear thunder

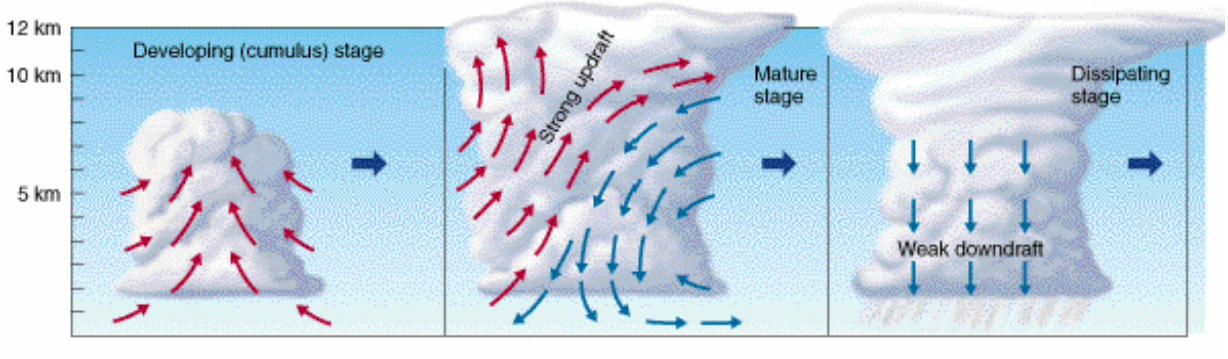
- Associated with cumulonimbus clouds
  - Generate heavy rainfall, thunder, lightning, occasional hail

- Require warm moist air which when lifted will release sufficient **latent heat of vaporization** that it will provide buoyancy necessary to maintain its upward flight

- Instability and buoyancy - triggered by a number of processes
  - enhanced by high surface T
  - most common in late afternoon and early evening

Stages of development

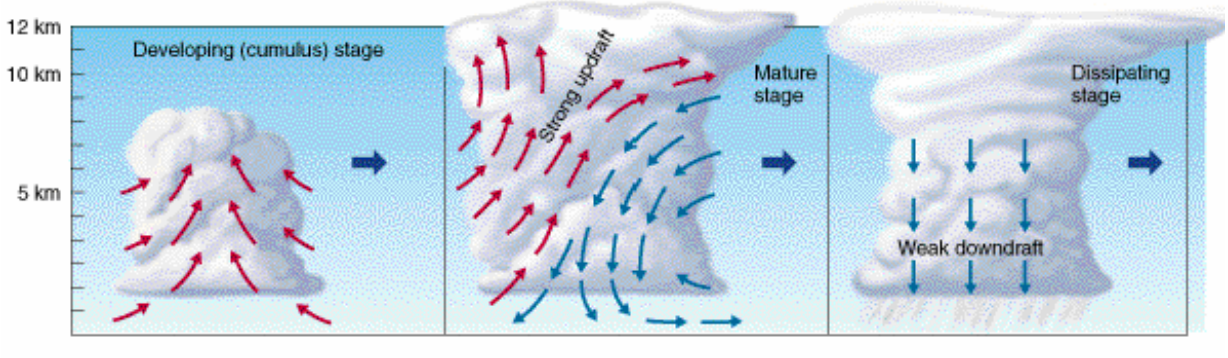
- Cumulus
- Mature
- Dissipating



Cumulus (developing)

- Unstable air begins to rise
- Need continuous warm moist air
- Dominated by updrafts - may reach speeds > 160 km h^{-1}
- Development of cumulus clouds
- Once cloud passes freezing level - Bergeron process—Ice crystals begin to form
  - Usually produces precipitation within an hour
  - Accumulation of precipitation in the cloud becomes too great for the cloud to support

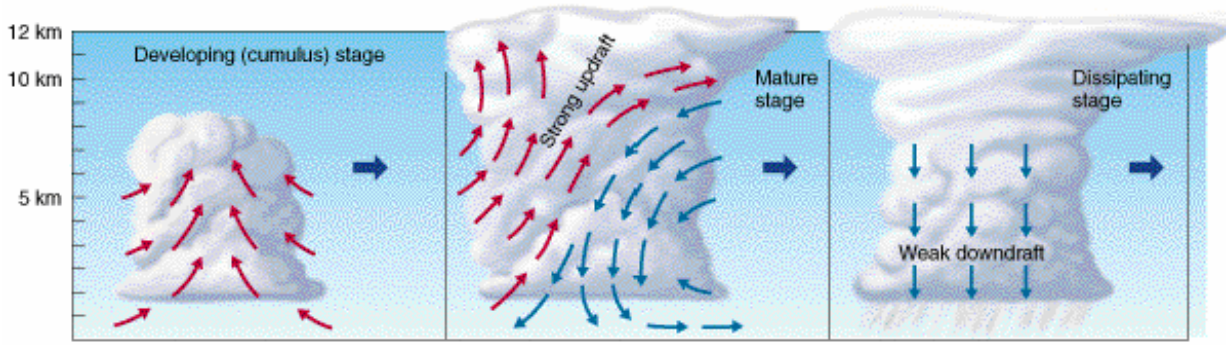
- Falling precipitation causes drag on the air - **downdrafts**
- Aided by: influx of cool dry air surrounding the cloud **- entrainment**
  - Intensifies the downdraft because the air is cool
  - Causing falling precipitation to evaporate which is a cooling process
  - Downdraft - cooling process



Mature Stage

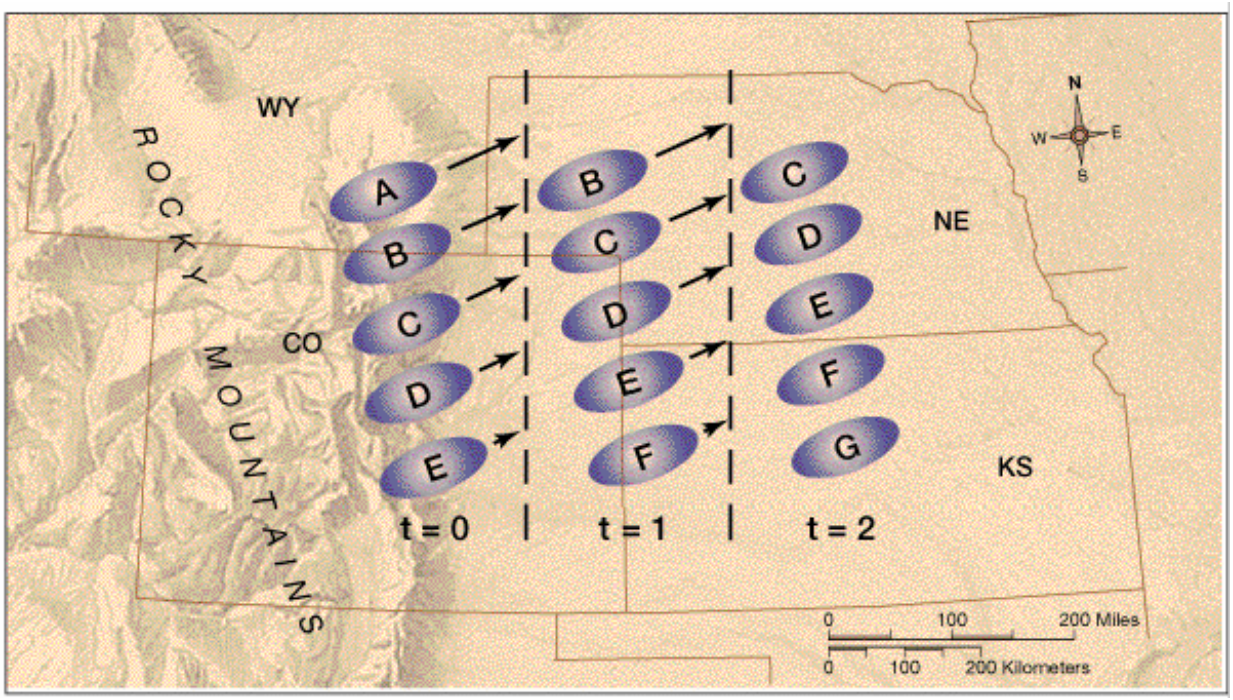
- When the downdraft leaves the bottom of the cloud -- precipitation is released
- At the surface - cool down draft spreads laterally - felt before precipitation reaches the ground
- At this stage:
  - updrafts (still enlarging the size of the cloud)
  - downdrafts co-exist side by side
- When cloud grows to the top of the unstable region - often located at the base of the warmer stratosphere - updrafts spread laterally - **anvil top**
  - Generally ice crystal laden cirrus
- Most active stage of the T/storm
  - Gusty winds

- Heavy precipitation
- Hail sometimes



Dissipating stage

- Downdrafts dominate throughout cloud
- Cooling effect of precipitation and influx of colder air end of T/storm
  - Without supply of moisture the cloud soon evaporates
- Single cumulonimbus cell within a T/storm complex has a life of 1-2 h
- As storm moves to fresh supplies of warm water laden air -- generate new cells



Squal Line Thunderstorm

Thunderstorm types

1) Isolated - produced with a warm humid air mass

2) Severe - produced by forceful uplifting along a cold front

Isolated Air mass T/storms

- generally occur in warm moist mT air
- most of the moisture, lower portion, can become unstable when lifted
- spring & summer - warmed sufficiently from below
- air mass T/storms most frequent
- strong preference for mid-afternoon when surface T are highest
- some after sunset: growth of immature cells re-stimulated by cloud top cooling

Severe T/storms

- frequently form along or ahead of a cold front in the wave cyclone
- Cold air advances into a region of warm air
- Warm air less dense - displaced upwards
  - If rising air sufficiently moist, the mechanical lifting condensation release of latent heat vertical cloud growth T/storm development begins
  - Sharp T contrast sharp pressure difference

- Formation of a severe T/storm that will produce tornadoes
  - presence of an inversion layer a few km above the surface
  - inversion prevents mixing of warm humid air in the lower troposphere with cold dry air above
  - surface heating continues to increase T and moisture content of the layer of the air trapped below the inversion
  - eventually the inversion is locally eroded by strong mixing from below - unstable air "erupts" explosively at these sites

- Some severe T/storms may occur 300 km ahead of the CF - Squall line