Why do we detect and locate lightning?

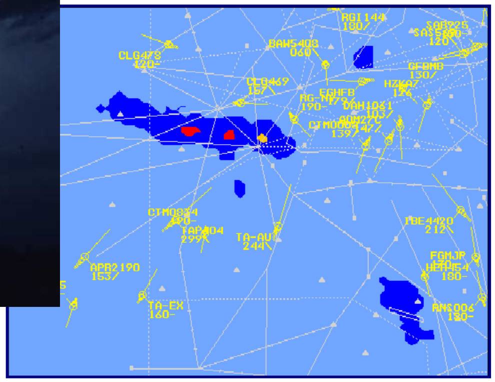
- **Lightning itself poses a electromagnetic threat to all things**
  - **Direct effects of lightning currents**
  - **Indirect effects through electromagnetic coupling**

- **The conditions that produce lightning also produce precipitation (rain and hail) and high surface winds**
  - **significant moisture must be moved to -10º to -30ºC (~4-12 km) altitudes with > 5 m/s updraft velocity (10 mi/hr) to create charge separation**
    - **“what goes up must come down” => momentum!**
    - **Lightning generally accompanies severe weather during the convective season**
    - **(animation)**
  - **Provides “surrogate” observation with good space:time continuity when other observations are not available**

- **Basic Research (physics, radio propagation, EMC engineering)**

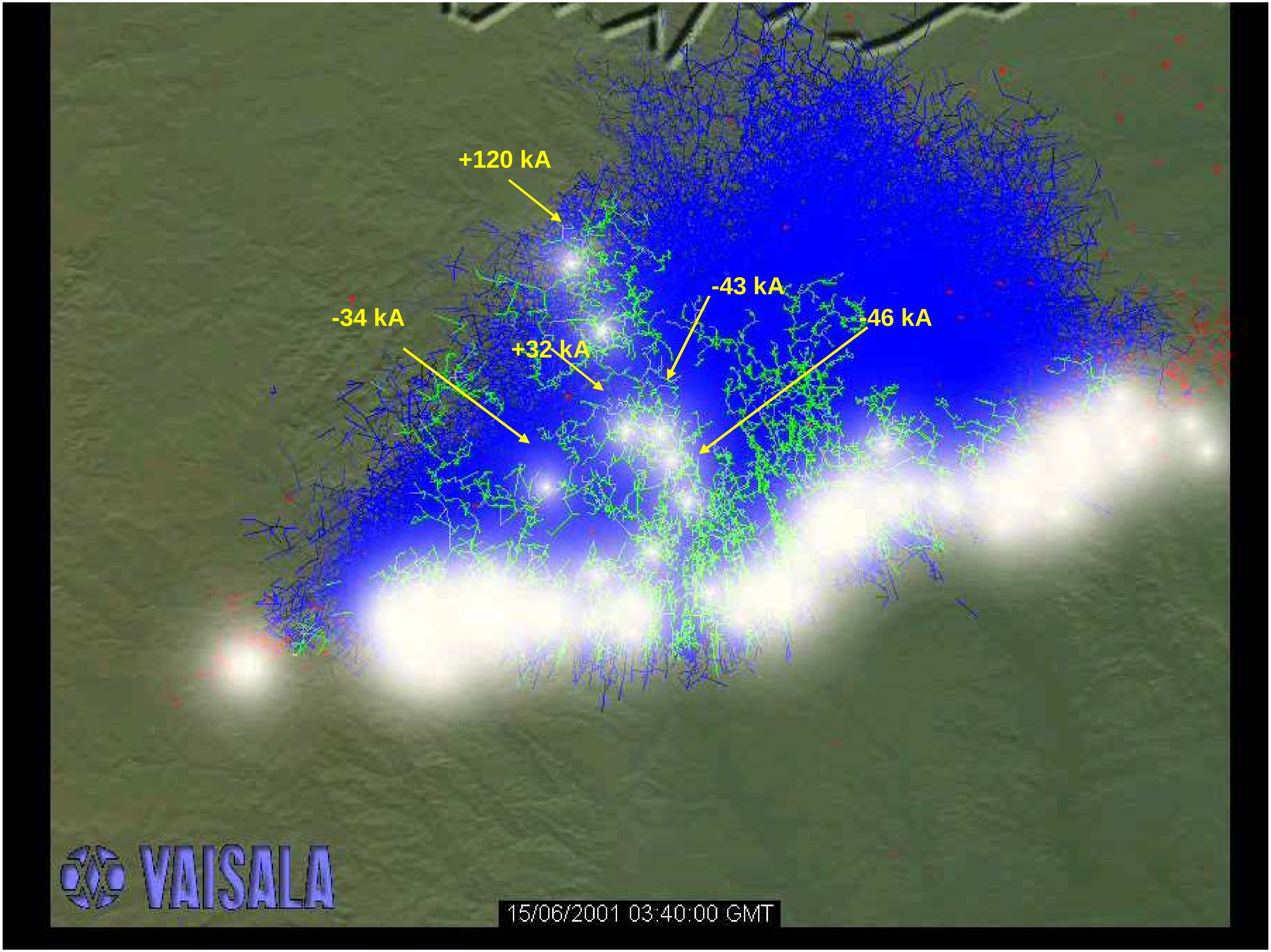
APPLICATIONS / USERS

- General Meteorology
- Aviation
- Defense
- Launch Facilities
- Electric power utilities
- Telecommunications
- Mission critical operations
- Recreation/Golf
- Forestry
- Insurance
- Rresearch



Meteorological & Hydrological Applications

- **Nowcasting**
  - **Most real-time data set, available in tens of seconds from actual event (LDAR data in real time)**
  - **Anticipate thunderstorm phase progression from cumulus to dissipation**
- **Hydrological Applications**
  - **Precipitation estimates by monitoring lightning rates and polarity (+/-) shifts**
  - **Early flood hazard identification**
  - **Mountain flash flood warning due to uniform coverage of LF systems in mountainous terrain where VHF-based LLS and radar technology performance is severely degraded**
- **Forecasting**
  - **Overlay lightning data with Radar and Satellite Imagery for identification of convective thunderstorm activity**
  - **Uniformly track and monitor thunderstorm activity over large geographic regions that cannot be affordably nor effectively covered by VHF-based LLS or radar technology**
- **Public Service Hazard Broadcasts**
  - **Lightning Safety Warning**
  - **Potential Wind shear, Microburst, Gust Fronts, Hail, & Tornado information in lightning data**
  - **Flood and Flash Flood Warnings**


+120 kA
-43 kA
-34 kA
-46 kA
+32 kA
VAISALA
15/06/2001 03:40:00 GMT

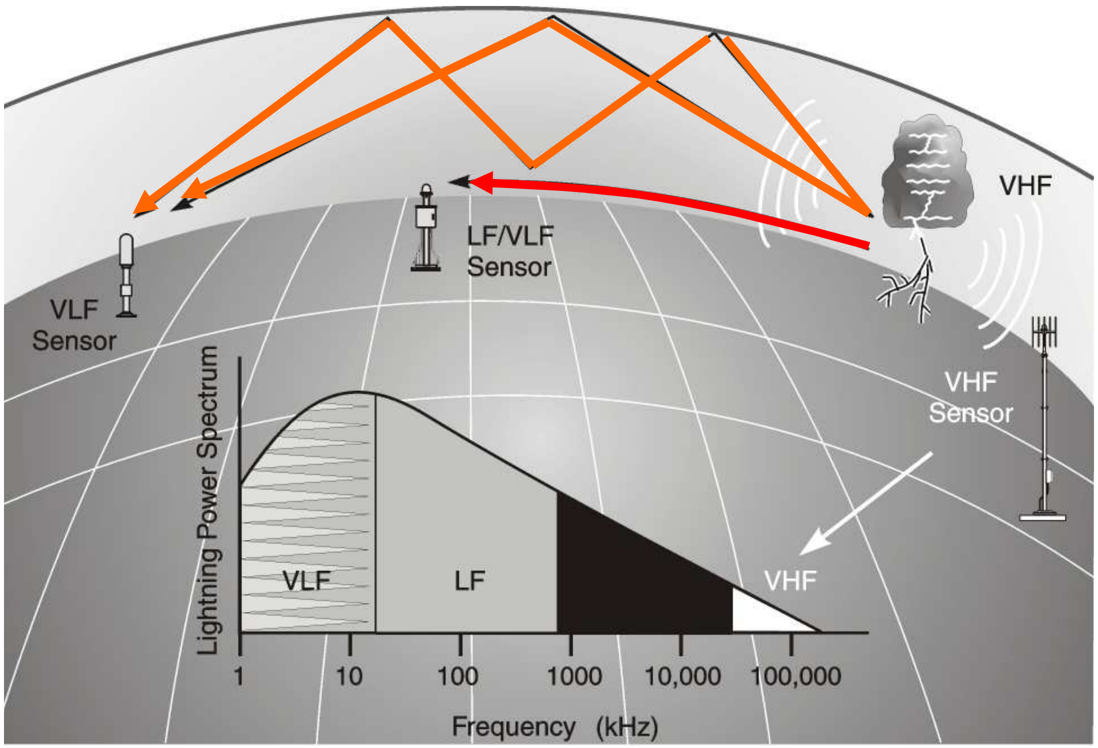
Lightning Detection and Location at VLF/LF and VHF frequencies

Ken Cummins

AE/ECE 489/589

April 2009

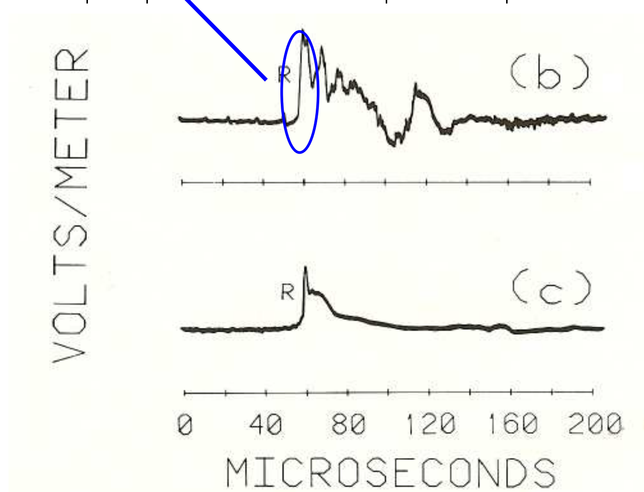
Lightning Electromagnetic Propagation



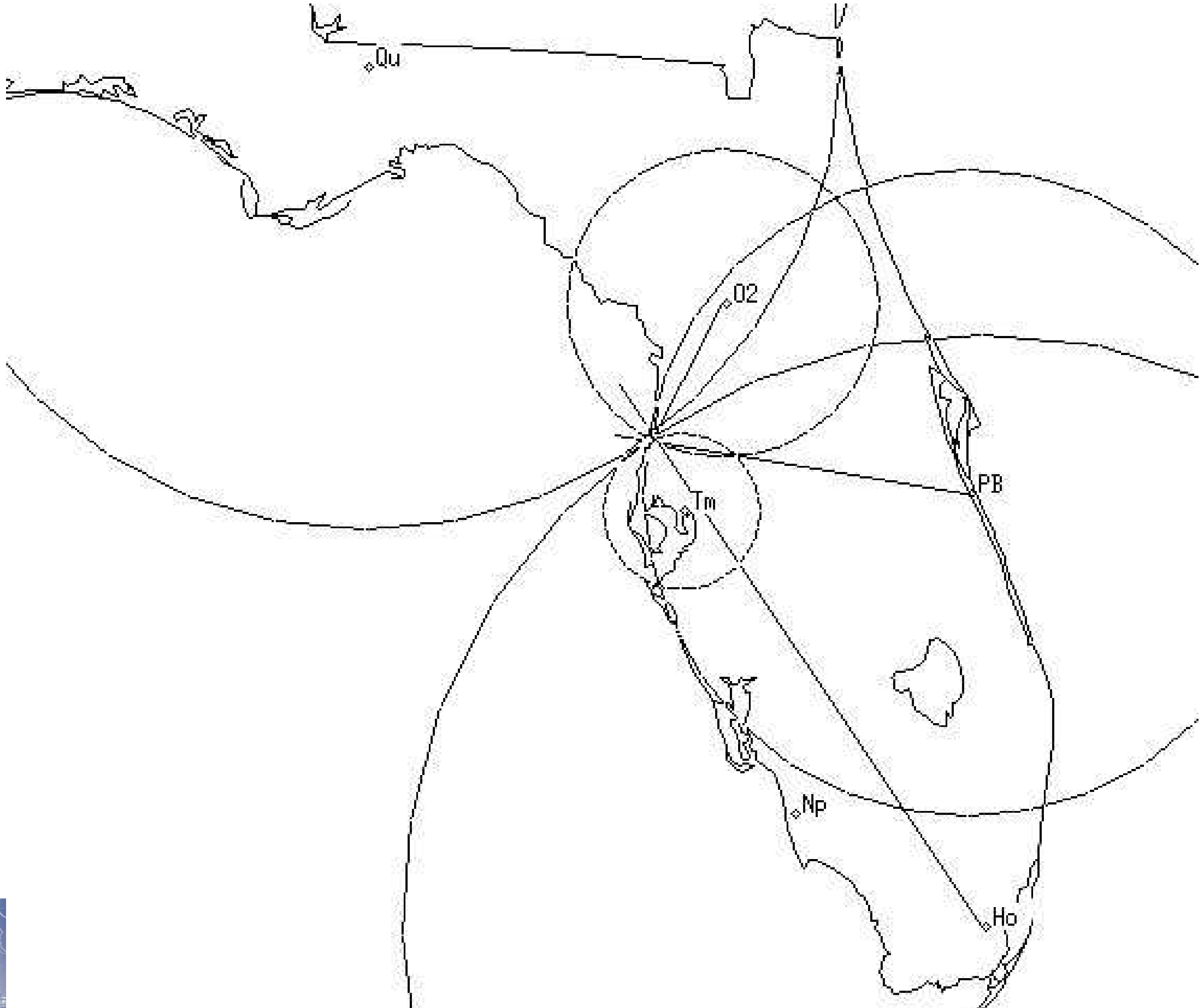
NLDN sensors are broadband: The "normal" CG lightning data set is produced by detecting ground wave signals (red path). In addition, the sensors also respond to ionospherically-propagated electromagnetic signals coming from long distances (orange path) that have the LF components filtered out by the propagation.

Rise-time determined by the highest frequencies emitted near ground level

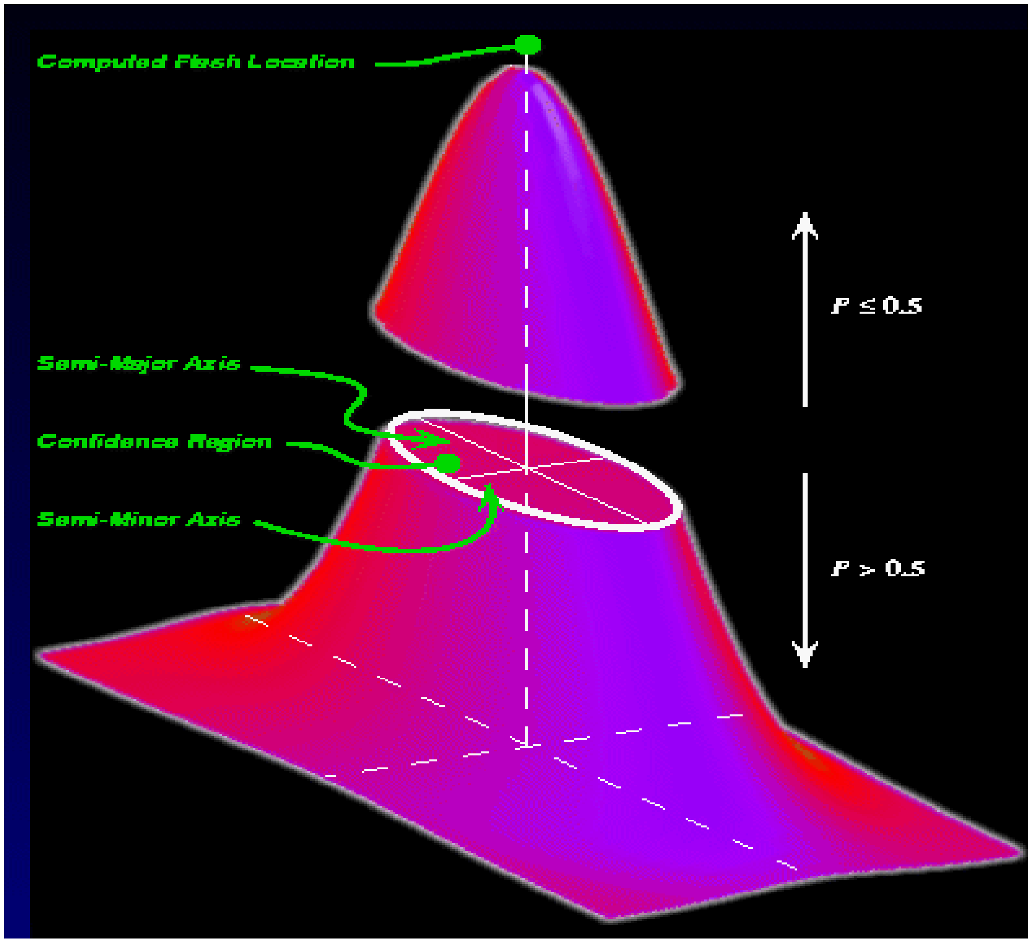
2	3	4 – 6	7 - 13	14
17 – 33 ms	...	50 – 83.5 ms	…	216 – 233 ms



Location algorithm combining angle and time information

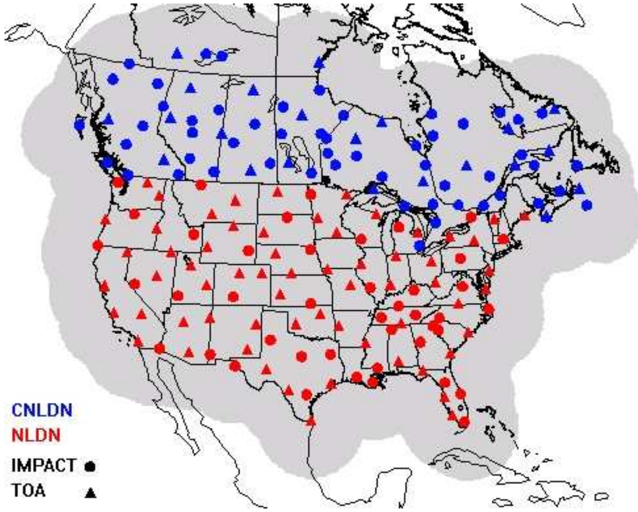


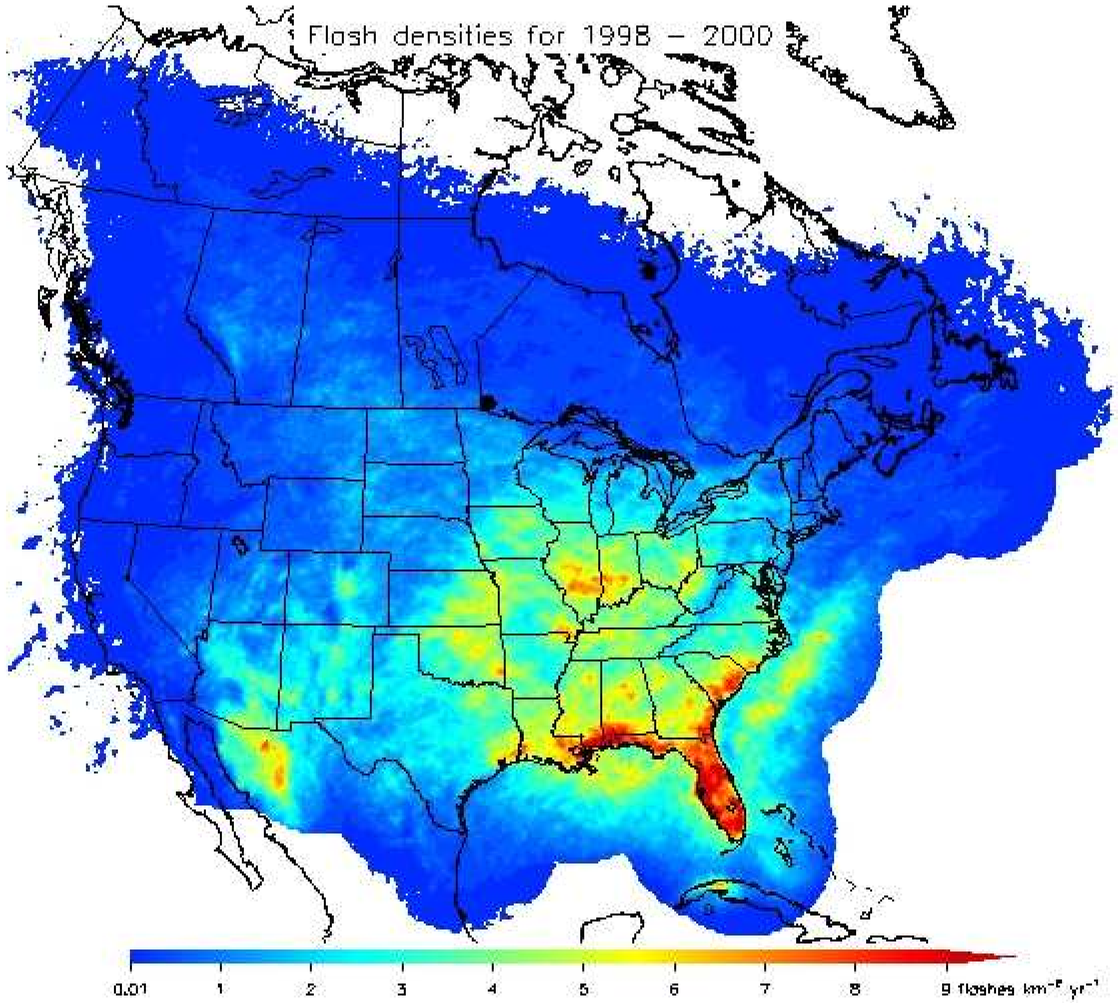
Position probability distribution: Location accuracy



When measurement errors are purely random, the error in the location is described by a 2-D Gaussian with the optimized position at the peak. The location accuracy is defined as the semi-major axis of the elliptical region formed by cutting the probability distribution at the 50% level.

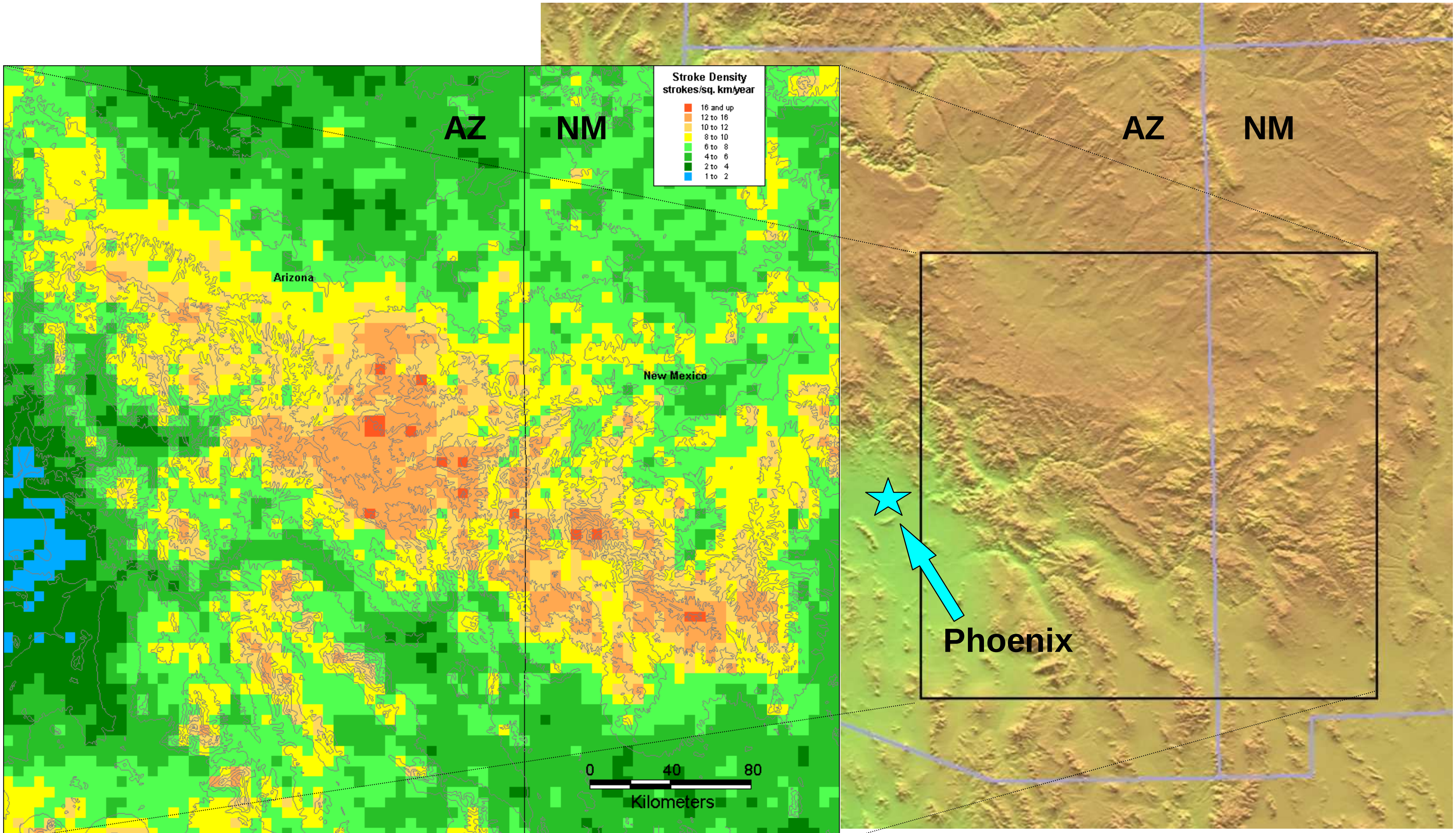
North American Lightning Climatology - GFD





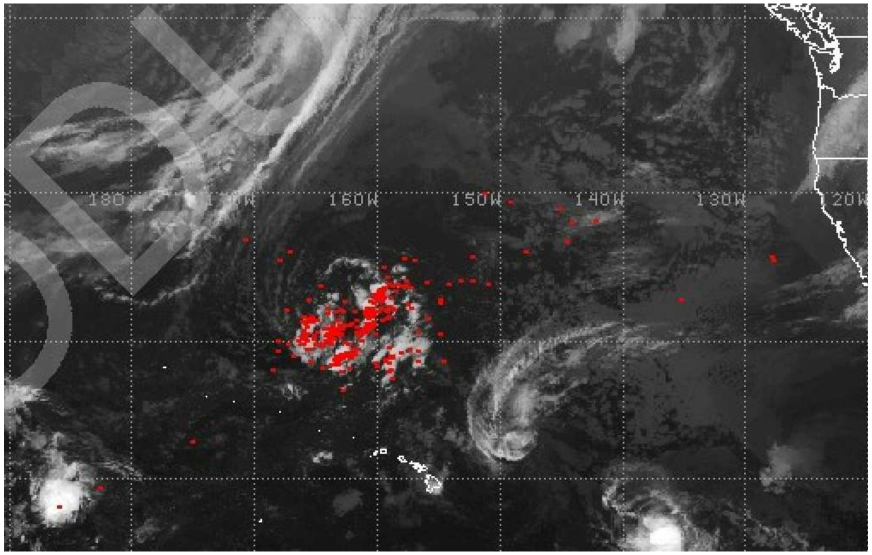
University

Location accuracy resolves terrain dependence of lightning activity

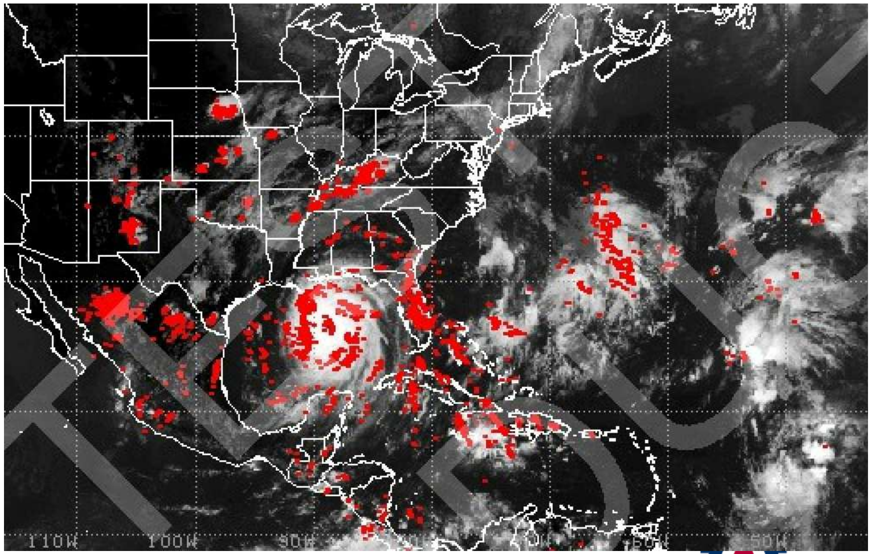


University of Arizona Institute of Atmospheric Physics

Long-range Lightning Samples

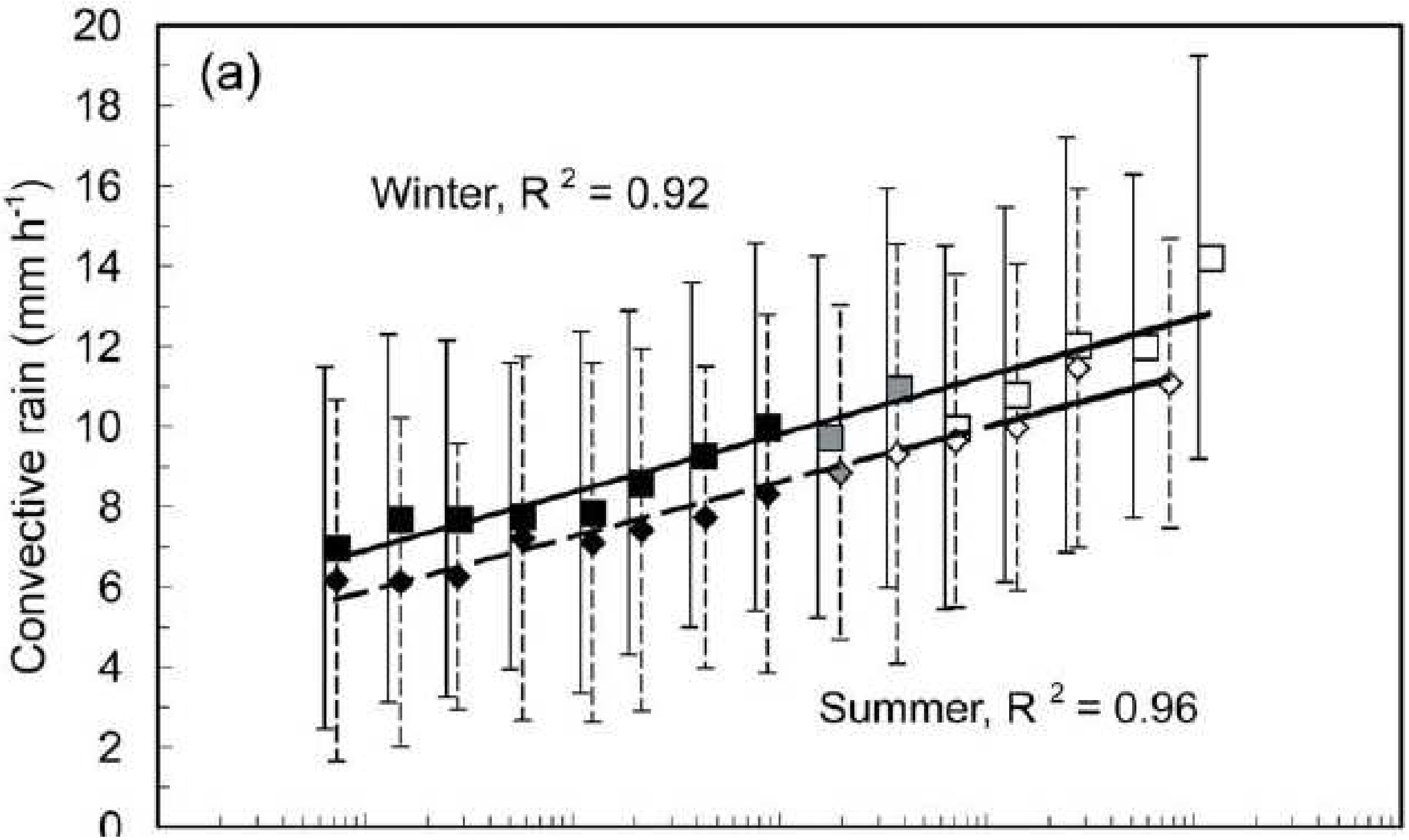


Long-range lightning data overlaid on IR satellite image on Sept. 23, 2005. Convection was associated with a storm system north of Hawaii.



Long-range lightning overlaid with IR satellite image showing lightning in outer rainbands and eyewall of Hurricane Katrina on August 28, 2005.

Convective Precipitation Estimation
Pessi and Businger 2009



CG Lightning as a signal source to study the near-surface electrical conductivity of the earth