An Enlightening Chat about Lightning

Chris Vagasky

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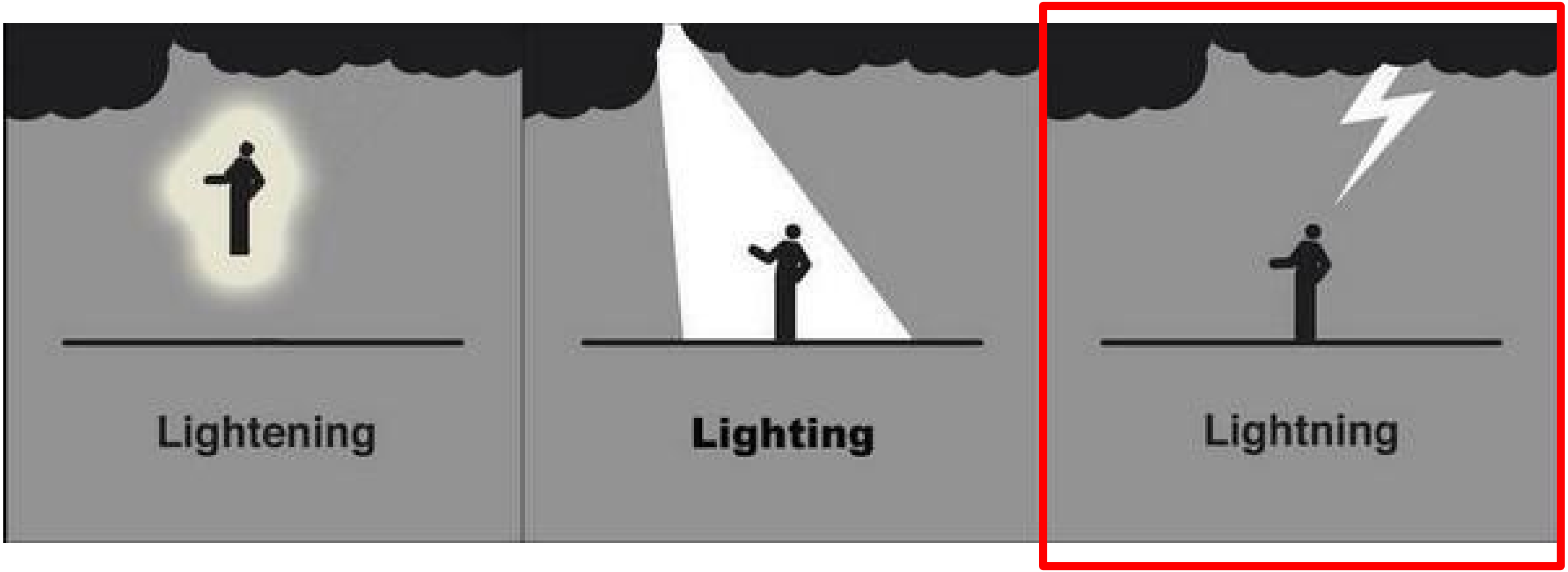
First Thing's First



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Next Thing's Next

- Meteorologist at Vaisala Inc. in Boulder, Colorado, since 2014
- Interested in weather measurements, applications of lightning data, and weather preparedness
- Will be installing a CoCoRaHS rain gauge in a few weeks when I move in to my new house

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What is Lightning?

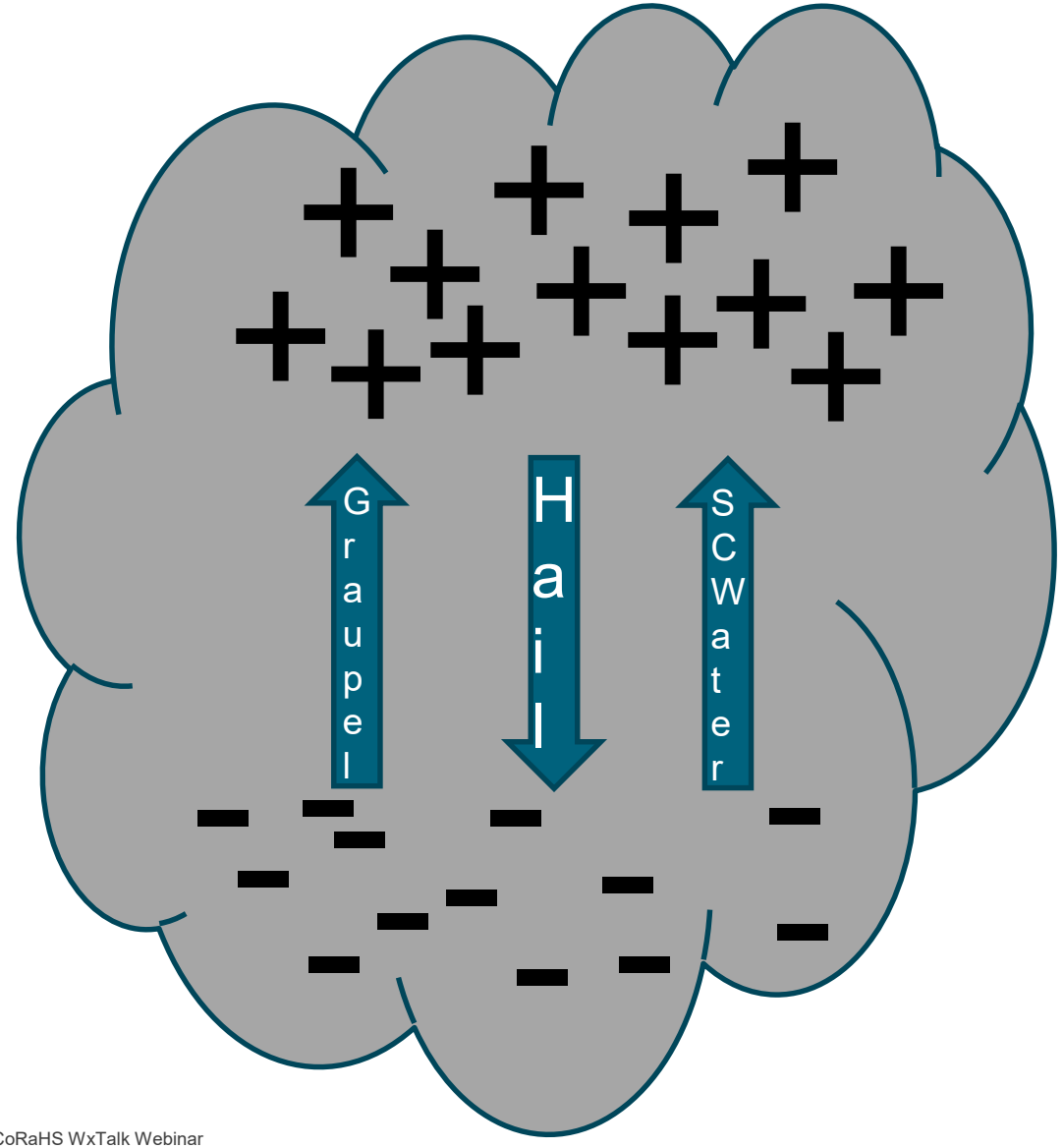
The Technical

- A transient, high-current electrical discharge with pathlengths measured in kilometers (AMS Glossary of Meteorology)

The Practical

- A large electrical spark that occurs between the cloud and ground, between two clouds, within a single cloud, or between the cloud and the air

How does lightning develop?



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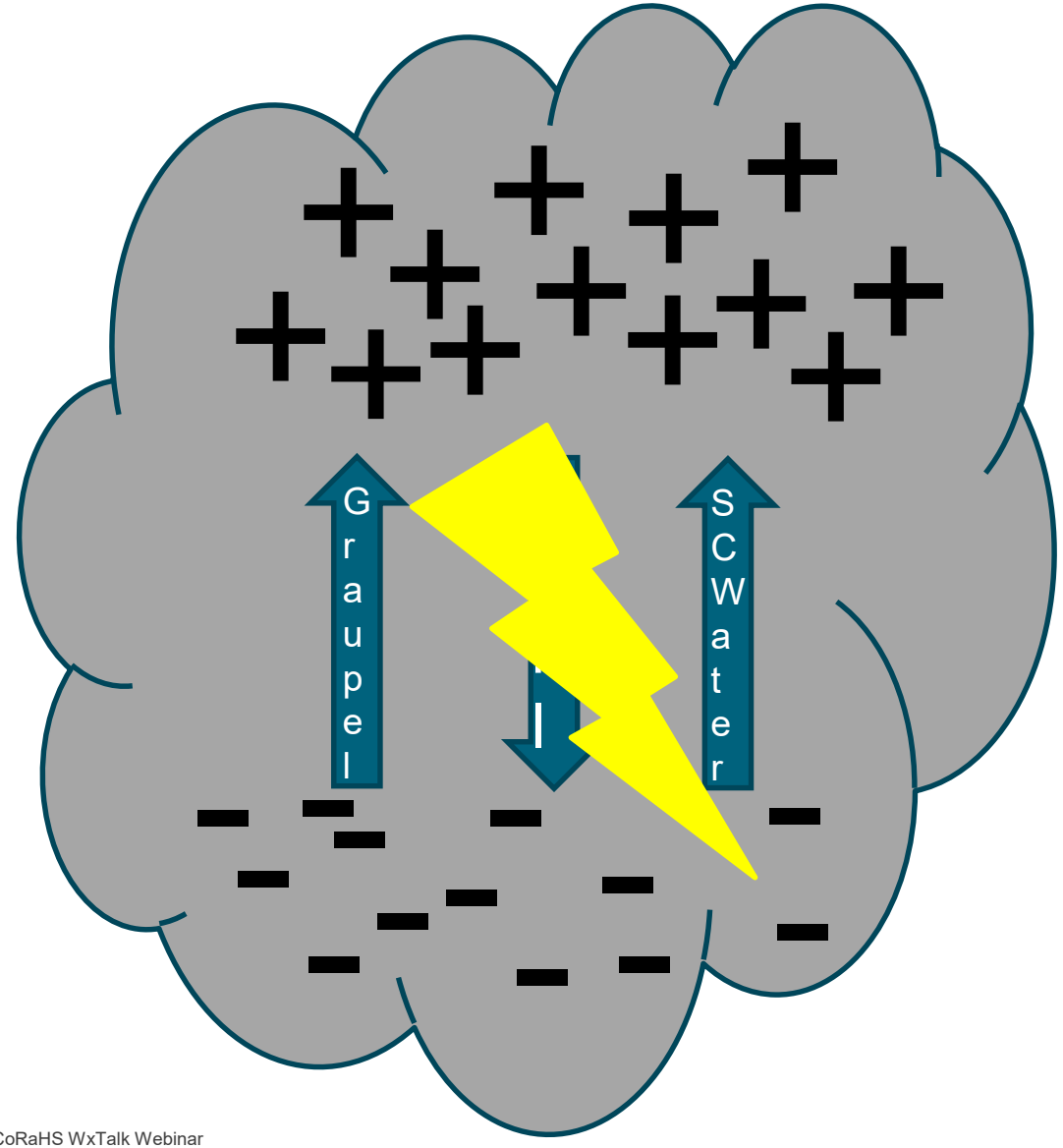
How does lightning develop?



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How is Lightning Detected?

You are Your Own Lightning Detection Sensor

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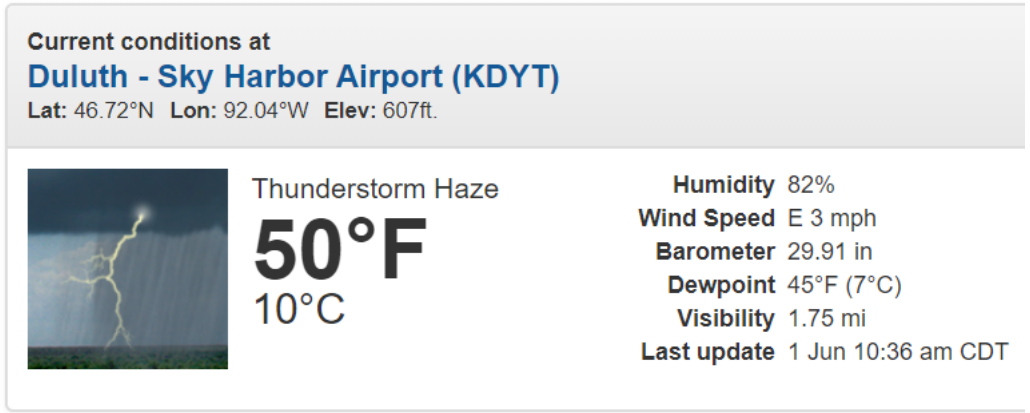
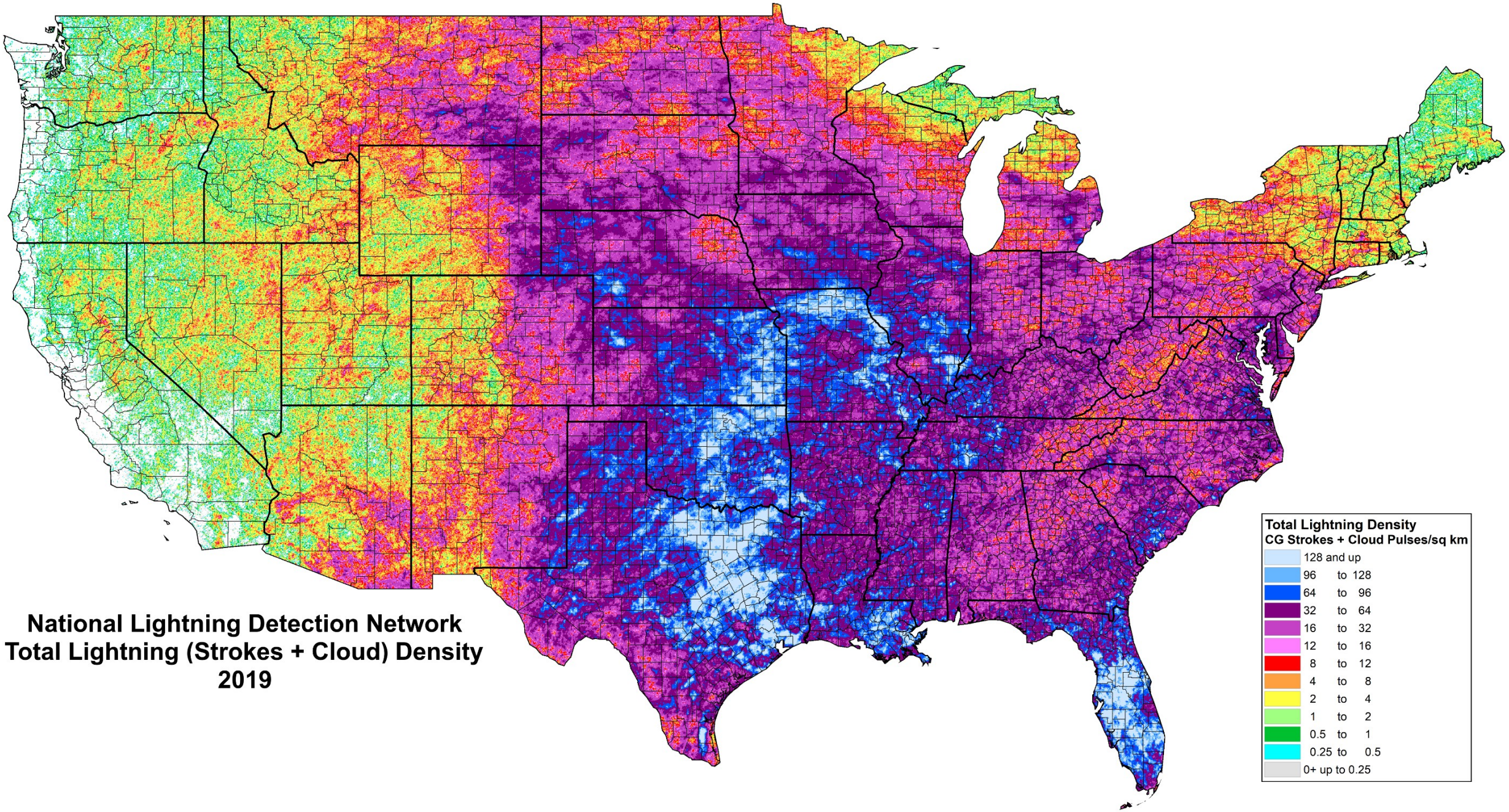
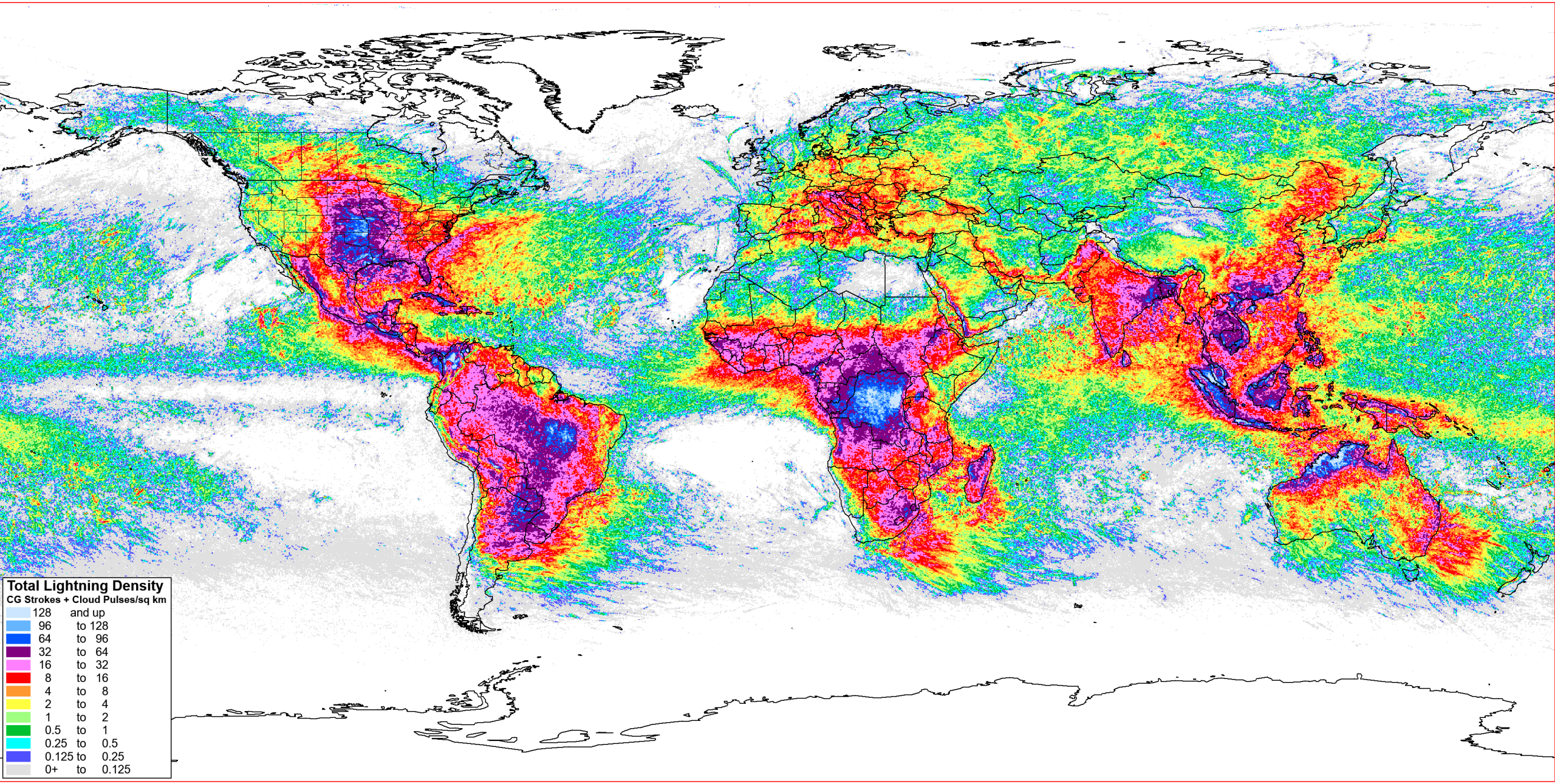
Single-Point Lightning Sensors



- Single-point lightning sensors provide a range and direction to a thunderstorm
- Magnetic field antennas point in the direction that the lightning came from
- The range is determined by analyzing the electromagnetic wave
- Range is about 30 miles and you don't get a precise location of the lightning


National Lightning Detection Network
Total Lightning (Strokes + Cloud) Density
2019
Total Lightning Density
CG Strokes + Cloud Pulses/sq km
128 and up
96 to 128
64 to 96
32 to 64
16 to 32
12 to 16
8 to 12
4 to 8
2 to 4
1 to 2
0.5 to 1
0.25 to 0.5
0+ up to 0.25



Total Lightning Density, 20 km grid **2019** **GLD360 v3.0 data: 2,353,476,704 events**

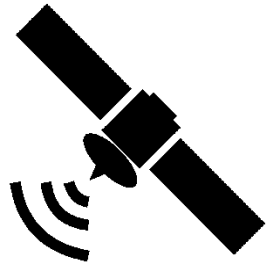
Lightning Detection Networks

- Consist of antennae spread out across a geographic region and “listen” for the electromagnetic waves from each lightning event
- Using magnetic direction finding, time of arrival, or a combination, the location of lightning can be determined
- Examples of lightning detection networks include the National Lightning Detection Network in the United States and the Global Lightning Dataset GLD360 around the planet

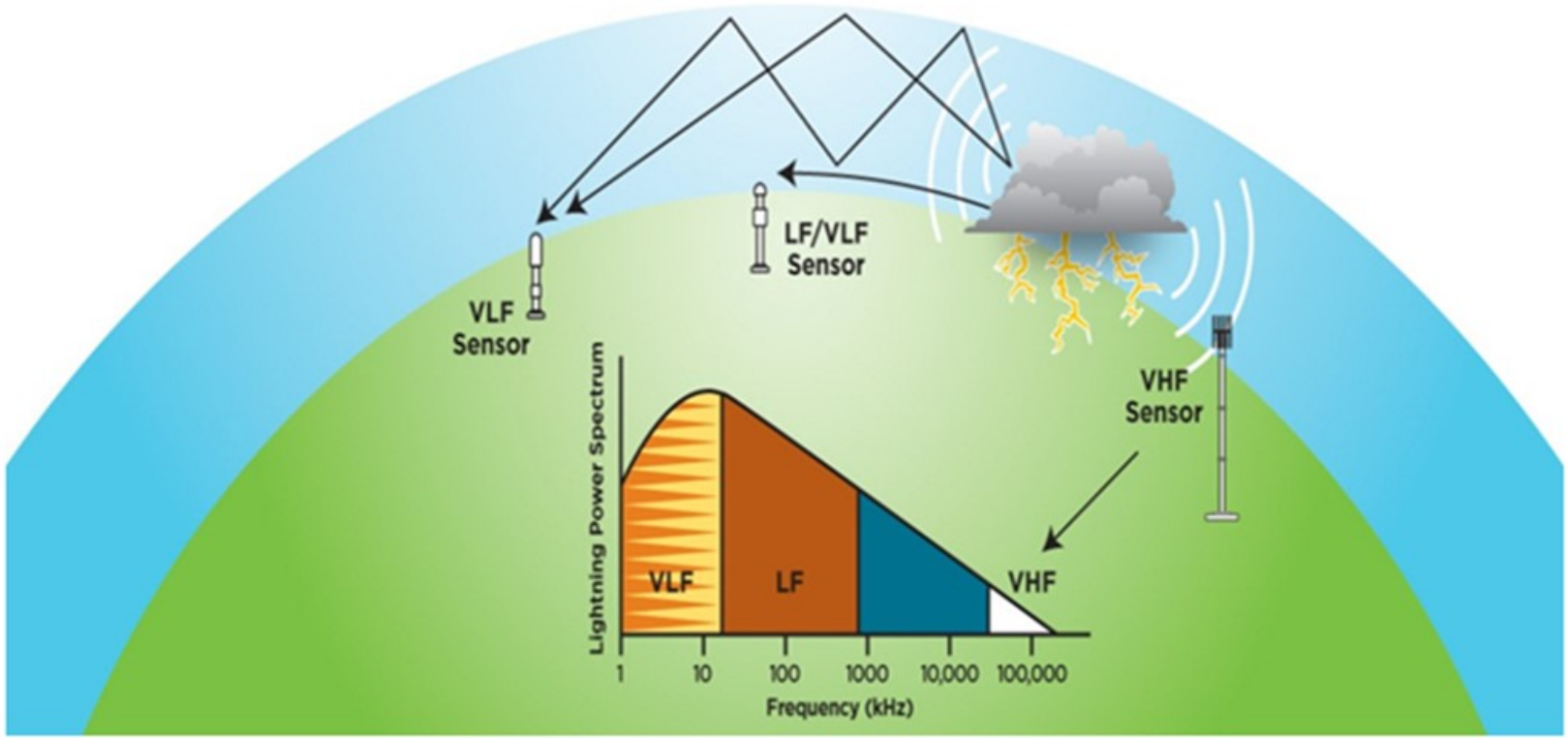
Lightning detection definitions

- Baseline – Distance between sensors
  - Uniform baselines lead to uniform coverage, varied baselines can mean better performance in some areas than others
- DE – Detection Efficiency
  - What percentage of lightning is detected?
- LA – Location Accuracy
  - How close to the actual contact point did the system locate the lightning?
- MDF – Magnetic Direction Finding
- TOA – Time of Arrival

How is lightning detected?



Optical Sensor



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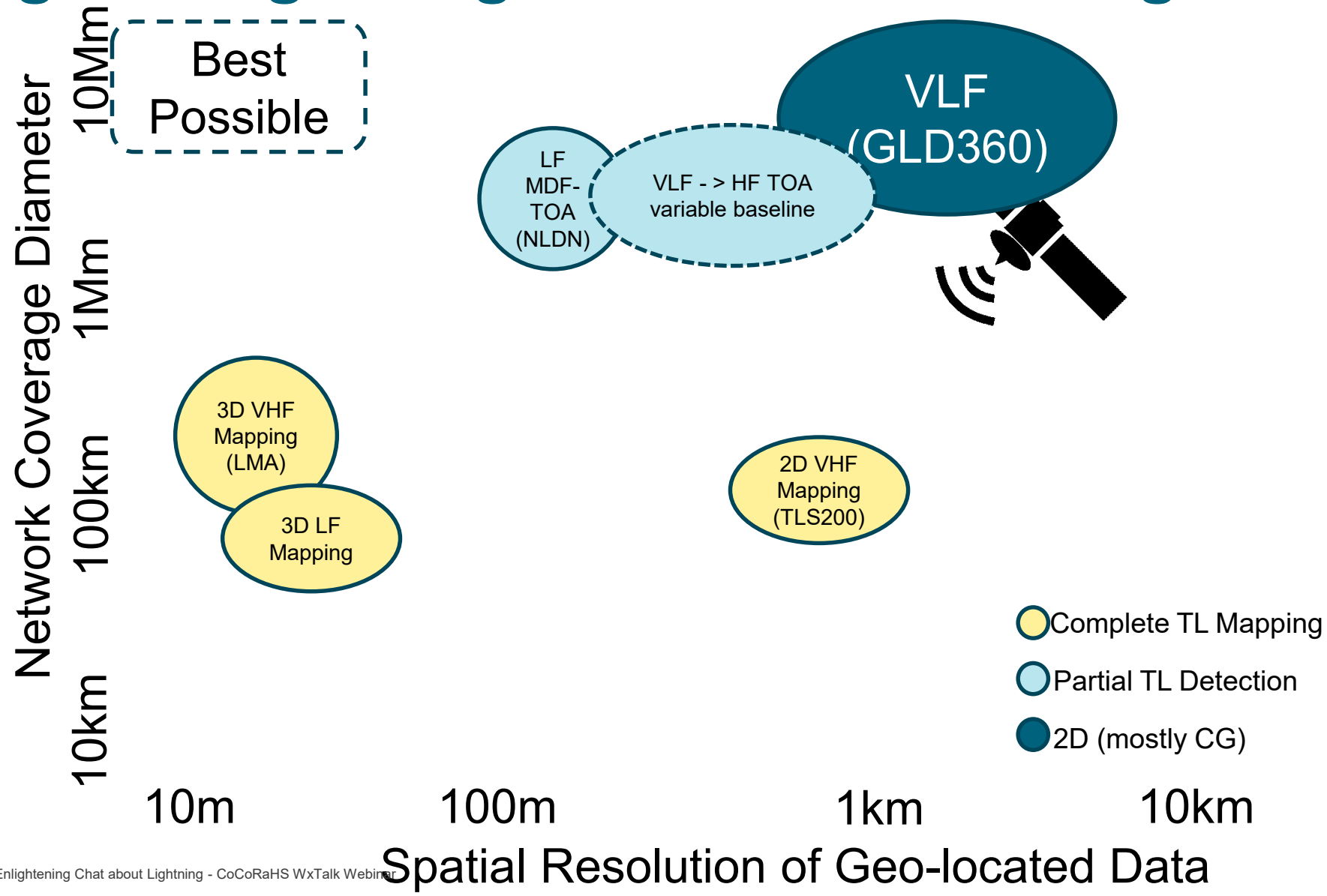
Existing U.S. lightning detection technologies



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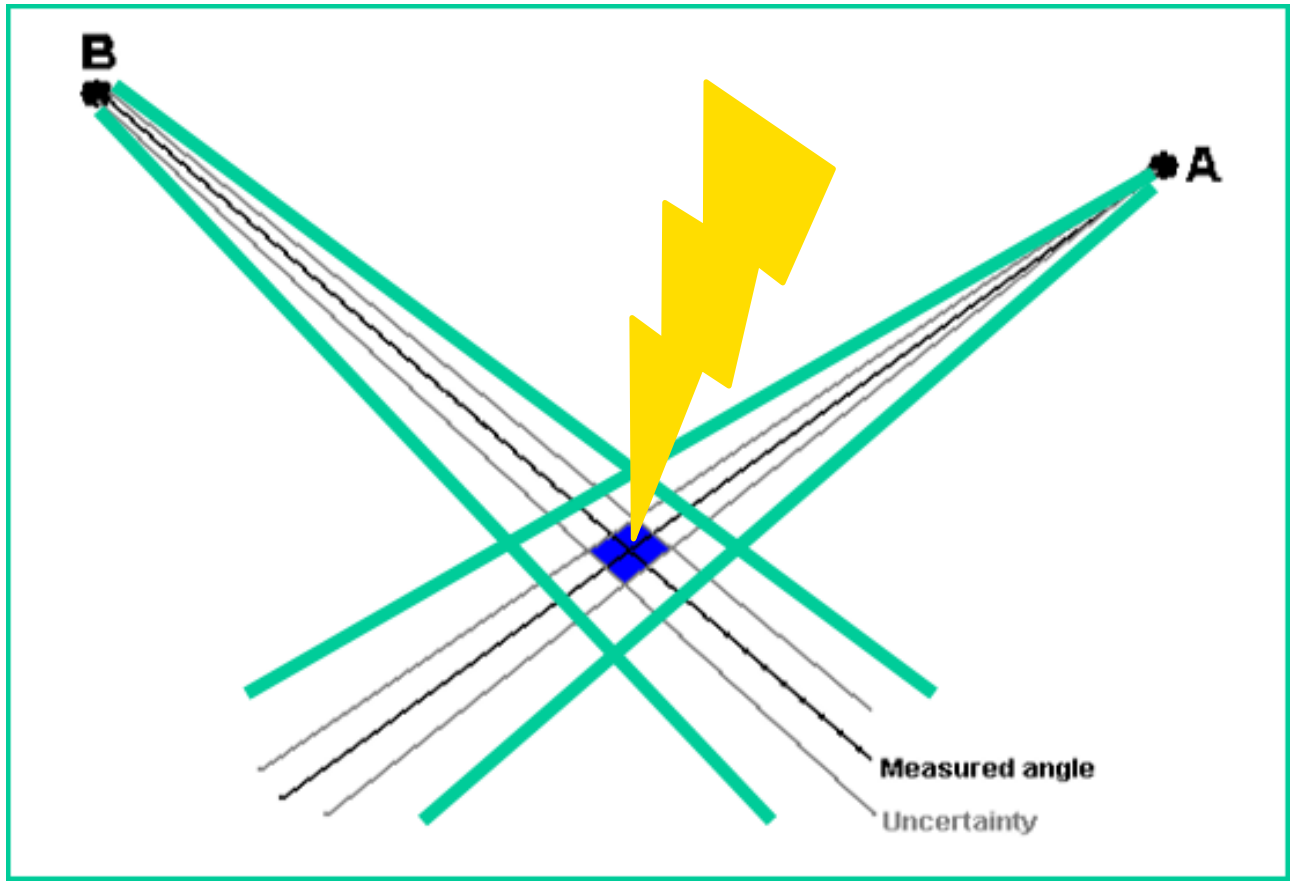
NLDN and GLD360 use both angle and time-of-arrival

- Angles



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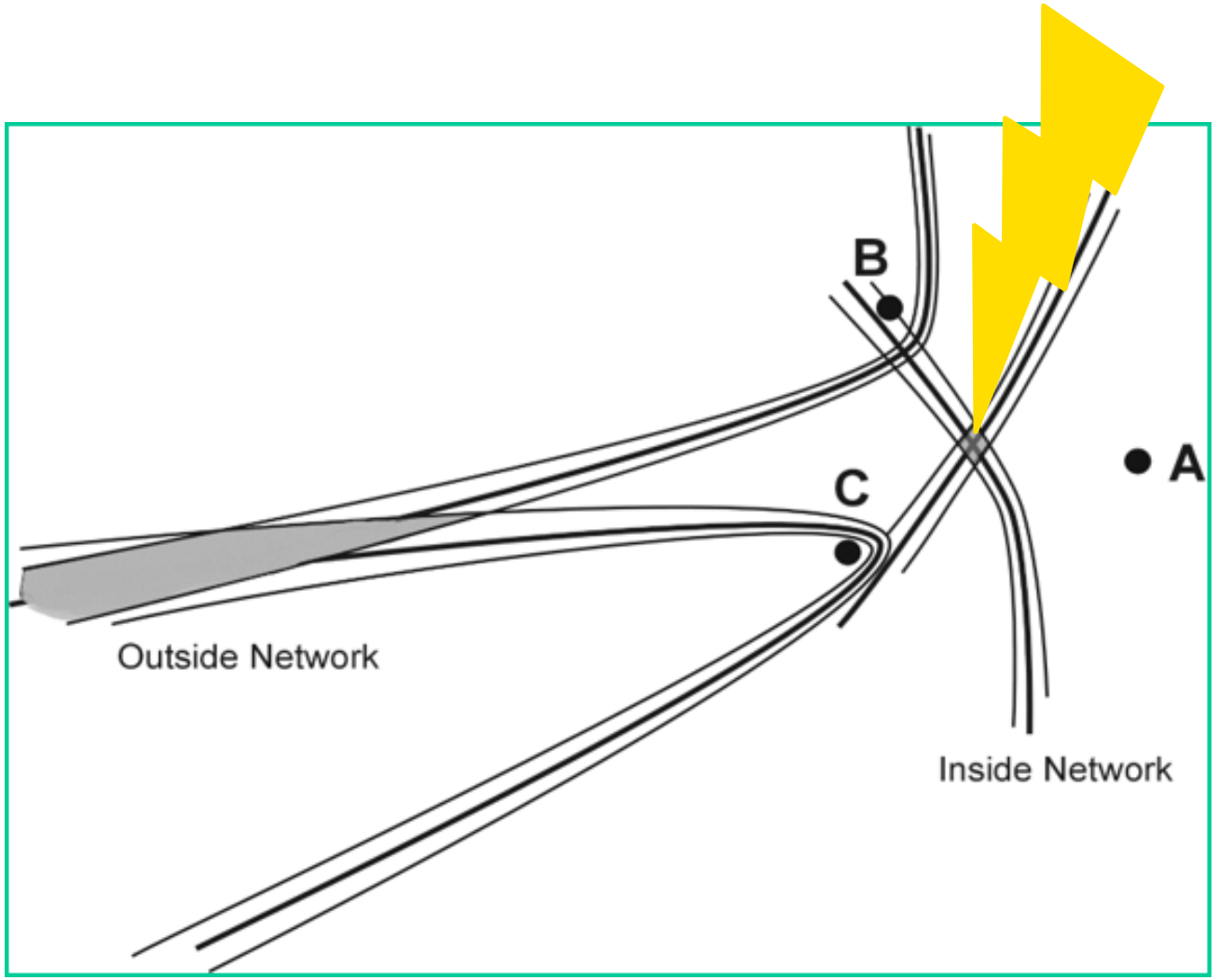
NLDN and GLD360 use both angle and time-of-arrival

- Time-of-arrival



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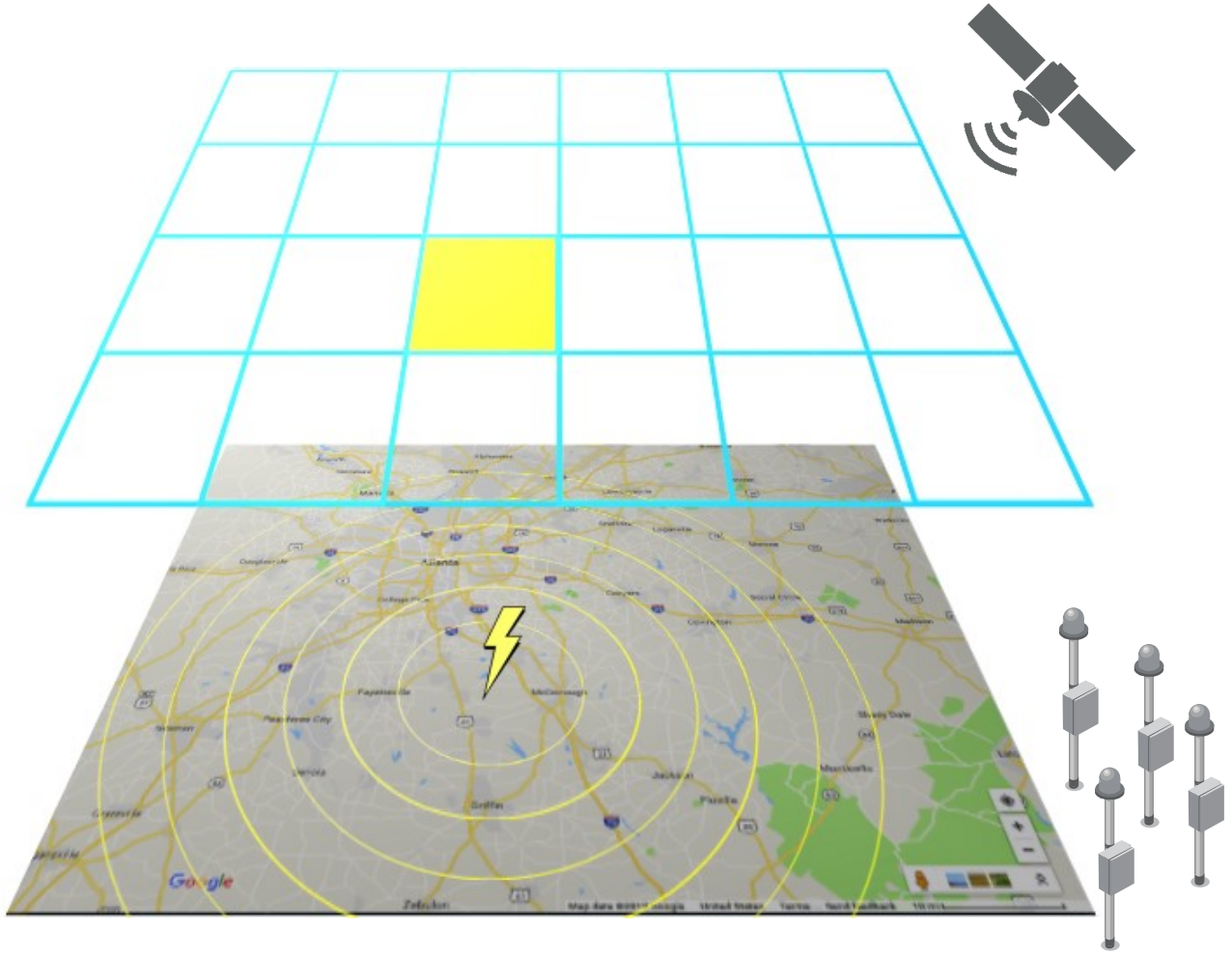
A View from Space



- The Geostationary Lightning Mappers on the GOES-East and GOES-West satellites look for the light that is produced from in-cloud and cloud-to-ground lightning
- The data are output in an 8km x 8km grid and do not differentiate between in-cloud or cloud-to-ground

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So what Exactly is Being Detected?

Cloud-to-Ground Strokes and In-Cloud Pulses

@BrettKHOU

- Cloud-to-ground strokes are why lightning appears to flicker
- These are the individual discharges that we see and are detected
- They usually last for microseconds, although some last up to 1000 times longer
- Lightning strokes can be grouped together as a lightning flash based on time and distance bounds

Cloud lightning makes up the majority of lightning in a thunderstorm. Lightning networks detect small portions of in-cloud events, which are called in-cloud pulses.

The Geostationary Lightning Mapper and Lightning Mapping Arrays do a very good job of showing the overall extent of the in-cloud flash.

Data Received from NLDN and GLD360

- Latitude/Longitude: Where did the event occur?
- Time: What time did it occur?
- Type: In-Cloud/Cloud-to-Ground
- Polarity: Positive or Negative
- Amplitude: How much electricity was transferred?
- Continuing Current: Was there continuing current? How long did the lightning stroke last?

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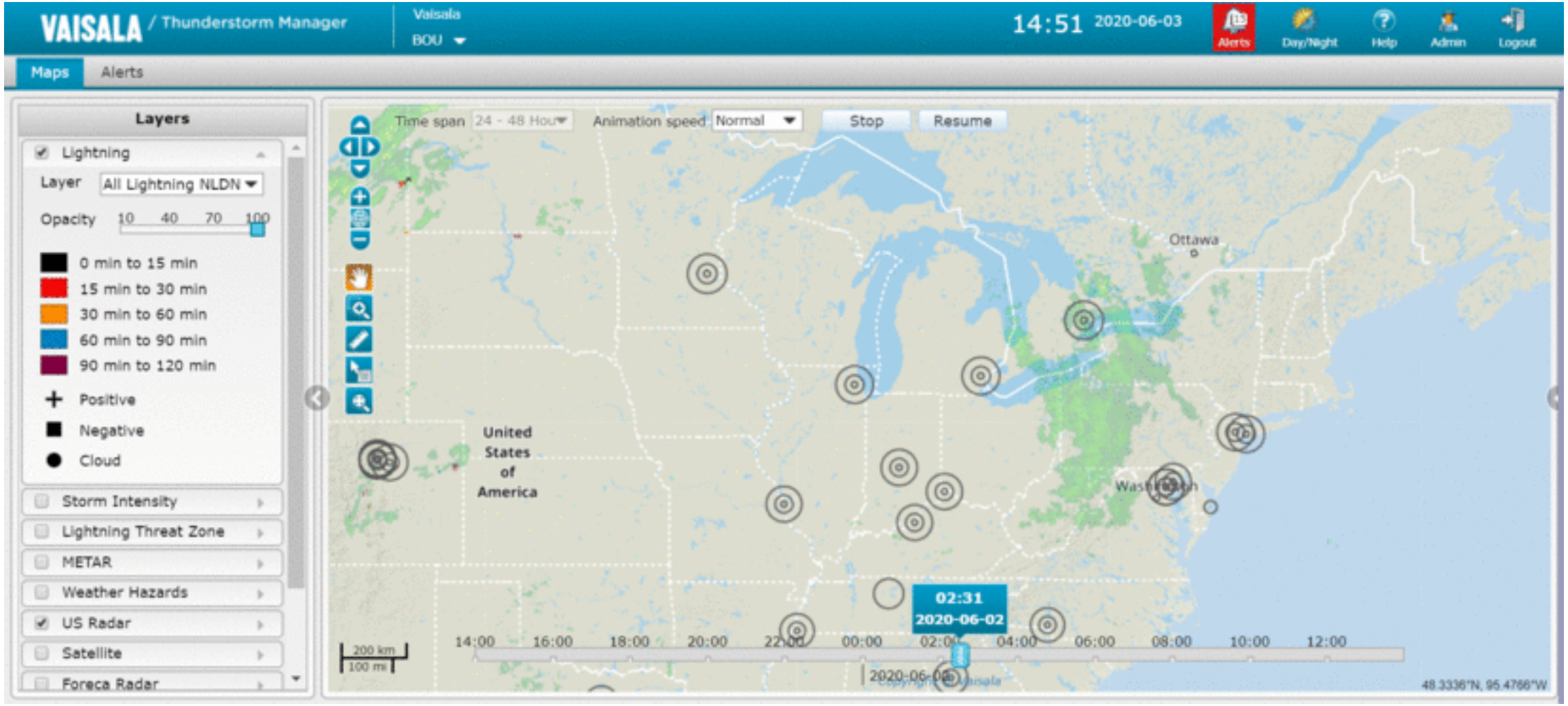
Uses of Lightning Data

Monitoring Thunderstorm Activity



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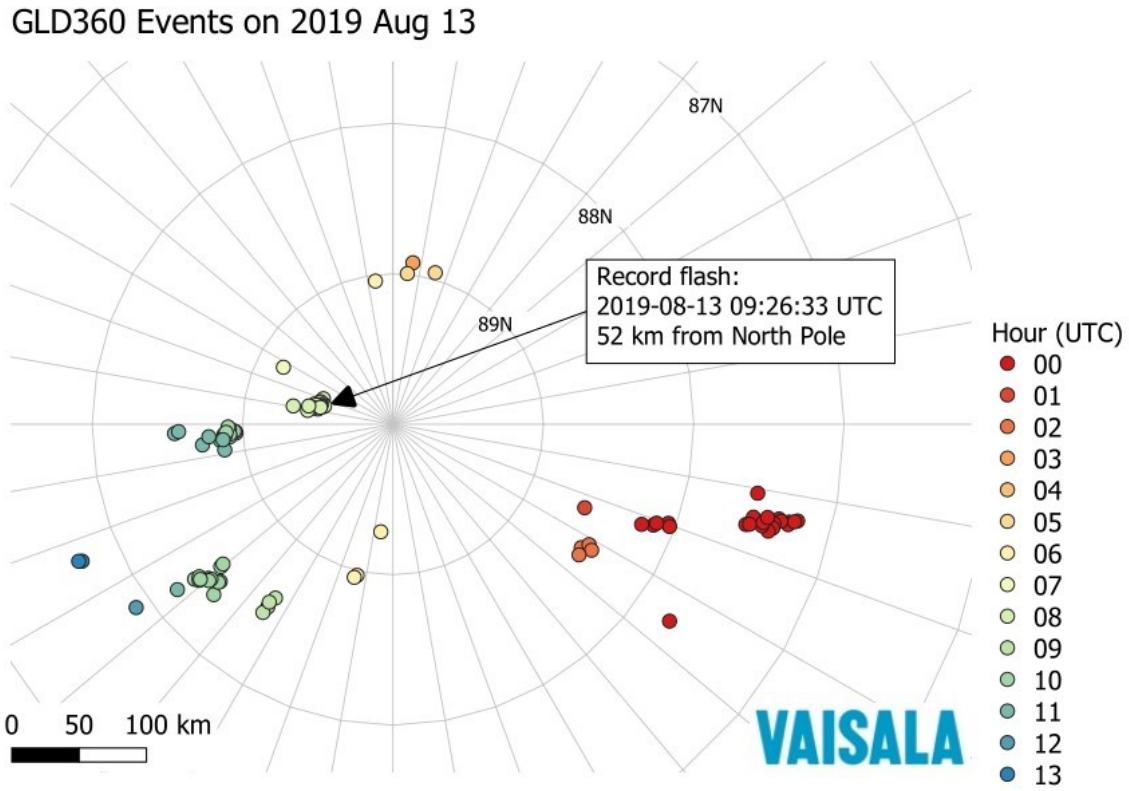
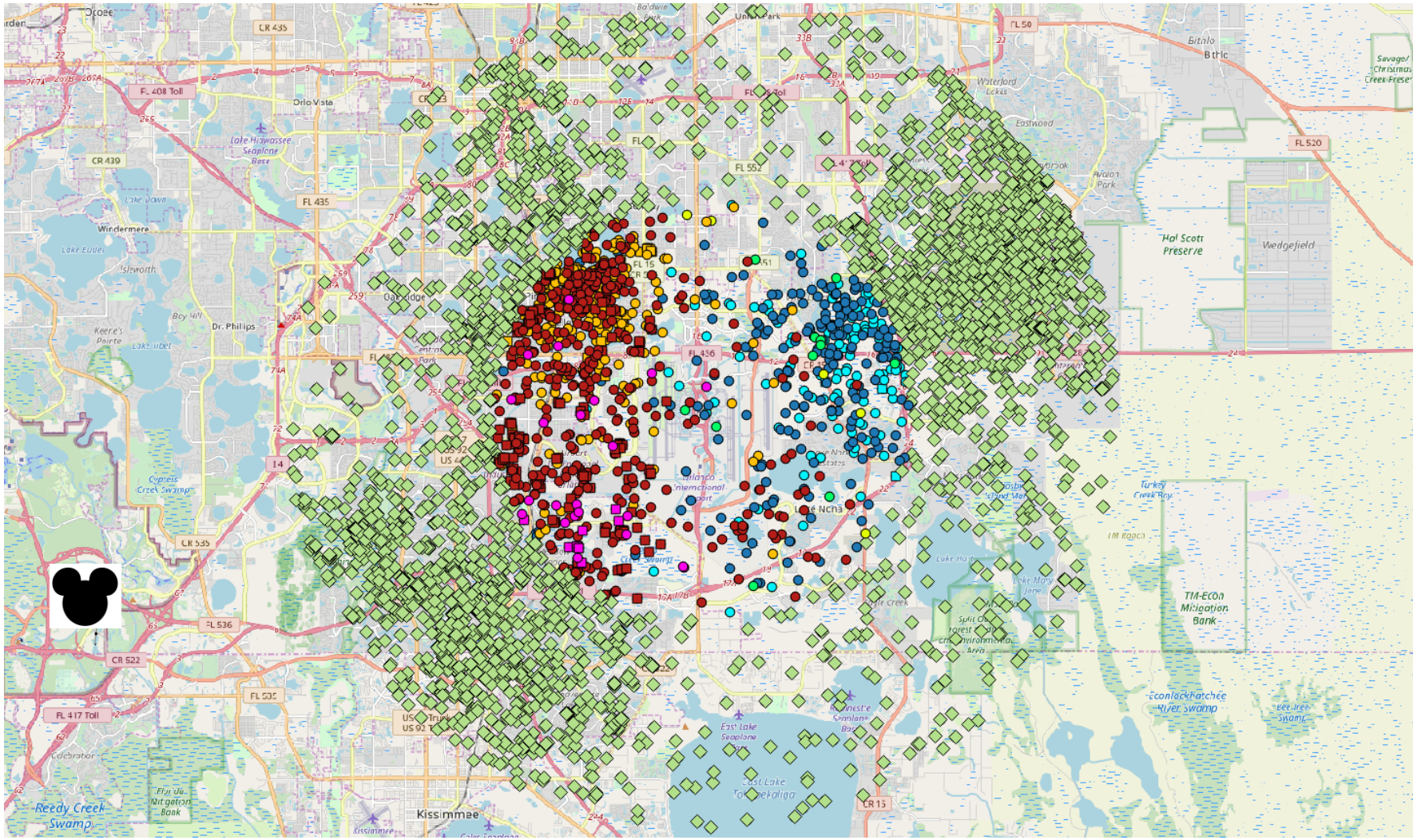
Thunderstorms Develop Globally



- This lightning flash holds the Guinness World Record for most northerly lightning flash detected – just 32 miles from the North Pole.
- Lightning was designated as an Essential Climate Variable by the World Meteorological Organization – monitoring lightning data is critical to understanding changes in the global climate

Aviation Safety



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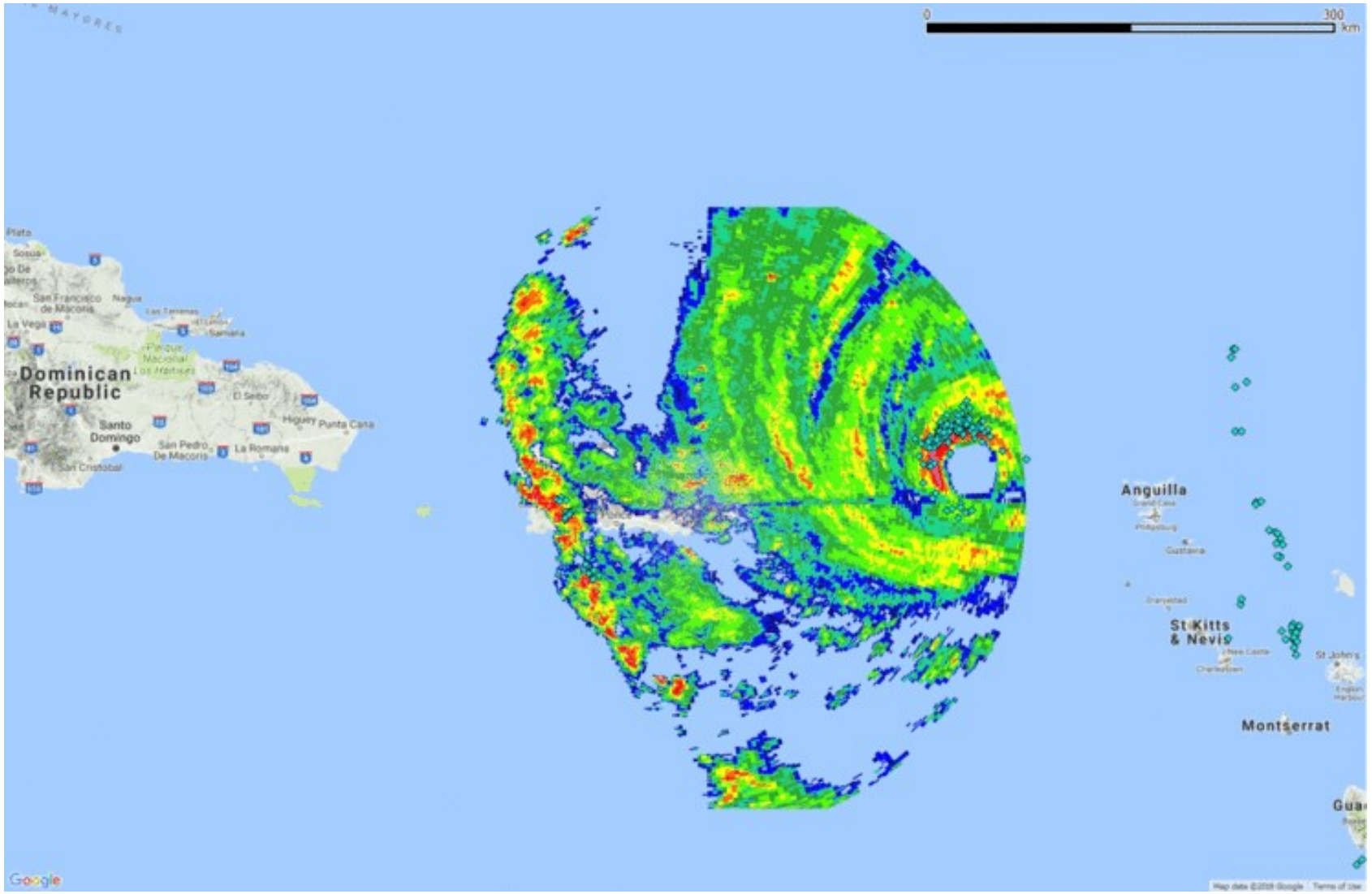
Aviation Safety

Tropical Cyclones



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Monitoring Volcanic Eruptions

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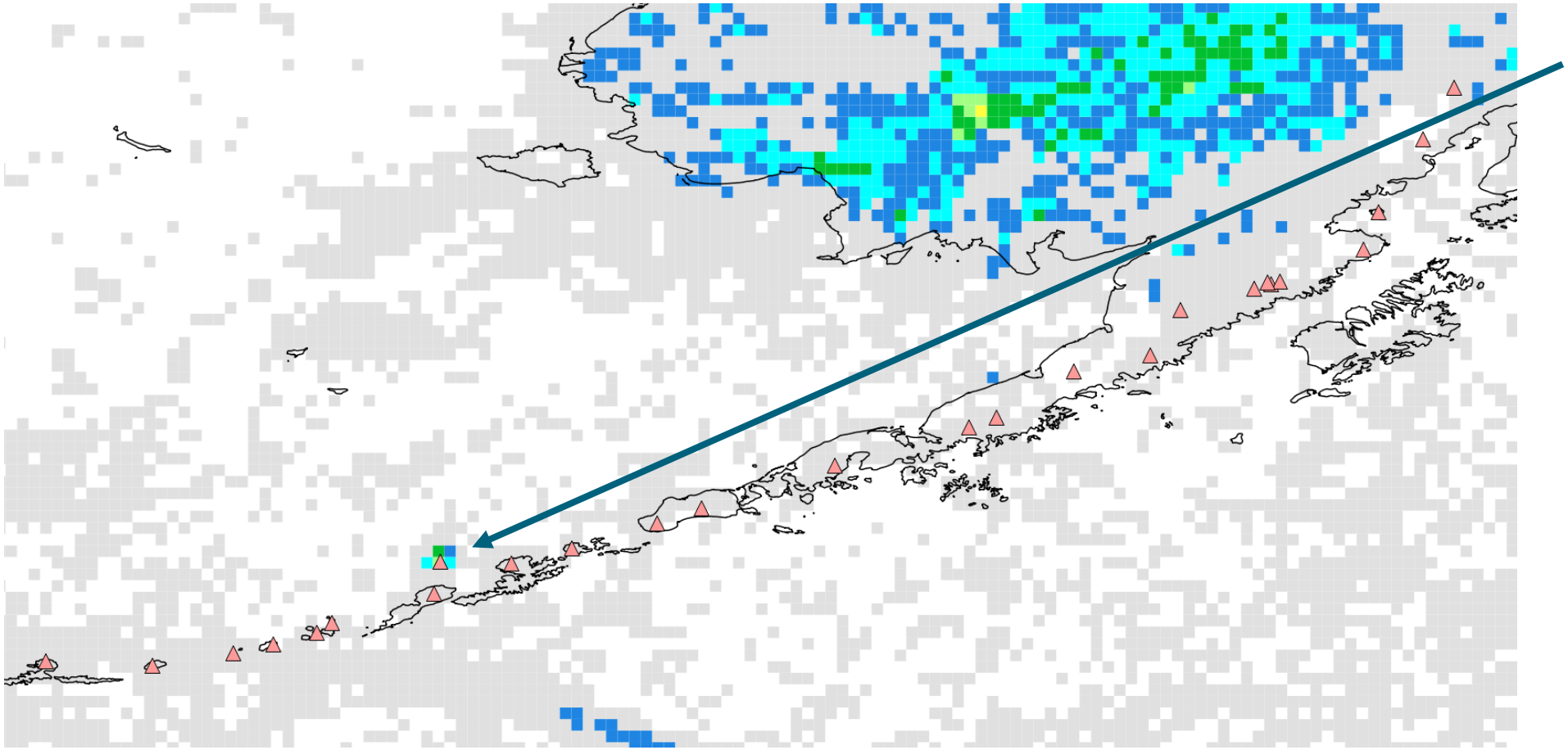
Volcanic Eruptions can Impact Regional Lightning Climatology



Bogoslof Volcano has impacts on global transportation when it erupts. Most of its eruptions produce lightning, allowing forecasters to monitor the eruption remotely.

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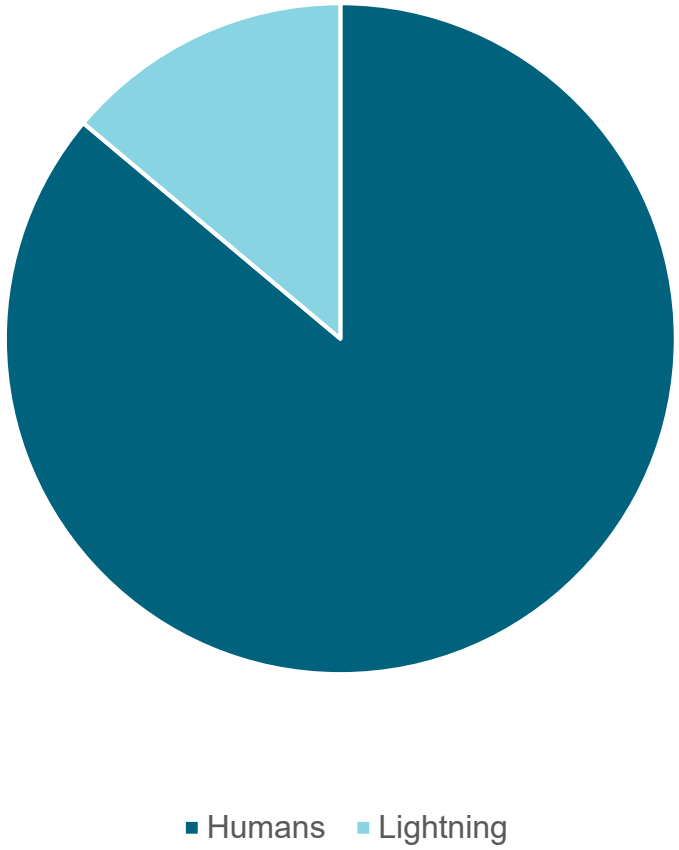
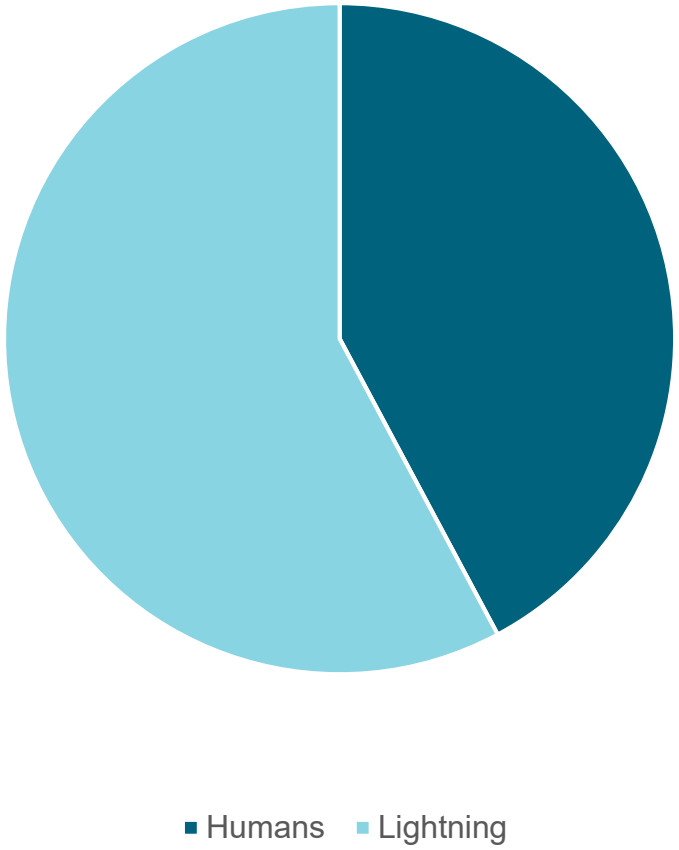
Lightning is Important for Wildfires

Fire Starts



Acres Burned



2001-2019 averages, NIFC

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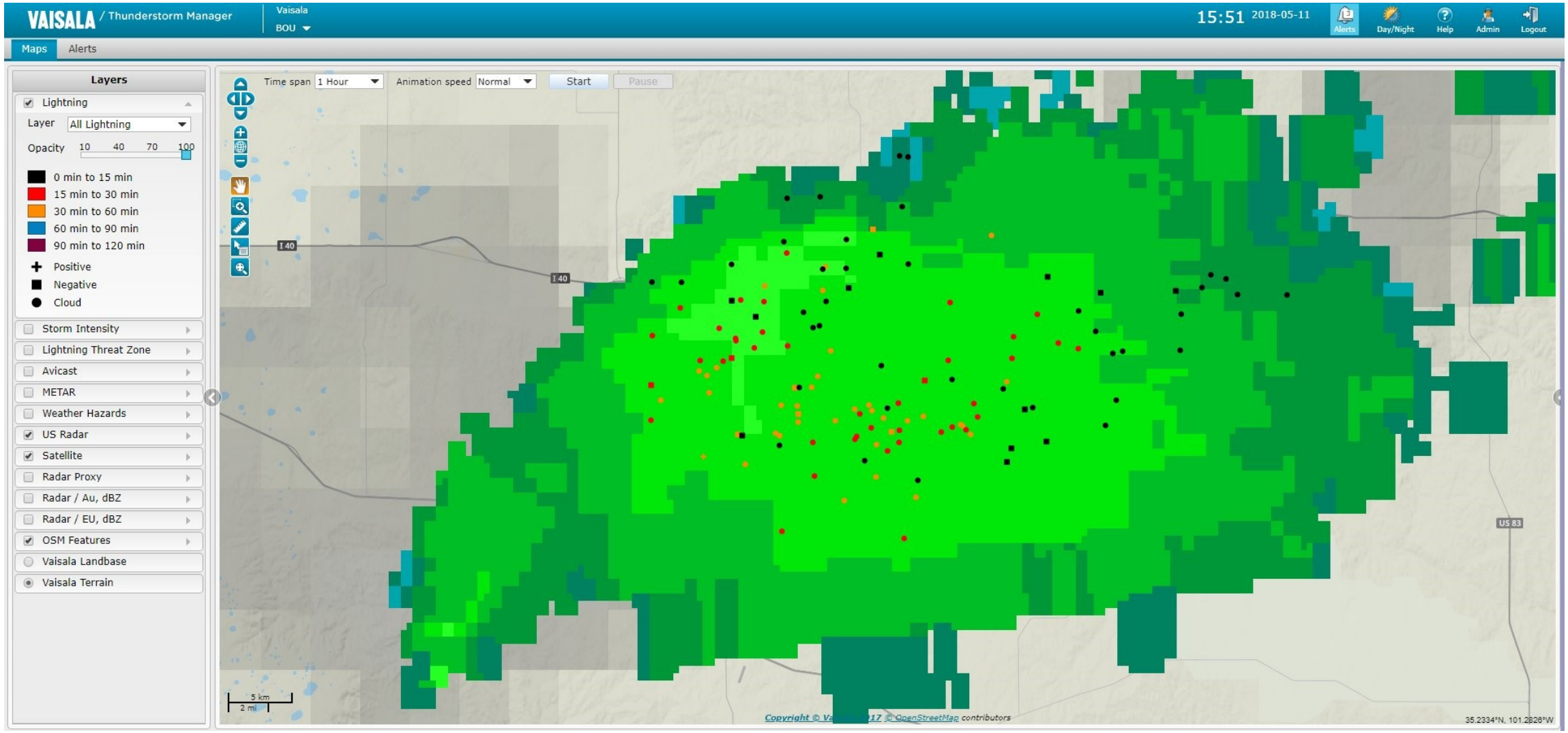
Sometimes Wildfires can Produce Their Own Lightning



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Which can Trigger Their Own Wildfires

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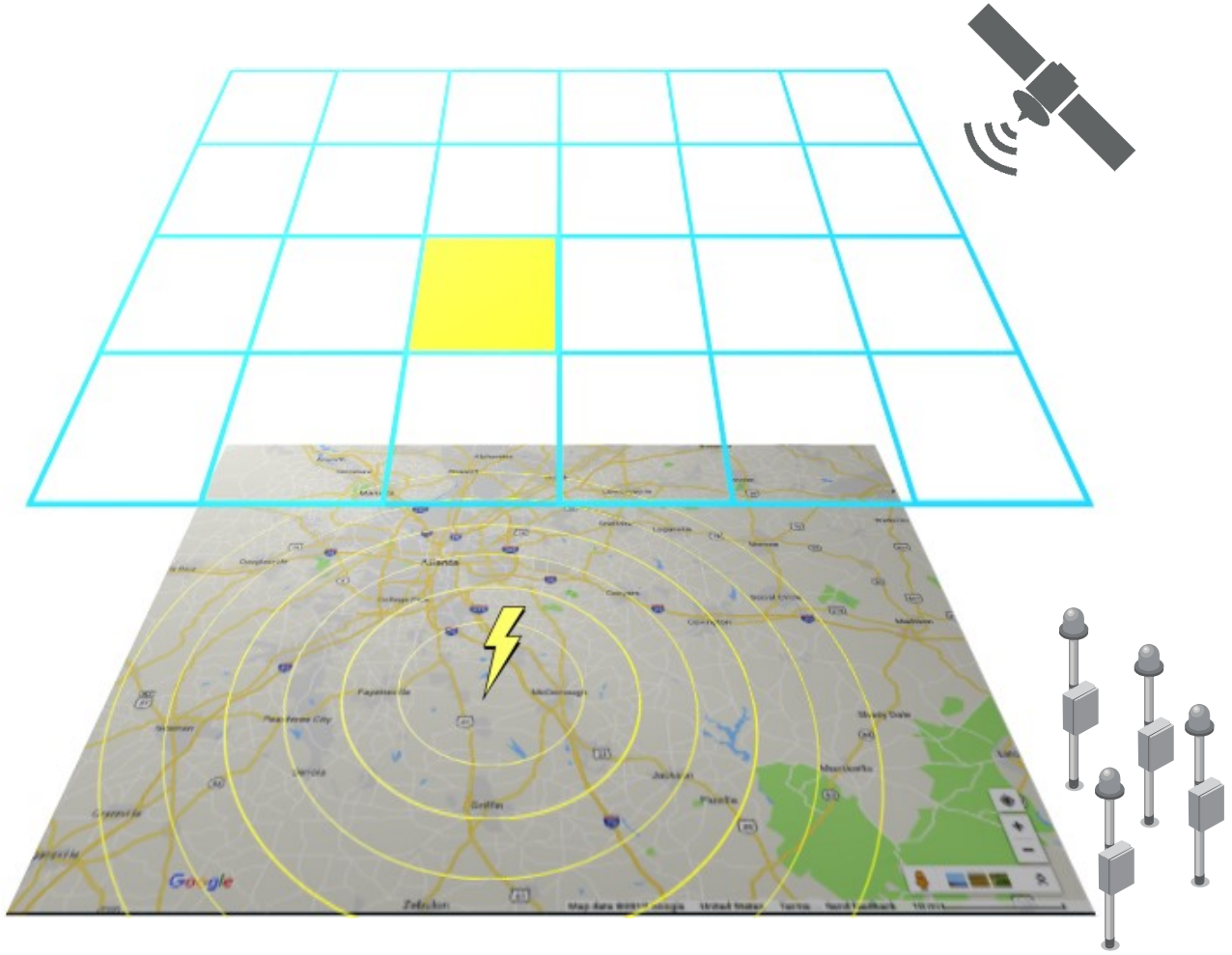
Continuing Current



- Some lightning strokes last up to 1000 times longer than normal lightning strokes
- GLM tells us how long individual lightning events last, NLDN and GLD360 tell us whether it was in-cloud or cloud-to-ground
- Cloud-to-ground strokes that last at least 10 ms are considered to have continuing current and are more likely to trigger wildfires or cause damage

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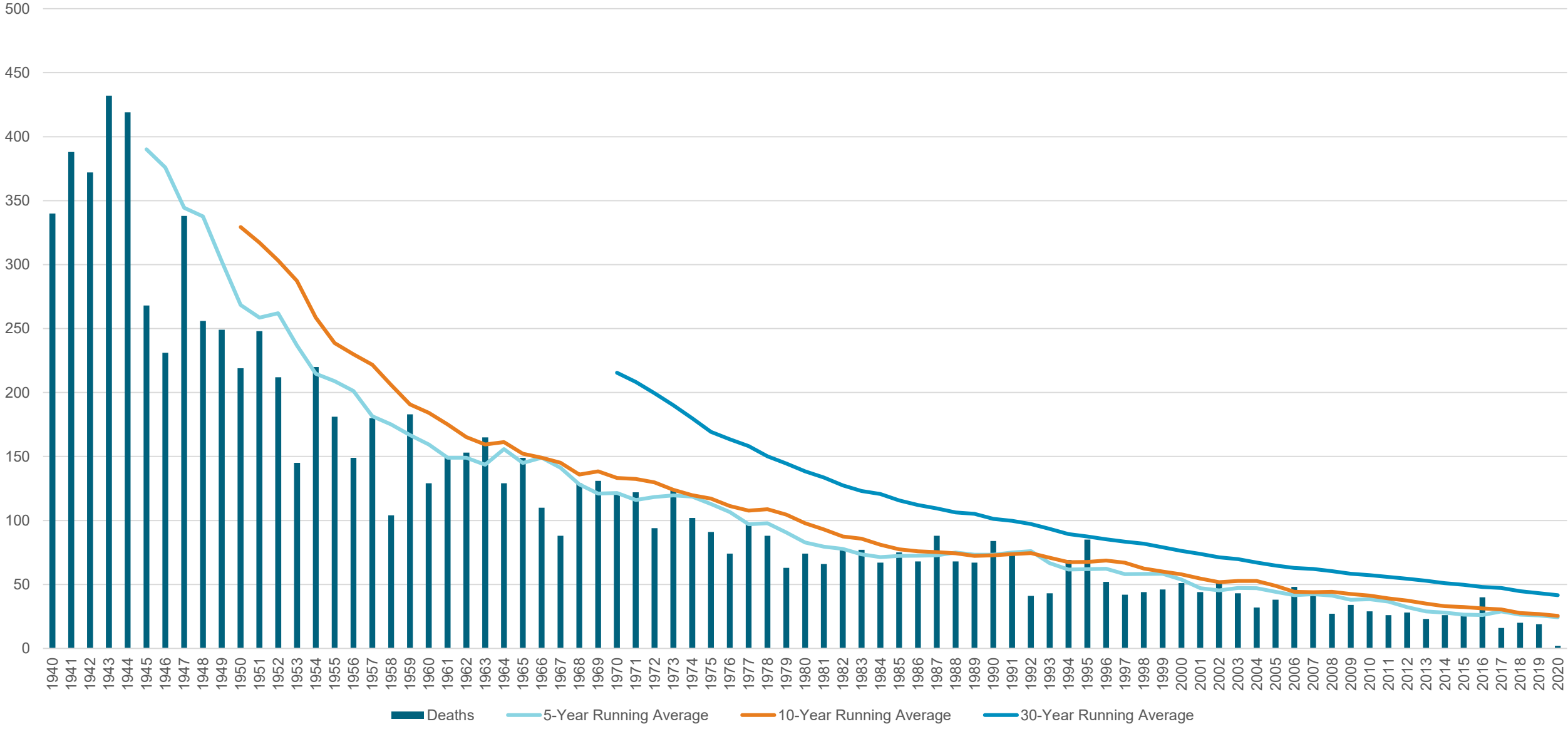
Lightning Safety

Lightning Fast Facts

- Temperature can be 50,000°F
- Can transfer hundreds of thousands of Amperes of current
- Up to 24,000 lightning fatalities around the world every year
  - Holle, R.L., 2016: *The Number of Documented Global Lightning Fatalities,* 24th International Lightning Detection Conference, San Diego.

US Lightning Fatalities 1940 - 2020



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2020 is the 20th Annual Lightning Safety Awareness Week

- June 21 – 27, 2020
- International Lightning Safety Day: June 28, 2020
- Each day focuses on different aspects of lightning and lightning safety
  - Sunday: Introduction to lightning science and lightning safety
  - Monday: The science of lightning and thunder
  - Tuesday: Lightning safety outdoors
  - Wednesday: Lightning safety indoors
  - Thursday: Lightning safety and sports activities
  - Friday: Medical effects on lightning victims
  - Saturday: Protecting your home from lightning

Basic Lightning Safety Principle

- No place outside is safe when thunderstorms are in the area

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Where to Seek Shelter from Lightning

- A substantial building – a building with plumbing and electrical in the walls
  - Picnic shelters, outhouses, and tents may keep you dry, but don’t protect you from lightning
  - Avoid electronics plugged into the wall and plumbing fixtures
- A metal-topped vehicle with windows rolled up
  - Avoid touching anything metal components in the car

A Few Key Takeaways

- Lightning is detected more than 2 billion times around the world every year
- There are multiple ways to detect lightning, with the best detection coming from lightning networks
- Lightning occurs in thunderstorms, tropical systems, volcanoes, and wildfires
- No place outdoors is safe when thunderstorms are in the area, so when thunder roars, go indoors

For more lightning discussions

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