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.

<table>
<thead>
<tr>
<th></th>
<th>Each have things in common but there are differences</th>
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<tbody>
<tr>
<td>o Thunderstorms</td>
<td></td>
</tr>
<tr>
<td>o Tornadoes</td>
<td></td>
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<tr>
<td>o Hurricanes</td>
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Scale

<table>
<thead>
<tr>
<th></th>
<th>Diameter</th>
</tr>
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<tbody>
<tr>
<td>Mid latitude</td>
<td>1600 km +</td>
</tr>
<tr>
<td>cyclone</td>
<td></td>
</tr>
<tr>
<td>Hurricanes</td>
<td>600 km</td>
</tr>
<tr>
<td>Tornado</td>
<td>0.25 km</td>
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- Tornado - does not show up on a weather map
## Motion

<table>
<thead>
<tr>
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<th>Inward, spiral</th>
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<tbody>
<tr>
<td>Mid latitude cyclone</td>
<td></td>
</tr>
<tr>
<td>Hurricanes</td>
<td>Inward, spiral</td>
</tr>
<tr>
<td>Tornado</td>
<td>Inward, spiral</td>
</tr>
<tr>
<td>Thunderstorms</td>
<td>Strong upward &amp; downward motion</td>
</tr>
<tr>
<td></td>
<td>Very variable, gusty winds</td>
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### 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
  o Negative flow of current from region of excess negative to region of excess positive (or vice versa)
  o Air is a poor conductor electrical potential (charge differences) must be very high before lightning will occur
  o Electrical discharge of lightning heats the air and causes it to expand explosively - expansion produces sound waves - hear thunder

• Associated with cumulonimbus clouds
  o 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


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 \(\Rightarrow\) condensation \(\Rightarrow\) release of latent heat \(\Rightarrow\) vertical cloud growth \(\Rightarrow\) T/storm development begins
  - Sharp T contrast \(\Rightarrow\) 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