

MR3522: Remote Sensing of the Atmosphere and Ocean

Lightning Detection from Space

Main Topics

- Geostationary Lightning Mapper on GOES
- Global lightning distribution

Why look for lightning?

Research benefits:

Can tell us information about microphysical and dynamic structures of clouds.

Changes in time tell us about how the electrical field balance on Earth varies over many years.

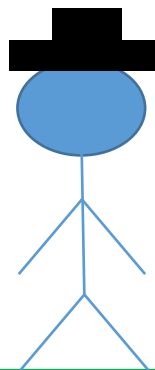
Societal benefits:

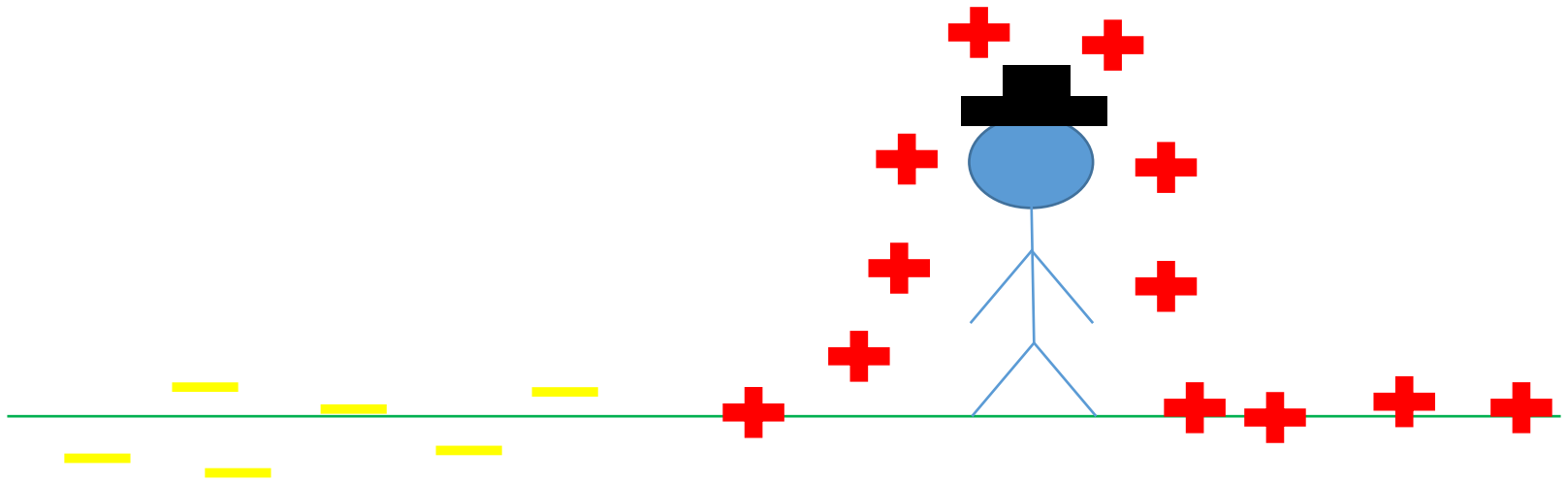
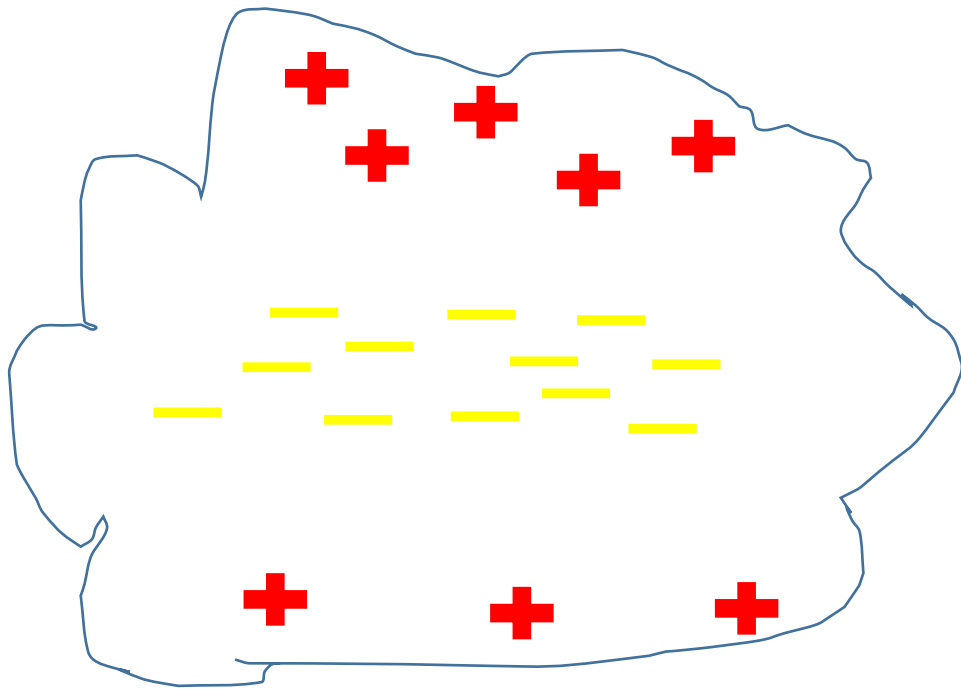
Faster detection of growing severe weather events

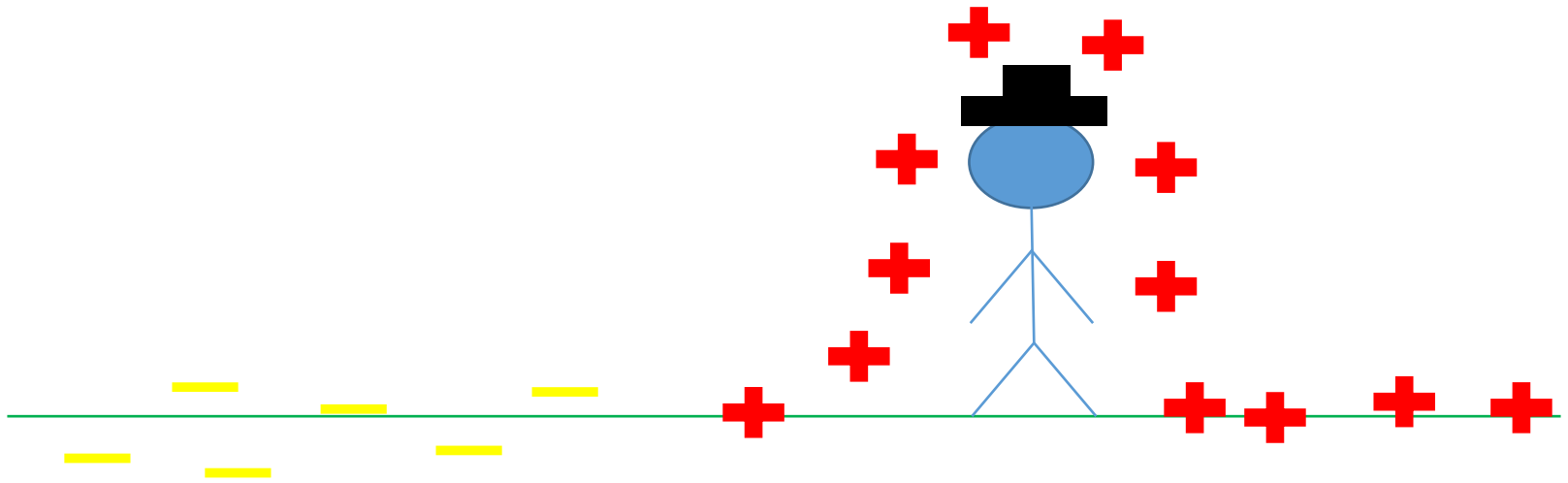
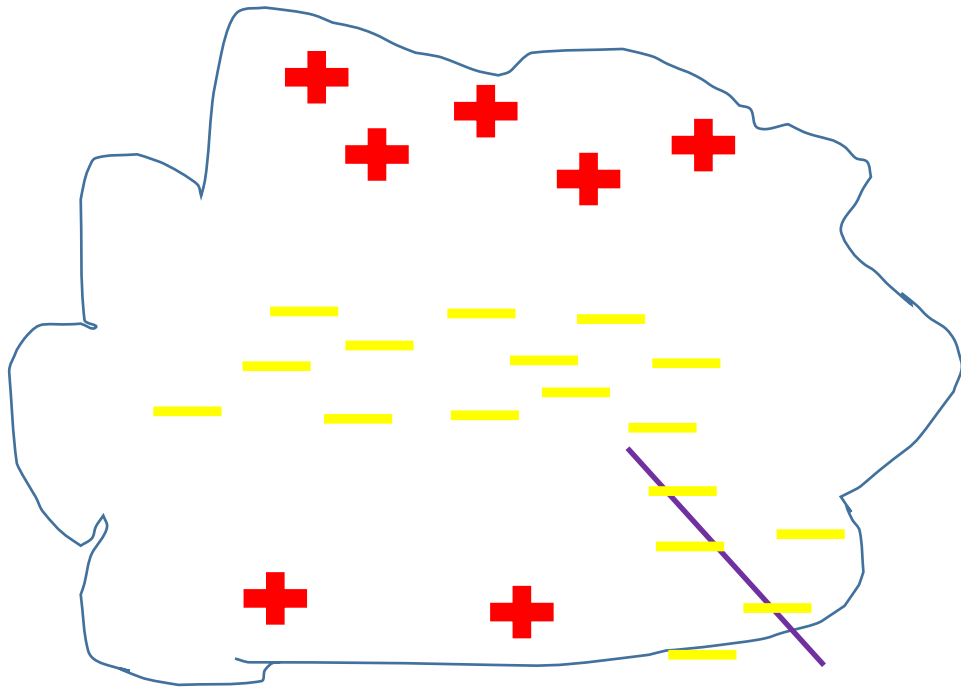
Lightning warning systems

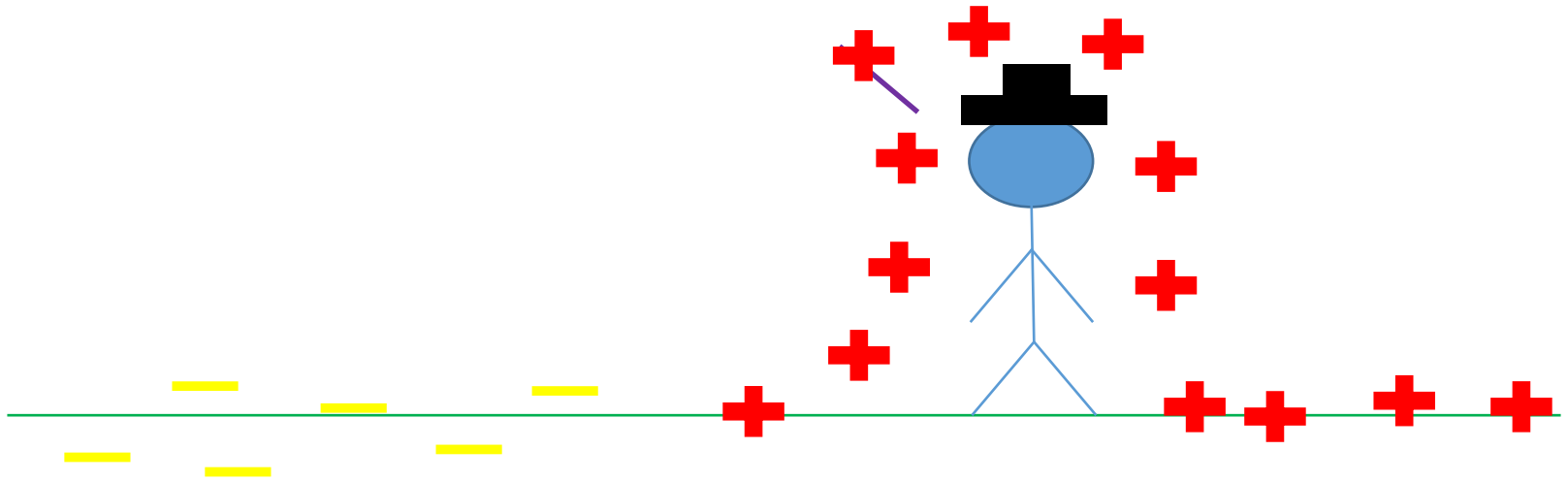
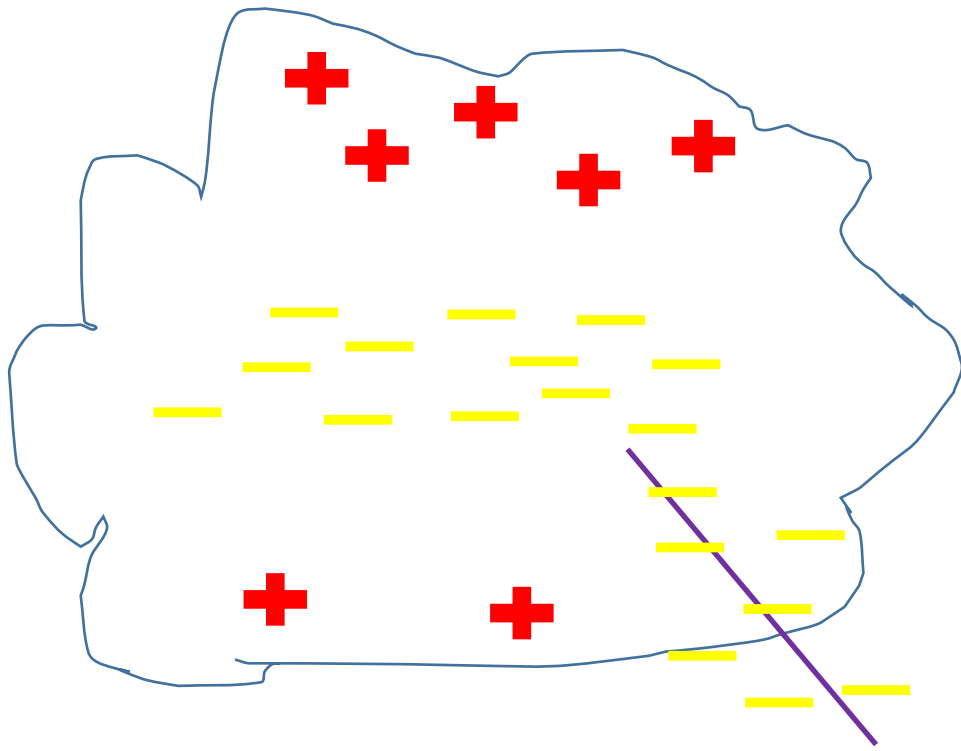
Insurance purposes: Validation that loss of life or property was caused by a lightning strike

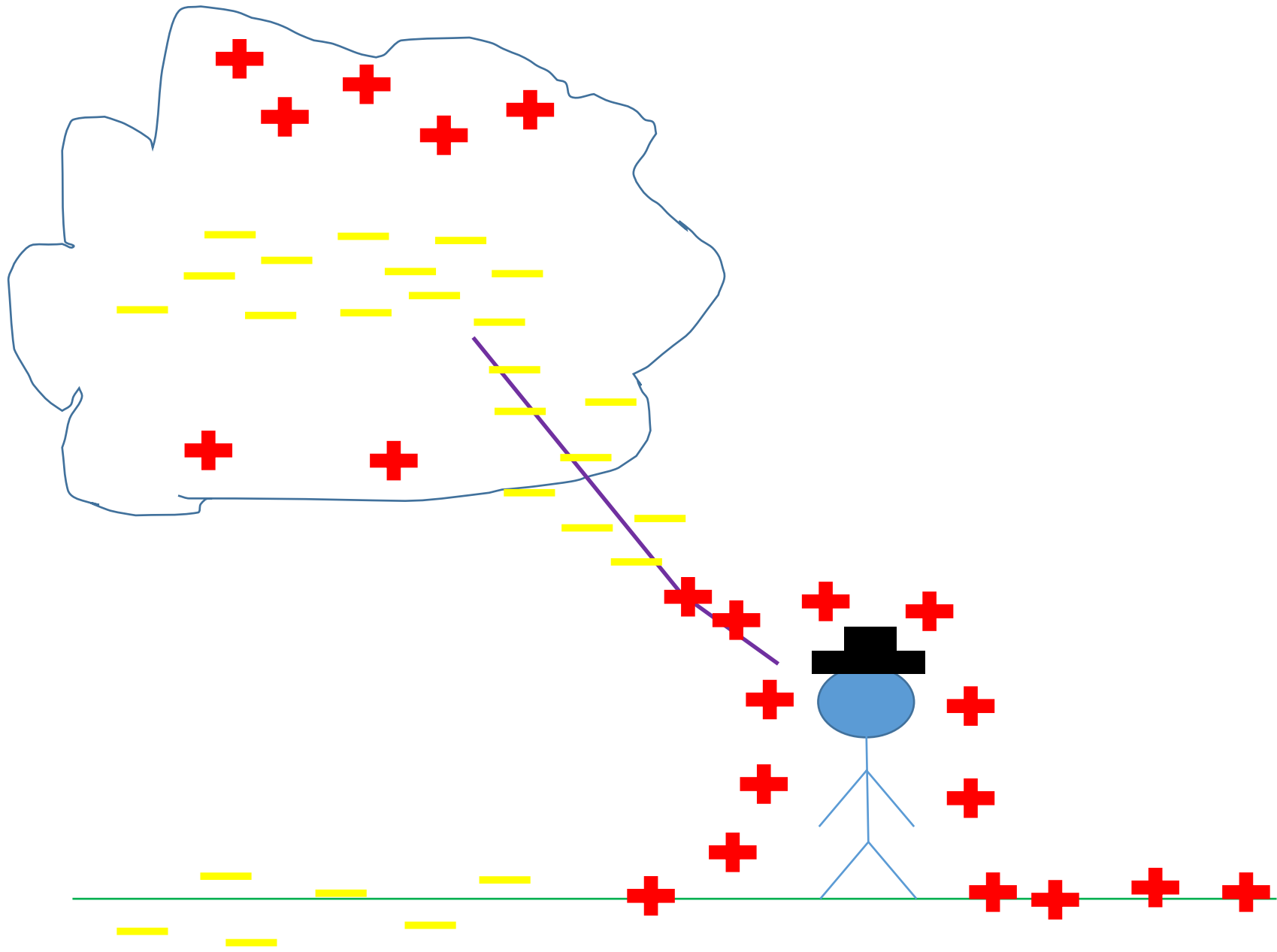
Cloud

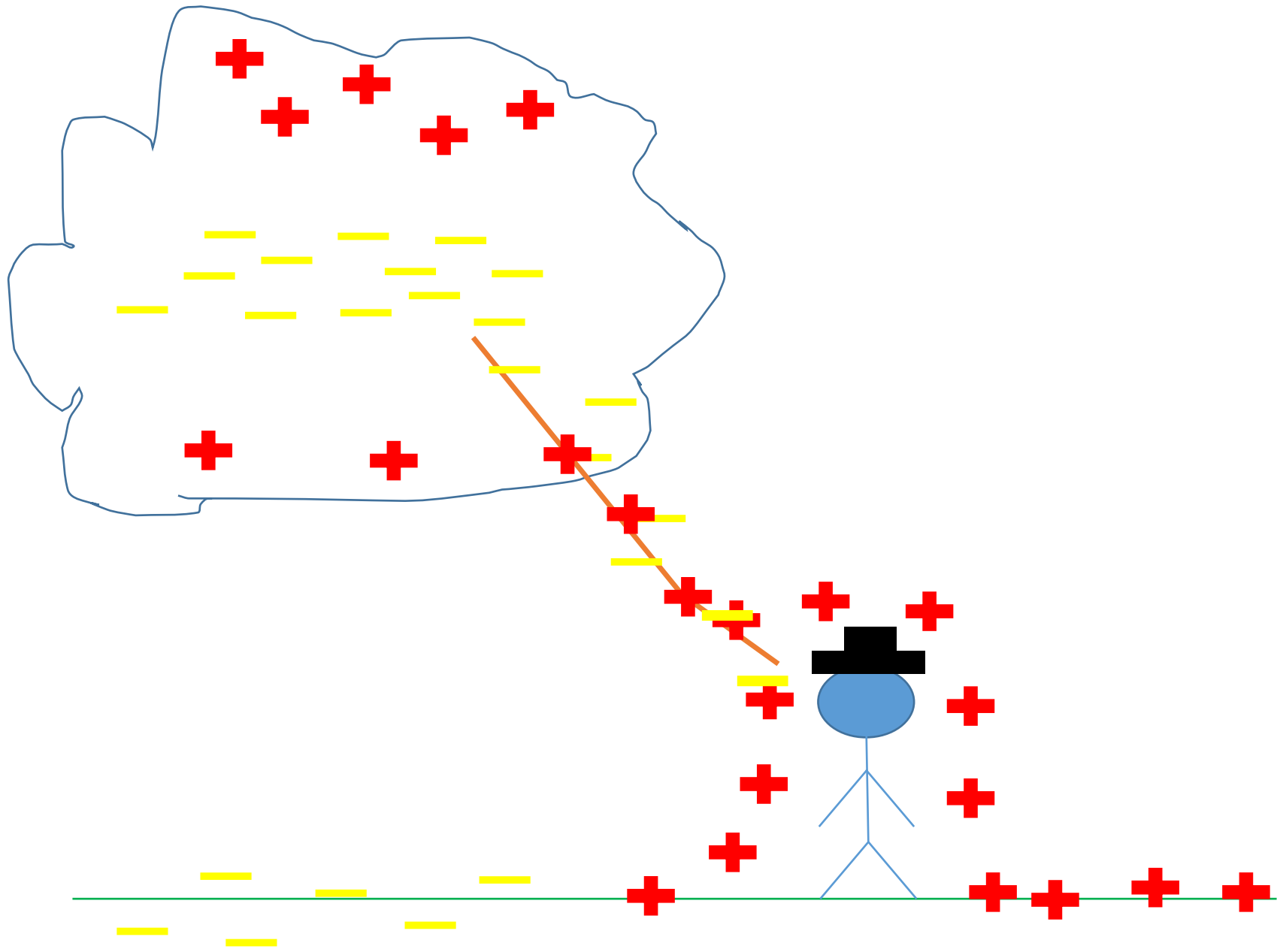


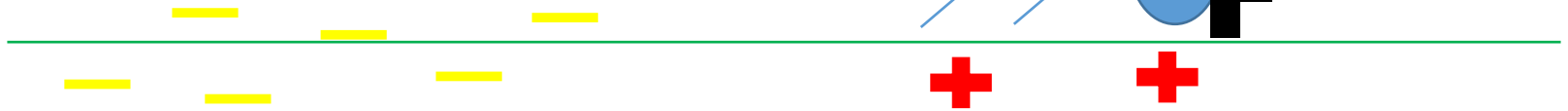
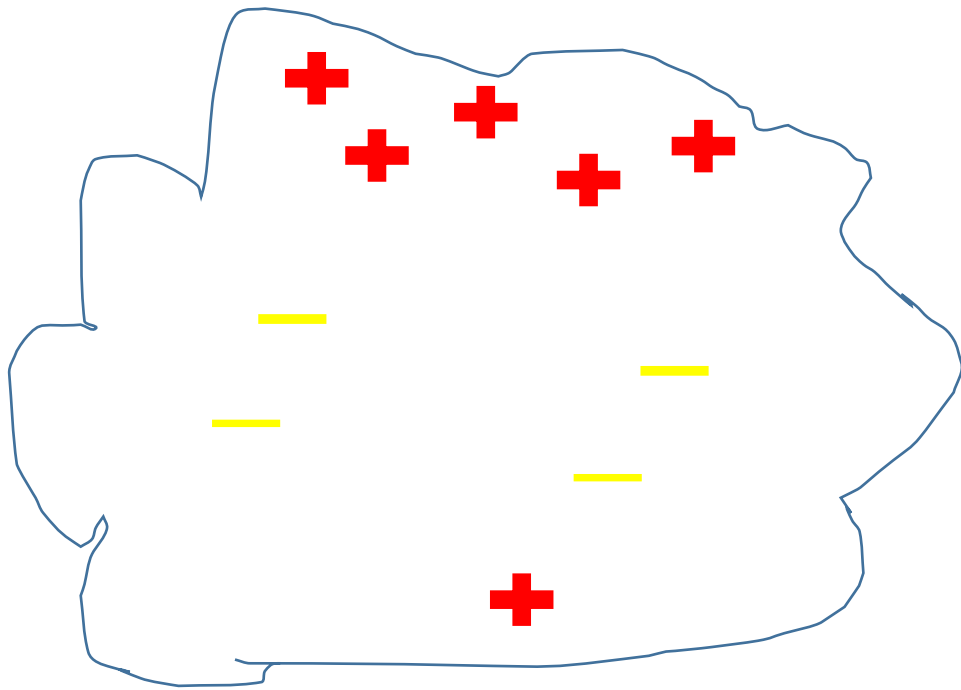




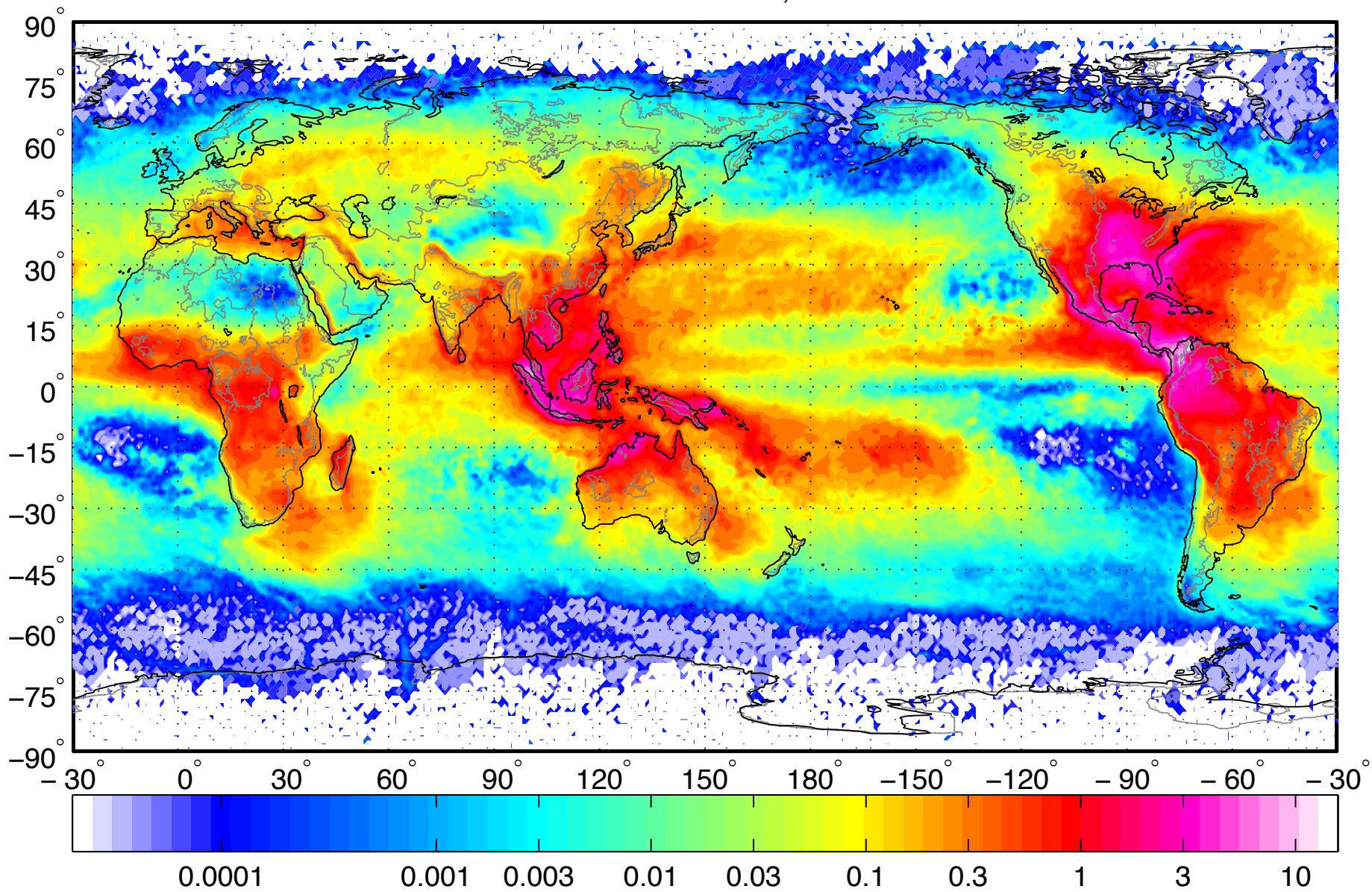






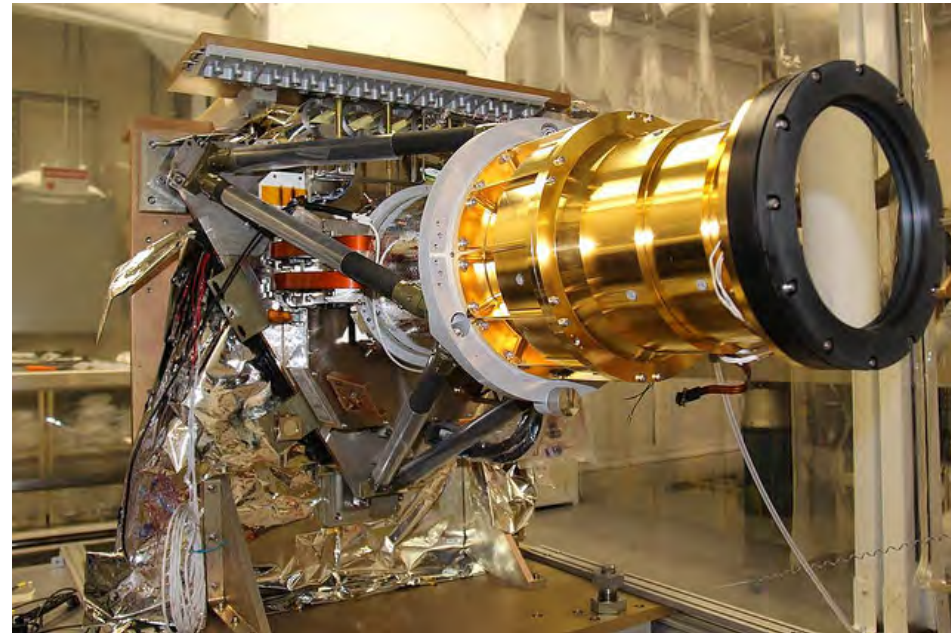
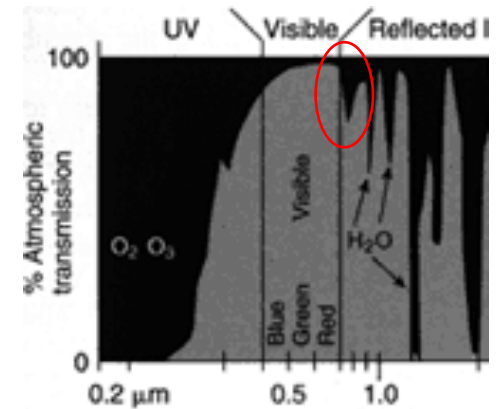


WWLLN annual mean, all hours



Geostationary Lightning Mapper on GOES-16, 17

- Similar to old Lightning Imaging Sensor (LIS) on TRMM
- One band at Near IR (777 nm): This is in an oxygen absorption/emission line, so lightning can be detected even in daylight.
- 8–14 km spatial resolution from geostationary orbit.
- 2 ms frame rate (500 fps)
- Coverage up to 52° latitude
- 20 second latency
- PRO: It has global coverage and can detect intra-cloud lightning effectively. About 90% detection rate of lightning.
- CON: Spatial resolution is low relative to ground-based networks.



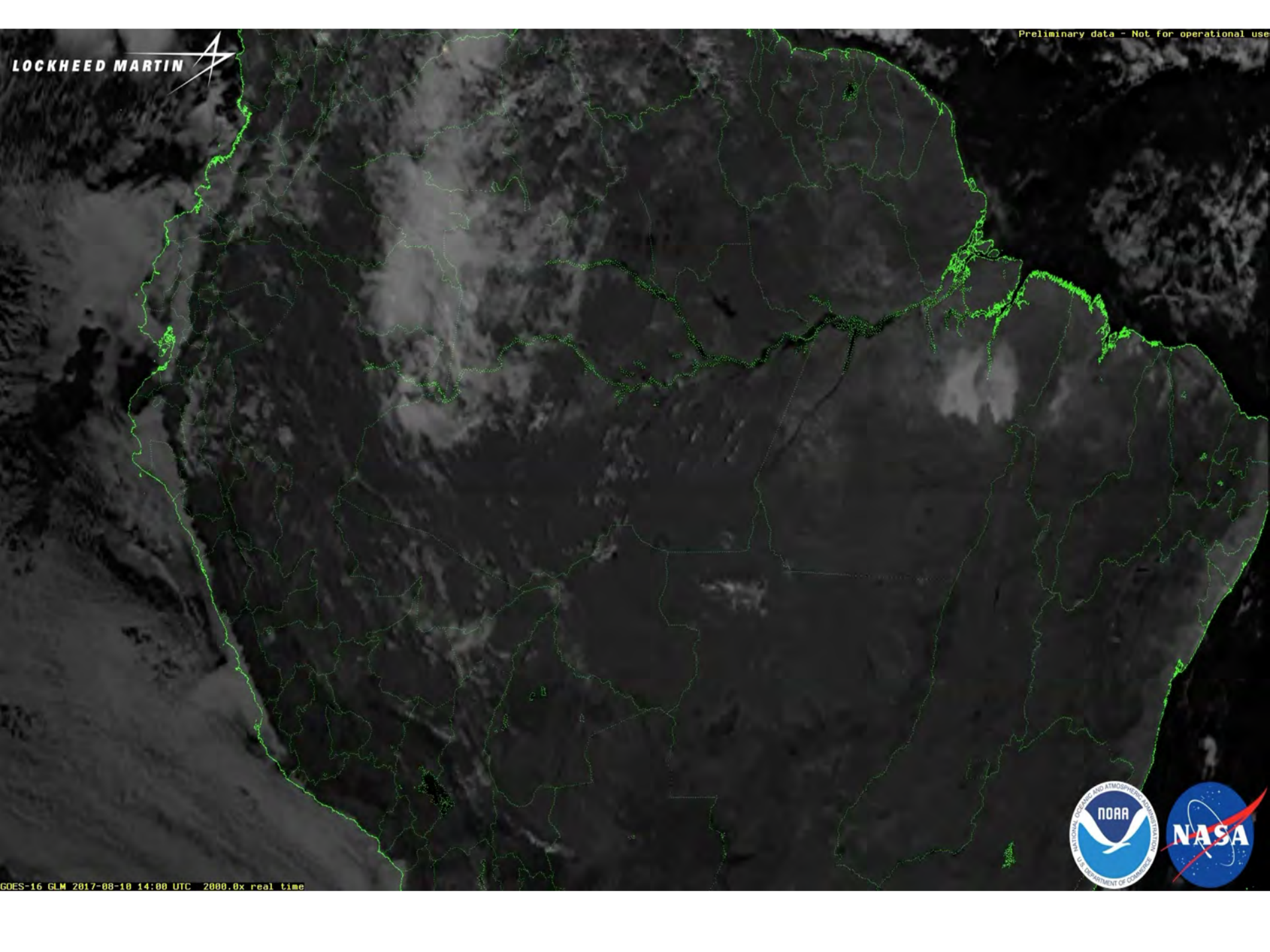
NOAA/NASA



59" tall

NOAA/NASA

LOCKHEED MARTIN



How is a flash detected from space?

Event: Single point exceeds background threshold within a 2 ms time frame.

Group: A spatially contiguous region of 2 or more events within the same 2 ms time frame.

Flash: Cluster of groups within 16.5 km and 330 ms of each other.

http://rammb.cira.colostate.edu/training/visit/quick_guides/GLM_Quick_Guide_Detection_Methods_June_2018.pdf

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Ground-based Lightning Detection

Main Topics

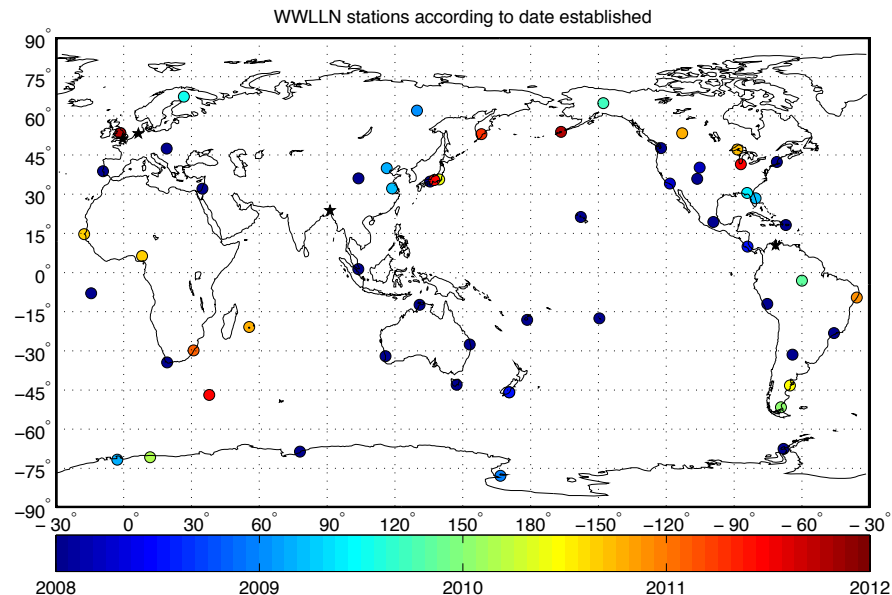
- VLF/VHF lightning detection
 - Time of arrival (TOA) technique
 - Direction finding (DF) technique
- Global and regional lightning networks

Ground-Based Lightning Detection

Networks generally operate in VLF or VHF. VLF is attenuated less so fewer sensors are required. However, VHF is more efficient at detecting pulses because the signal is usually stronger.

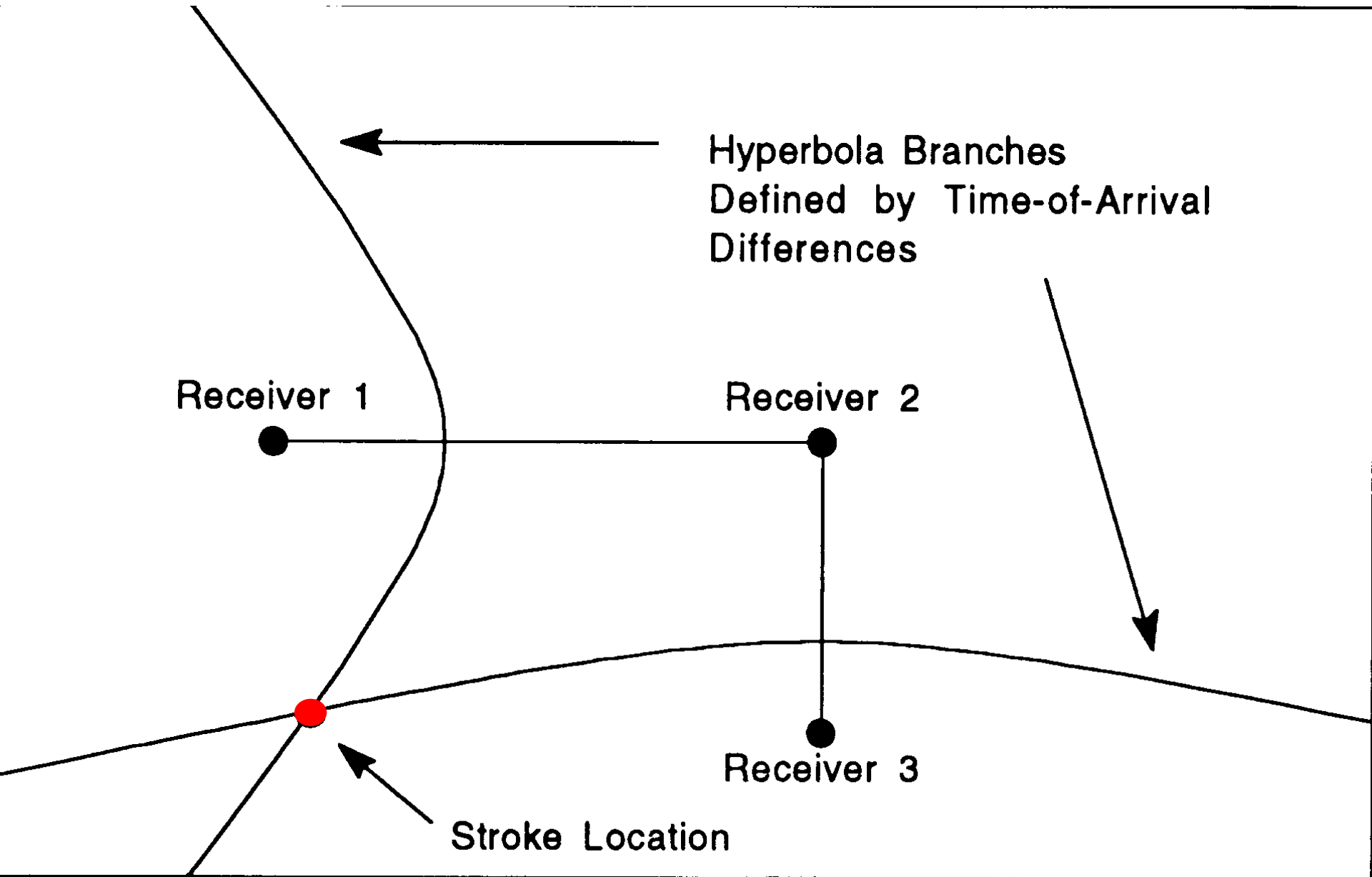
Two primary methods for detecting lightning for large networks:

- Time of arrival techniques (TOA)
- Direction-finding

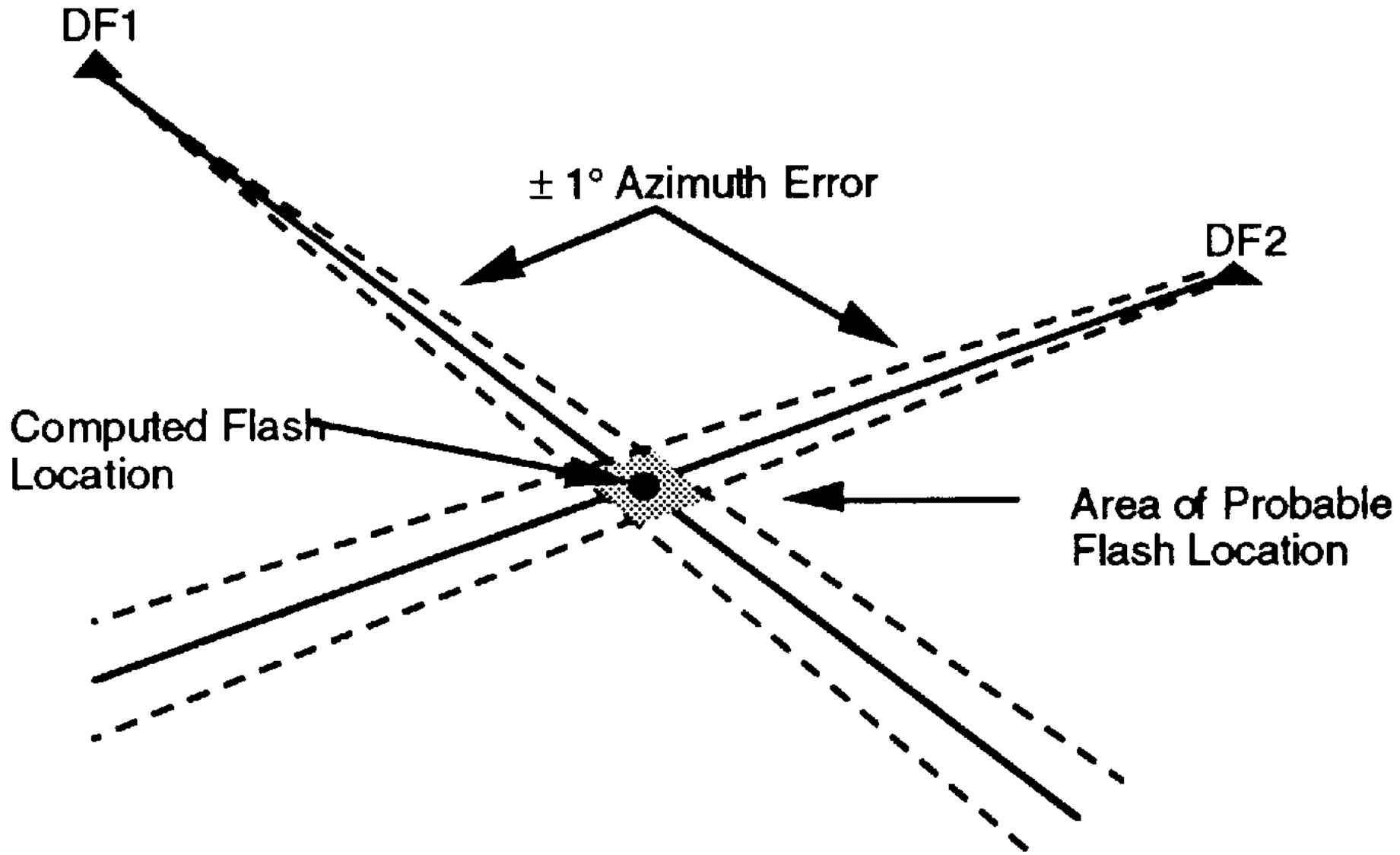


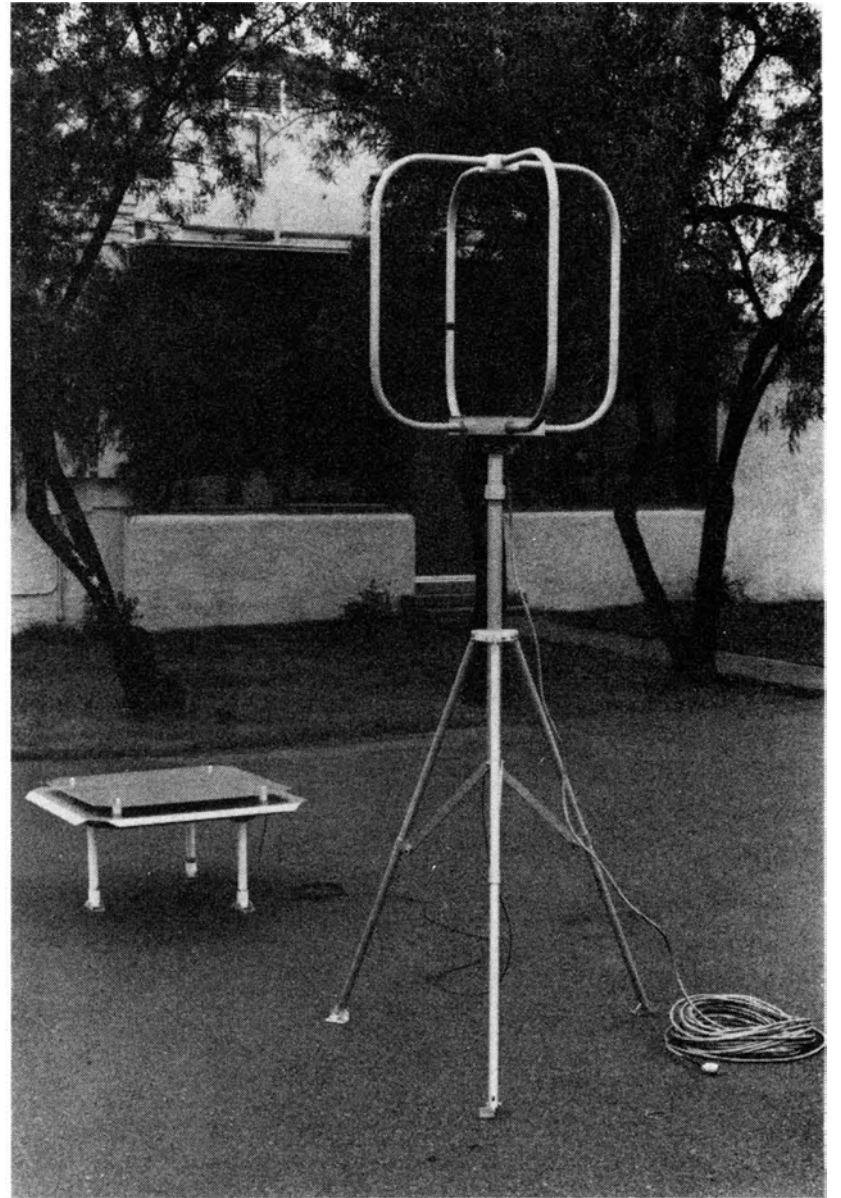
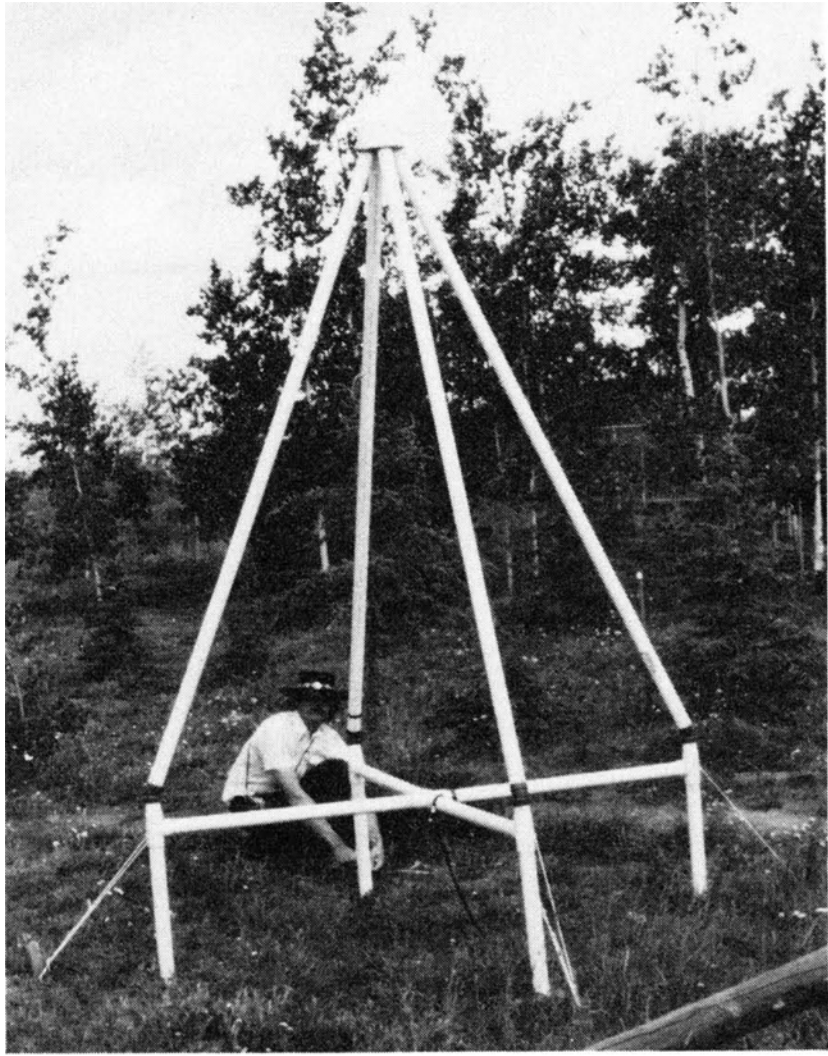
WWLLN stations

Time of arrival (TOA) technique



Direction Finding technique







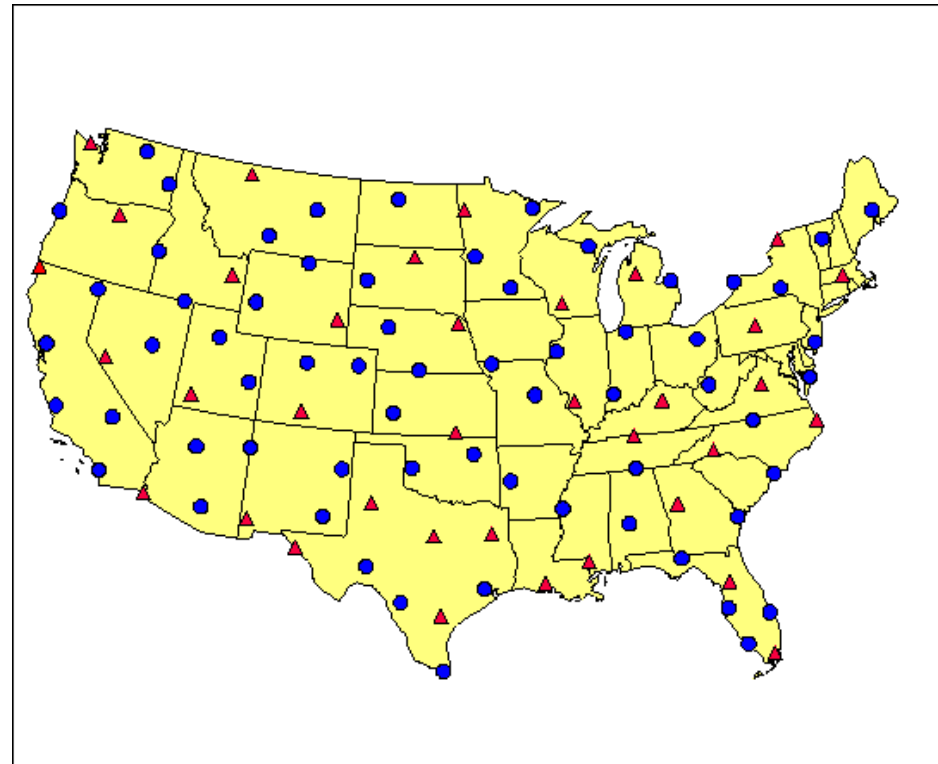
U.S. National Lightning Detection Network (NLDN)

- Private; owned by Vaisala
- 100 stations across U.S.
- Thunderstorm detection efficiency near 100%
- Cloud-to-Ground flash detection efficiency greater than 95%
- Cloud-to-Cloud flash detection efficiency of 50-60%
- Cloud-to-Ground vs. Cloud-to-Cloud classification accuracy of 85-90%
- Median location accuracy of <200m
- Sensor network uptimes over 99.9%
- Data center availability greater than 99.9%
- Event timing precision of 0.5 microsecond RMS
- Accurate peak current measurements with a median error of better than 15%

Efficient over land, but not very useful over open, isolated ocean!

Red = IMPACT (DF sensors)

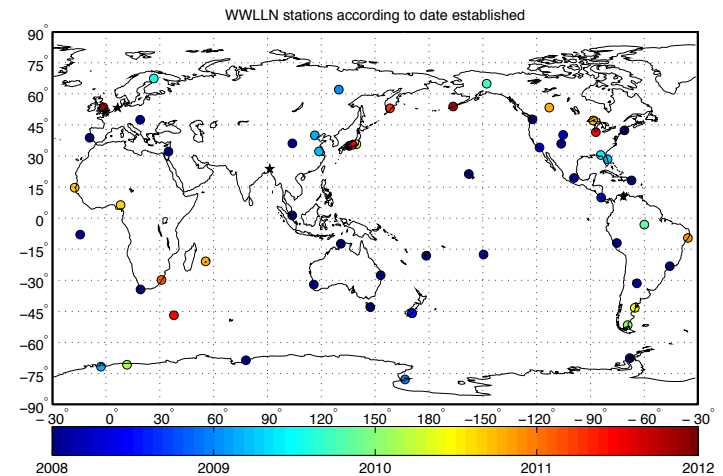
Blue = TOA sensors



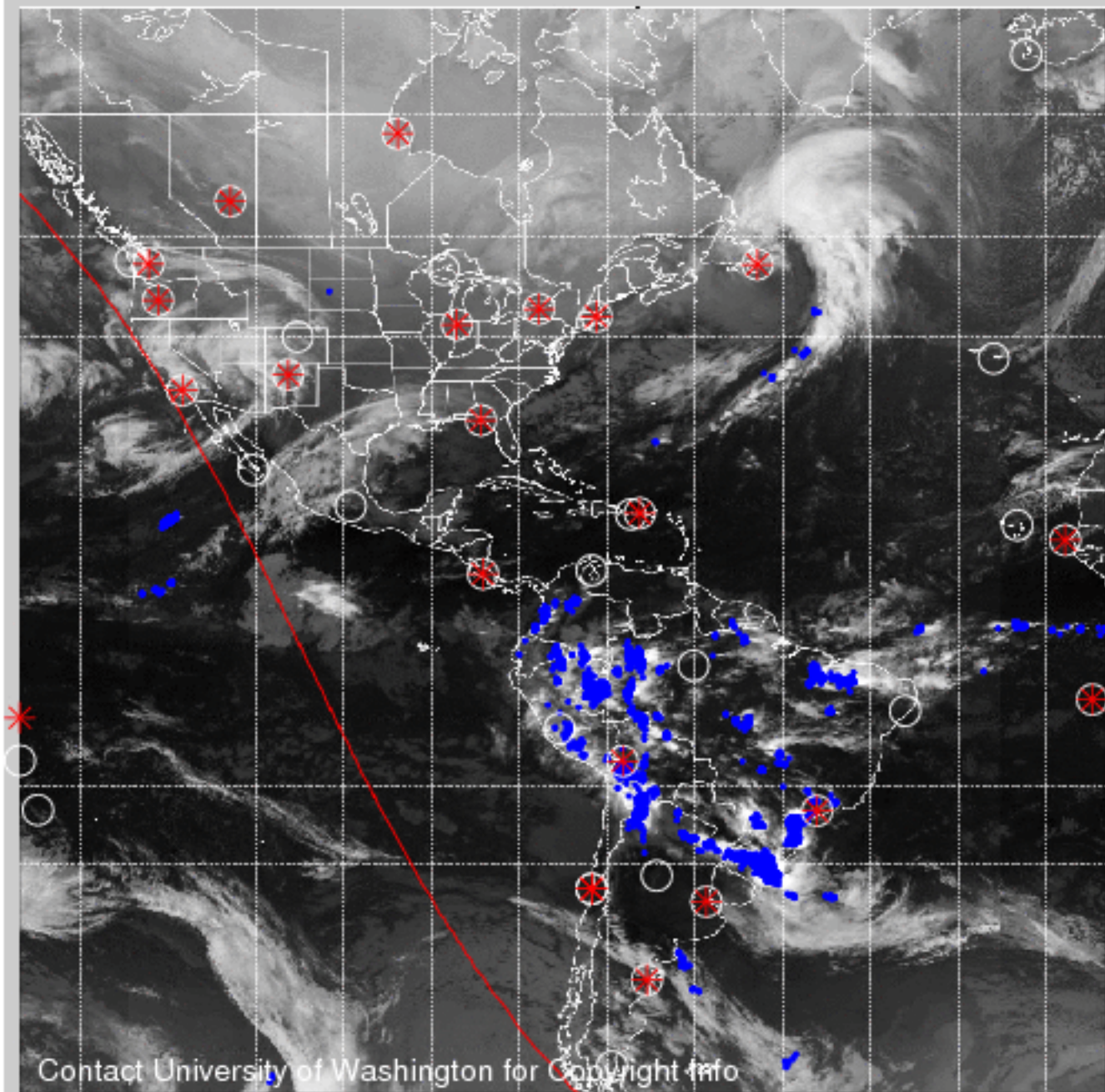
Global Networks

World Wide Lightning Location Network (WWLLN)

- Surface based detection network works in VLF: 3–30 kHz based on TOA technique
- Less attenuation at this wavelength, so signal propagates farther; therefore, fewer sensors needed for global coverage
- Can detect lightning from over 1000 km away, but detection efficiency is still only 20–30%.
- Cloud-Cloud (intracloud) lightning difficult to detect with any ground-based network. CG preferentially seen where stations are sparsely located.



Lightning (blue dots) on 16/01/2019, 60min prior to 01:20:00 UT



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Global Networks

Earth Networks Total Lightning Network (ENTLN)

- Surface based detection network works in VHF: 1Hz–12MHz; Higher frequency allows for improved detection of cloud flashes.
- Flashes with return stroke are CG; without a return stroke are considered CC.
- Also uses TOA detection
- Requires about 5 sensors
- Network of 700 sensors (more sensors needed to get global coverage at VHF frequency), but most are in U.S.
- Still has about 60% detection efficiency globally.

Some interesting very high resolution videos of lightning detected via interferometry here:
<http://lightning-interferometry.com/index.php/videos/>