Chapter 11 – Lightning, Thunder and Tornadoes

*Understanding Weather and Climate*
Aguado and Burt

Bolt From the Blue

Photo Courtesy of John Schroeder
**Lightning**

- Lightning occurs when a voltage gradient in the cloud(s)/ground overcomes the electrical resistance of the air.

- Types:
  - Cloud to cloud (CC)
  - Cloud to ground (CG)

**Charge Separation**

- Positive charges accumulate in the upper portions and negative charges in the lower portions of the cloud.
  - Exact cause unknown!
  - Lightning only occurs in clouds that extend above the freezing level.
Lightning Facts

- Electrical current – 20,000 A
- Temperature – 54,000°F
- Total Power Transfer – 100-watt light bulb for a minute

Cloud to Ground Lightning

- Stepper Leader – invisible downward leader
- Spark from the Ground – completing pathway for flow of electrons
- Return Stroke – brightly illuminated, transfer positive charge from surface to cloud base
- Dart Leader – repetitive process to remove remaining negative charge at cloud base
Thunder

• Thunder is caused as air explosively expands in response to the extreme heat of lightning.
• The speed of sound is slower than the speed of light, thus there is often a lag between the lightning and the resultant thunder.

Air Mass Thunderstorms

• Life Cycle
  – Cumulus Stage
  – Mature Stage
  – Dissipative Stage
Severe Thunderstorms

• Wind speeds in excess of 58 mph
• Hail larger than 0.75 inches
• Funnel cloud or tornado

• Types:
  – Mesoscale Convective Systems (MCS)
    • Squall Lines, Mesoscale Convective Complexes (MCC)
  – Supercell Thunderstorms

Severe Thunderstorms

• Severe thunderstorms require:
  – Wind shear
  – High water vapor content in the lower troposphere
  – A trigger mechanism
  – Potential instability
Potential Instability

Mesoscale Convective Complexes
Squall Lines on Radar

Squall Lines
Bowing Squall Line

Supercell Thunderstorm
Mesocyclone Formation

- Dependent on vertical wind shear
- Updrafts tilt horizontal vortex tubes vertically
- Stretching of the vortex tube provides a narrowing column of rotating air
- Can lead to wall clouds, funnel clouds and tornadoes
Supercell Thunderstorm

Supercell Storm

Mature

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ATMO 1300

Supercell Thunderstorm

Schematic of Surface Conditions Common with a Supercell Thunderstorm

Gust Front (boundary between cold and warm air)

Cold Air from Storm downdraft

Heavy Rain & Hail

Possible Tornado

Storm Updraft Region

Wind from Environment

Light to Moderate Rain

Grass Fire

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Doppler Radar Detection of Supercell Thunderstorms

Objects moving toward antenna increase waves' frequency.

Objects moving away decrease waves' frequency.

http://www.usatoday.com/weather/tg/wsupercell/wsupercell.htm

Mesocyclone Detection

Air Motion Towards the Observer
Incoming = Green Colors

Air Motion Away From the Observer
Outgoing = Red Colors
Anvil Back Sheared Anvil

Upper Level Flow

Updraft

Forward Flank
Rain Free
Updraft Base
Wall Cloud

(c) R.A. Prentice, 1999

Downdraft

Photo Courtesy of Jeremy Massey, Ralls/Crosbyton May 27, 2002
Thunderstorm Climatology

[Map showing thunderstorm activity across the United States with color-coded regions indicating different days of thunderstorms.]

[Another map with a legend for Base Reflectivity, showing radar data with color-coded intensity levels.]
Detailed Reflectivity Data

Detailed Reflectivity Data
Tornado Climatology

Average annual tornado incidence per 10,000 sq. km.

- 15.0-20.0
- 10.0-14.9
- 5.0-9.9
- 1.0-5.0
- Under 1.0

Global Distribution of Tornadoes
Tornado Climatology

Table 11-1  Tornadoes in the United States, 1950-1994

<table>
<thead>
<tr>
<th>Rank</th>
<th>State</th>
<th>Average Annual Number of Tornadoes</th>
<th>Average Annual Number of Tornadoes per 10,000 sq km</th>
<th>Average Annual Number of Fatalities</th>
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<td>1</td>
<td>TX</td>
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</tr>
</tbody>
</table>

U.S. Tornadoes, 1950–95

Mean annual number of tornadoes

19
Tornado Climatology
Tornado and Supercell Thunderstorm

Tornado Damage

- Buildings do not explode
- Winds and windborne debris are primary causes for property damage and loss of life.
  - Do not open your window
### Tornado Damage

#### Table 11-2  Fujita Intensity Scale

<table>
<thead>
<tr>
<th>Intensity</th>
<th>Wind Speed (km/hr)</th>
<th>Wind Speed (mph)</th>
<th>Typical Amount of Damage</th>
</tr>
</thead>
<tbody>
<tr>
<td>F0</td>
<td>&lt;116</td>
<td>&lt;72</td>
<td>Light: Broken branches, shallow trees uprooted, damaged signs and chimneys.</td>
</tr>
<tr>
<td>F1</td>
<td>116–380</td>
<td>72–212</td>
<td>Moderate: Damage to roofs, moving autos swept off road, mobile homes overturned.</td>
</tr>
<tr>
<td>F2</td>
<td>181–253</td>
<td>113–157</td>
<td>Considerable: Roofs torn off homes, mobile homes completely destroyed, large trees uprooted.</td>
</tr>
<tr>
<td>F4</td>
<td>333–419</td>
<td>207–260</td>
<td>Devastating: Frame houses completely destroyed, cars picked up and blown downwind.</td>
</tr>
<tr>
<td>F6</td>
<td>&gt;513</td>
<td>&gt;319</td>
<td>Inconceivable: Might possibly occur in small part of an F4 or F5 tornado. It would be difficult to identify the damage done specifically by these winds, as it would be indistinguishable from that of the main body of the tornado.</td>
</tr>
</tbody>
</table>

### Watches and Warnings

- **Watch** – the atmosphere is conducive to producing severe weather and/or tornadoes
  - Issued by Storm Prediction Center (SPC)
- **Warning** – Doppler radar or a storm spotter has indicated that severe weather and/or a tornado is occurring or probable
  - Issued by local National Weather Service (NWS) office.