10. Severe Local Storms (Thunderstorms)

Lightning....
- Causes thousands of deaths and tens of thousands of injuries each year
- Occur with all thunderstorms
- Most frequent hazard, but least damaging to property
- In USA causes more than $1 billion in insured losses each year

Tornadoes....
- Rarest of the severe weather hazards, but highest damage ratios
- Cause hundreds of deaths and thousands of injuries each year
- Can produce wind speeds in excess of 300 km/h
- Can be 2km wide and stay on the ground over 75 km

Straight-line winds.....
- Can exceed 150 km/h
- Can cause destruction equal to a tornado, but has the largest footprint of severe weather hazards
- Are extremely dangerous to aviation

Hail....
- Can be larger than softball (10 cm in diameter)
- Smaller damage ratios, but over large areas
- In USA causes more than $1 billion crop and property damage each year
Where does severe weather occur?
Polar Jet Stream – tornadoes, hail storms, lightning and straight line winds

Equator ITCZ - lightning
(b) Meanders form in jet stream
Severe Weather occurs along COLD fronts.
Along the Cold front, **cold, dry heavy** air collides with **warm, moist lighter** air

⇒ Lighter air rises rapidly (buoyancy force)
The Thunderstorm Life Cycle (~1 hour)

**Developing Stage**
- Towering cumulus cloud indicates rising air
- Usually little if any rain during this stage
- Lasts about 10 minutes
- Occasional lightning

**Mature Stage**
- Most likely time for hail, heavy rain, frequent lightning, strong winds, and tornadoes
- Storm occasionally has a black or dark green appearance
- Lasts an average of 10 to 20 minutes but some storms may last much longer

**Dissipating Stage**
- Downdrafts, downward flowing air, dominate the storm
- Rainfall decreases in intensity
- Can still produce a burst of strong winds
- Lightning remains a danger
Straight-line winds are any winds not associated with the rotation of a tornado. Straight line winds are responsible for most thunderstorm wind damage.
Derecho

Blowdown
July 4th, 1999
Total Area = 291,000 ha

courtesy of Ontario Ministry of Natural Resources
4 July 1999 Damage
Derecho Damage Characteristics

• Concentrated area of damage and/or wind gusts > 25 m/s (90 km/h)
• Major axis length > 200 km
• Organised pattern
• Minimum of 3 separated reports of damage or wind gusts > 33 m/s (120 km/h)
• Spatial and temporal continuity
Driving through a Derecho
Microburst
Flying into a Microburst

A pilot flying into a microburst must anticipate sudden and strong changes in wind direction and speed.

Initially a headwind is encountered that lifts the plane, followed by a strong downdraft, and when leaving the storm a tailwind causes a loss of altitude.
Hail Storms

Diagram showing warm updrafts and cold downdrafts with direction of movement at 0°C.
Hail Formation

Hail too large for cloud to hold falls to earth causing strong cold downdraft

Hail growing in circulating convection currents

Freezing Level

Rain drops being sucked into the updraft
Hail Size Related to Updraft Intensity

35-55 km/h ..... Smallest hail
88 km/h .......... Golf ball size
160 km/h ........ Softball size
<table>
<thead>
<tr>
<th>Hail Diameter (mm)</th>
<th>Comparison</th>
<th>Damage</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-5</td>
<td>Ice pellets, not hail</td>
<td>-</td>
</tr>
<tr>
<td>5-20</td>
<td>Pea, hazelnut, marble</td>
<td>Virtually no damage, slight damage to plants</td>
</tr>
<tr>
<td>20-30</td>
<td>One euro coin</td>
<td>Panes in glasshouses, cloches broken; vehicles, fruit and vegetables extensively damaged</td>
</tr>
<tr>
<td>30-40</td>
<td>Walnut, table tennis ball</td>
<td>Car paintwork damaged, glasshouses destroyed, felt or asbestos roofs pierced, branches broken from trees, birds and poultry killed</td>
</tr>
<tr>
<td>40-60</td>
<td>Golf ball, billiard ball</td>
<td>Damage to windows and glass roofs; bodywork of cars and aircraft pitted</td>
</tr>
<tr>
<td>60-80</td>
<td>Tennis ball</td>
<td>Damage to roofing tiles. Significant structural damage (facades, metal cladding, window frames), risk of serious injury</td>
</tr>
<tr>
<td>80-110</td>
<td>Baseball, grapefruit</td>
<td>Aircraft bodywork badly damaged; humans and animals seriously endangered, paving stones pitted, severe damage to forests</td>
</tr>
<tr>
<td>&gt;110</td>
<td>Small melon, softball</td>
<td>Risk of fatal injury to humans and animals, damage to the fabric of buildings</td>
</tr>
</tbody>
</table>

Source: Munich Re’s Highs and Lows Weather Risks in Central Europe, 2008
Hail damage

Agricultural Damage
Observed hail track from August 3, 2009 storm. Red=heaviest damage – many trees down, all crops destroyed, severe tree stripping. Yellow = heavy hail damage - 70% or more crop loss siding damage, windows broken, car damage.
Deadliest Hailstorms – Deccan Plateau

- Northern India/Bangladesh
- Home to the largest hailstones in the world (2.25lbs)
- April 14, 1986 – 92 people died
Costliest Natural Disaster – Australia

- Costliest natural disaster in Australia’s history was a hailstorm
- April 14th, 1999
- 500,000 tonnes of hailstones
- Total damage 3 billion dollars
### TOP 5 costliest hailstorms worldwide

<table>
<thead>
<tr>
<th>Country</th>
<th>Date</th>
<th>Loss (in Euro)*</th>
<th>Region</th>
<th>Size / weight of the hailstones</th>
</tr>
</thead>
<tbody>
<tr>
<td>Australia</td>
<td>April 14, 1999</td>
<td>2.3 bn</td>
<td>Sydney area</td>
<td>Grapefruit size</td>
</tr>
<tr>
<td>USA</td>
<td>April 10, 2001</td>
<td>1.5 bn</td>
<td>Missouri and Illinois</td>
<td>500 g</td>
</tr>
<tr>
<td>Germany</td>
<td>July 12, 1984</td>
<td>1.5 bn</td>
<td>Munich</td>
<td>Baseball size</td>
</tr>
<tr>
<td>USA</td>
<td>May 5, 1995</td>
<td>1.3 bn</td>
<td>Dallas and Fort Worth</td>
<td>Baseball size</td>
</tr>
<tr>
<td>USA</td>
<td>April 28, 2012</td>
<td>1.2 bn</td>
<td>St. Louis area</td>
<td>Baseball size</td>
</tr>
</tbody>
</table>

*Figures recalculated in 2012 values.

Source: Allianz, Insurance Council of Australia, NOAA, National Weather Service, USA

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In US hail storms are the #1 driver for insurance losses from severe weather.
Lightning Production in Thunderstorms
Lightning Rods & Fulgurite

Metal rods that are grounded by wires provide a low resistance path for lightning into the earth, which is a poor conductor.

Lightning reaches 30,000 degrees C!! Electric currents of 30,000 Amperes. The fusion of sand particles into root like tubes, called fulgurite, may result.
An Introduction to...
LIGHTNING SAFETY!
www.lightningsafety.noaa.gov

What You Need To Know...

1. NO PLACE outside is safe when storms are in the area.
2. If you hear thunder, lightning is close enough to strike you.
3. When you hear thunder, *immediately* move to safe place.
4. Stay there until 30 minutes AFTER you hear the last sound of thunder.

Lightning is one of the top 3 storm-related killers in the United States!
WHEN THUNDER ROARS GO INDOORS

Lightning Fatalities For Outdoor Sports

- 40% Soccer
- 27% Golf
- 17% Running
- 10% Baseball
- 3% Football
- 3% Other

step 1
Leave the field immediately

step 2
Seek shelter in an enclosed building or car

Wait 30 minutes after hearing thunder to return outside

weather.gov/lightning
Put on waterproofs and sit on a mat or rucksack, with knees drawn up.

- Positive charges
- Negative charges
- Ground currents
LIGHTNING INJURIES

A bolt of lightning can send as much as 30 million volts of electricity across a body. Scientists still don’t understand how some victims survive and why symptoms can appear much later. Here are some of the common injuries which can be temporary or permanent.

**Immediate**

The type of injuries a victim gets depends on various circumstances such as the path the lightning charge takes.

- Seizures
- Confusion
- Amnesia
- Headaches
- Dizziness
- Nausea
- Blindness
- Deafness
- Cardiac arrest
- Muscle pain
- Decreased libido or impotence
- Burns

Lightning strike victims rarely exhibit burns unless they are in contact with conductive materials such as water or wires.

For a few milliseconds, the body is exposed to millions of volts of electricity. The body’s motor system undergoes considerable stress.

The air around a lightning bolt is heated up to 30,000°Celsius for a split second. This causes sweat and rain water to "explode" instantly. This explosion rips clothing and shoes from the victim.

**Delayed**

- Memory deficit
- Distractability
- Difficulty processing information
- Personality changes
- Irritability
- Chronic pain
- Post traumatic stress disorder
- Phobias
- Seizures
- Sleep disorders

Source: Wilderness Medicine (Auerbach, Mosby, 5th ed. 2007) and Spiegel Online

GRAPHICS © 2009
Fig. 3: **Ground current** causes roughly half of all lightning injuries to humans. The difference in voltage between one foot and the other drives current through us. In this simplified illustration the cow has a 100kV (100,000 volts) differential, one farmer has a 50kV differential, and the other farmer has her feet together so her voltage difference is close to zero. See Uman’s book (2008, ch.5) for a more precise representation of ground current distribution.
Norway 2016
300 Reindeer killed

USA 2015
75% of lightning is within clouds – Intracloud (IC)
25% of lightning is between cloud and ground (CG)
Lightning triggered by aircraft during takeoff
Global Lightning Distribution
Global tornado frequency

Hot Spot of activity in the United States Mid-West
In US tornadoes are #1 driver for **loss of life** in severe weather
How do we get tornadoes?

Gust front-induced shelf and roll cloud
Wall Cloud Rotation

(C) 1999 Neal Rasmussen
Tornado
Storm Chasers – “Twister”
Fujita Scale

F0
<116 kph
Gale

F1
117-180 kph
Moderate

F2
181-253 kph
Significant

F3
254-332 kph
Severe

F4
333-416 kph
Devastating

F5
416-509 kph
Incredible
This is a Landsat 5 TM scene of southeast Oklahoma City Metro Area, taken on May 12, 1999. On May 3, 1999, a category F5 tornado crossed the southern portion of the Metro Area. The track is the light foggy curved line.

Landsat 5 TM, Ch. 4,5,3

USDA
Foreign Agricultural Service
Your Best Options for Tornado Safety Are (In This Order)

1. In an underground storm shelter, storm cellar, basement or engineered safe room designed to withstand a tornado
2. On the lowest floor of a sturdy building:
   • Stay away from doors, windows and outside walls.
   • Put as many walls between you and the tornado as you can.
   • Use pillows, couch cushions, sleeping bags, a mattress or blankets to cover up.
   • If you or your children have helmets, wear them!
   • If you have an infant, put them in their car seat or carrier.

Other important sheltering reminders:
• Wear long pants, long sleeve shirt, and real shoes (not flip flops or sandals!)
• Charge your cell phone and take it with you to shelter
• Make sure you know what you’ll do with your pets. Find leashes and carriers now

You can survive almost every tornado if you follow these guidelines!

NWS Norman, OK
Is Climate Change impacting Severe Weather Frequency and Intensity?

It is not clear how CC may impact Severe Weather…

- Some modeling studies imply less thunderstorms, but more intense storms as the globe warms
- Warmer temperatures and more moisture in the atmosphere should result in stronger storms
- But changes in the jet stream, may shift storm patterns resulting in increases/decreases in different regions.
- It is likely that the severe weather season may shift or become longer due to warmer temperatures.
- Whatever happens with CC, growth in population makes countries ever more vulnerable to risks from severe weather.
Annual Tornadoes 1950-2012
Goodland 19 County Warning Area
Total: 845  63 Year Average: 13.4
Homework