Lightning in Florida

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Lightning Facts

• ~ 20 million cloud to ground flashes in U.S. each year
  – Half have more than one strike point
  – 30 million strike points in U.S. annually
• Plus 5 to 10 times as many cloud flashes
• 73 people killed each year in U.S.
  – 300 documented injuries
  – Undocumented probably much higher
Insurance Statistics for 1998

• 26,500 house fires due to lightning
• Total insurance claims $ 1 Billion
• Total costs $ 5-6 Billion
Thunderstorms

- 1,800 in progress now
- 16 million per year
- To have thunderstorm:
  - Low level moisture
  - Instability
  - Lifting Mechanism
Life Cycle

- Tops 20,000 to 65,000 ft
- Updrafts and downdrafts
- Liquid, supercooled water, ice
What Causes Lightning?

• Ben Franklin--it’s electrical, giant spark

• Storm must have ice to yield lightning
  – No ice--no lightning
  – Over Southeast, storm tops at least -20°C, ~20,000 ft tall

• Many collisions among particles--separates the charge
Charge Distribution

• Ice crystals at top--positive charge
• Negative charge at bottom--larger ice particles and liquid
• Charge separation yields enormous electrical potential
• Millions of volts
Types of Lightning

- Discharge within cloud between negative base and positive top (intra-cloud)
- Inter-cloud strike (cloud-to-cloud)
- Discharge between negative and positive charge centers
- Typical cloud-to-ground lightning between ground and negative charge centers
Cloud Lightning

- Intra-cloud is most common
- Internal--diffuse flickering
- Perhaps exits cloud
- Perhaps on outer edge of cloud
- Also...Inter-cloud lightning
Cloud to Ground Lightning

- ~ 40% of flashes
- Most damaging
- Most dangerous
- Best understood
- Most begin in lower cloud
- Most deliver negative charge to ground
- A series of events.....
Stepped Leader

- Too faint and fast to see
- Moves downward
- 50 m increments
- 50 µsec interval
- 150 km/sec velocity
- 20 milli sec process
- Establishes conducting path
Ground Streamer

- Also, very fast and faint
- Positive charge moves up
- Highest nearby object
- Conducting path established
Return Stroke

- The visible component
- ~1 inch diameter
- Moves upward
- Velocity = 80,000 km/sec
- Peak current = 10-20 kA
- Duration = 60 µ sec
It’s Not Over Yet...

- Still large potential difference
- Conducting path established
- So…pause of 40 milli sec
- Dart Leader
  - Moves downward
  - 2 milli sec duration
  - Speed of 2000 km/sec
- Another return stroke
- Series 3-4 dart/return strokes (up to 26)
- Total time is ~ 1/4 sec
Summary

- Total elapsed time ~ 1/4 sec
A Closeup View
Some Tidbits

• Taller the storm--greater the flash rate
• For 50,000 ft storm top--- ~1 flash/sec
• With greater flash rates---greater percentage of intra-cloud flashes
Positive Flashes

• Originate in upper cloud
• Dangerous
  – Often strike away from rain (5-10 mi away)
  – Or in stratiform rain area
  – Longer duration (1 sec)--set fires
  – Carries greater peak current--more injuries

• Seems related to severe thunderstorm phenomena
Thunder

- Lightning temperature $\sim 50,000 \degree F$
- Shock wave
- Speed of sound vs speed of light
- $V_{\text{sound}} \sim 1$ mile per 5 sec
- Nearby lightning cracks
- Farther lightning rumbles
Lightning Detection by Satellite

- Optical detectors see day or night
- Polar orbiting satellites don’t provide continuous coverage
- Detects all types of lightning (Inter…, Intra…, Cloud to ground)
- 90% detection efficiency of what it sees
- 4-7 km horizontal resolution
• Most lightning in Intertropical Convergence Zone
• More over land than water
Ground Based Detection

- National Lightning Detection Network
  - 106 sensors
  - Global Atmospheric, Inc.
- Magnetic direction finders
- Time of arrival sensors
- Cloud to ground flashes only
- ~ 85% detection efficiency
- Location accuracy 0.5 to 1.0 km
- Detect ~ 25 million strokes per year
Example for Single Storm
Florida Summer Climatology

- Flashes/km$^2$/5mon.
- Four maxima
- Complex coastlines
- Lake Okeechobee
- South FL minimum
- Panhandle min
With Easterly Winds

- Sea breeze on east coast is weak
- Sea breeze on west coast is strong
- Complex coasts
With Westerly Winds

- West coast sea breeze is weak
- East coast sea breeze is strong
- I-4 Corridor
With Northwest Winds

- Dry flow
- Fewer storms
- Less lightning
- Most along east coast
FL Leads Nation in Lightning Deaths

• Most dangerous activities (in order)
  – Work/play in open fields
  – Boating, fishing, swimming
  – Working on farm or road equipment
  – Playing golf
  – On telephone
  – Repairing/using electrical appliances
Lightning is Powerful!
Lightning Hazards
Safety Rules

• If outdoors, get indoors
• Don’t be (or under) tall objects
• Crouch down--don’t lie down
• Don’t use telephone or appliances
• Can strike 10 miles away from rain
• If you hear thunder, you are in danger
• Beware of the first and last flashes
• Perform CPR and M-M resuscitation
Conclusions

• Lightning is complex
• Lightning is dangerous
• Florida is lightning capital of the U.S.
• Don’t be a casualty