North Georgia Lightning Mapping Array: July 21, 2016 Damaging Winds Case Study

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NGLMA SUMMARY

North Georgia Lightning Mapping Array

- Network of 12 sensors (Figs. 1,2) that measure VHF radiation emitted from lightning
- Measures total lightning, the combination of cloud-to-ground (CG) and intracloud (IC) lightning
- Looking for trends in data that indicate severe weather will occur to provide earlier warnings
- Data streaming in real-time to National Weather Service Office in Peachtree City, GA
- Web site available for EM and academic partners: http://nglma.gtri.gatech.edu

Objective

- Provide total lightning data to decision-makers to increase situational understanding
- Increase warning lead time for severe weather events, especially in marginal or complicated cases
- Increase NWS forecaster confidence when issuing warnings

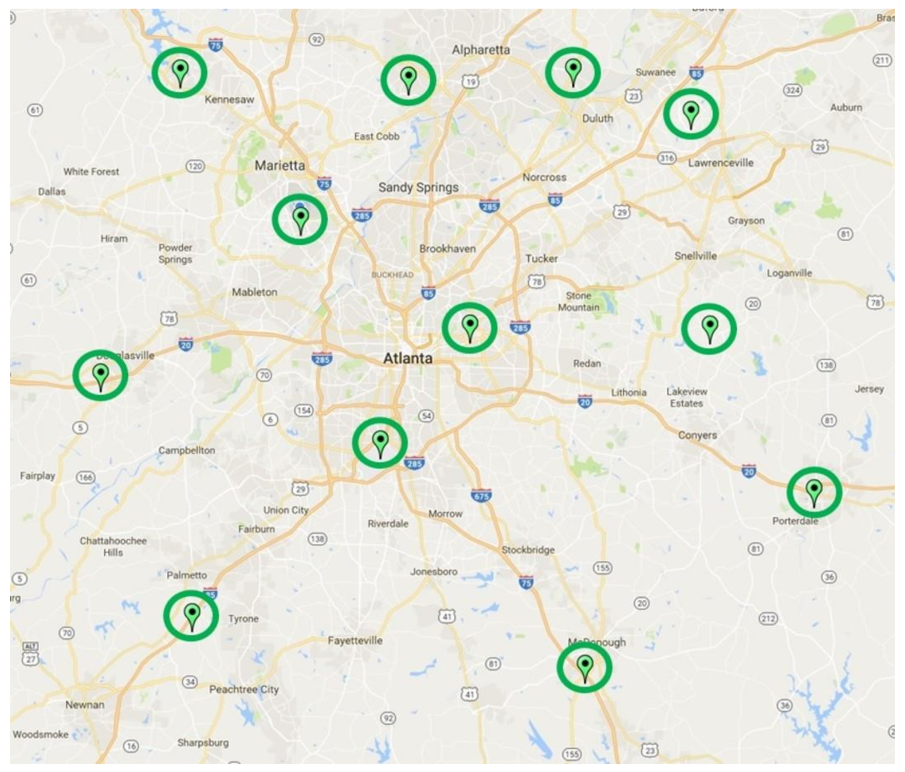

Figure 1: Current NGLMA locations.

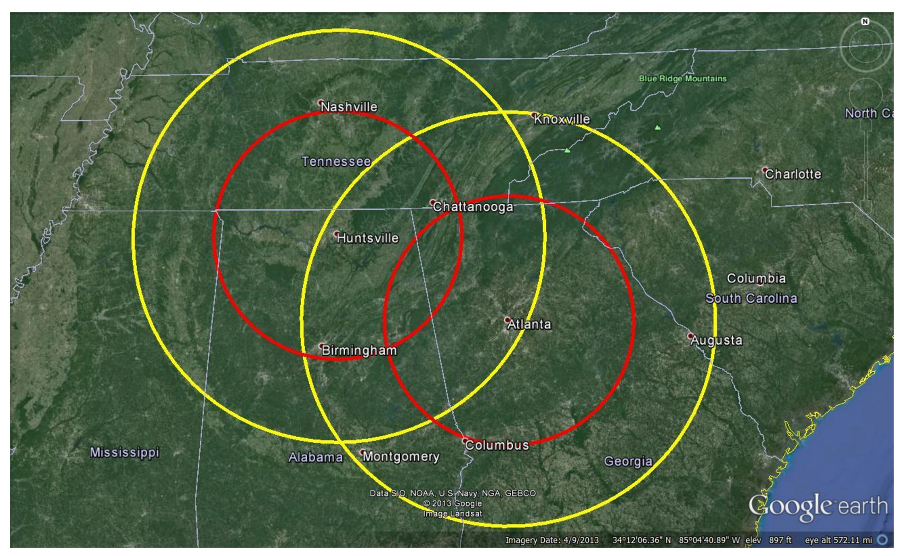

Figure 2: Range rings for 3D (red, 95 miles) and 2D (yellow, 155 miles) coverage of the NGLMA and North Alabama LMA.

WHAT IS TOTAL LIGHTNING & WHY IS IT USEFUL?

What is Total Lightning?

- Total lightning is the combination of CG and IC lightning
- NGLMA observes lightning "sources", short sections of the lightning flash path (Fig. 3)
- Majority of all lightning is IC flashes, not CG (Fig. 4)
- Total lightning detection complements radar and CG detection systems,

Why is Total Lightning Useful?

- Observes IC flashes that other CG detection networks cannot
- IC lightning often precedes the first CG strike by several minutes
- Rapid increase in total lightning indicates a storm likely to produce severe weather in 5-15 minutes.
- Can give a forecaster confidence to issue an early warning.
- Updates every minute vs. radar update time of 5 minutes

Figure 3: Single point detection from CG network (top) versus NGLMA detection of lightning sources (bottom).
(image courtesy NASA SPoRT).

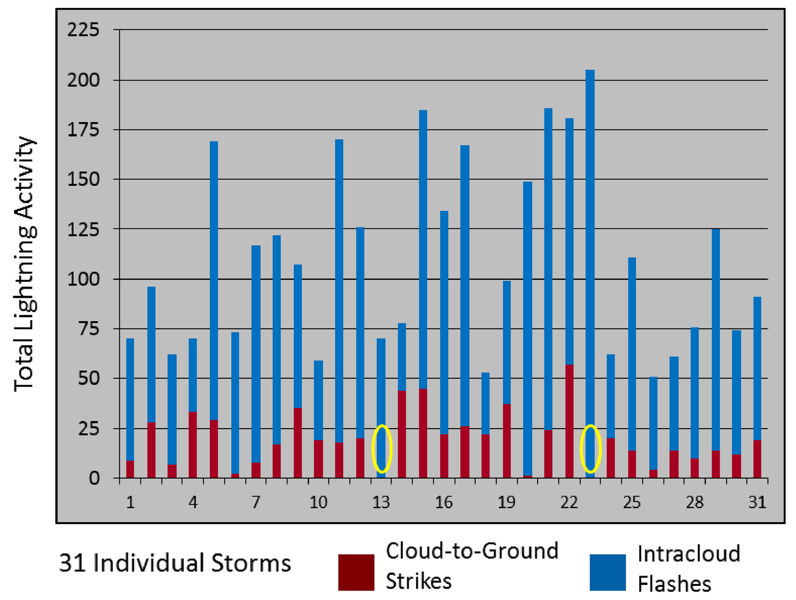

Figure 4: Frequency of CG (red) and IC flashes (blue) in 31 storms.
(image courtesy NASA SPoRT).

NORTH GEORGIA LIGHTNING MAPPING ARRAY

NGLMA Setup

- System designed by New Mexico Tech, assembled, installed and operated by GTRI
- Detects total lightning by measuring VHF in unused channel 6 TV band (82-88 MHz) at each sensor location
- Uses GPS to determine precise time of arrival of VHF at each sensor
- The processing computer receives data from sensors and calculates source locations
- VHF Antenna and GPS mounted on roof (Fig. 5, bottom) and connected to shielded box that houses a PC104 computer (Fig. 5, top) and FPGA-based analyzer.
- Data is sent back to processing computer at GTRI, analyzed and then posted to the public website
- Updates every minute

Figure 5: LMA sensor box and a typical antenna installation

EPISODE OVERVIEW

- Slow moving airmass thunderstorms developed over the Atlanta area on the afternoon of July 21, 2016, a number of which reached severe levels.
- NWS Peachtree City issued a severe thunderstorm warning at 2028 UTC for a cell near Alpharetta.
- A second cell developed just south of the warned storm. This second cell produced damaging winds, resulting in a LSR at 2040 UTC.

ANALYSIS METHOD

- Archived NEXRAD Level III data was used to track the center of the cell from formation at 2023 UTC, through the LSR at 2040 UTC, until 2045 UTC.
- A 0.1° x 0.1° analysis box was drawn around the storm center to encompass the storm and determine the area in which lightning should be used for analysis.. (Fig. 6)
- At each new radar scan, the storm center was used to produce a new analysis box.
- XLMA software (Fig. 7) was used to determine the number of flashes occurring within the analysis box for each minute between 2023 and 2045 UTC
- The one minute flash rates were combined to produce two second average flash rates in order to use a 2σ lightning jump algorithm (LJA). (Schultz, et al. 2011)

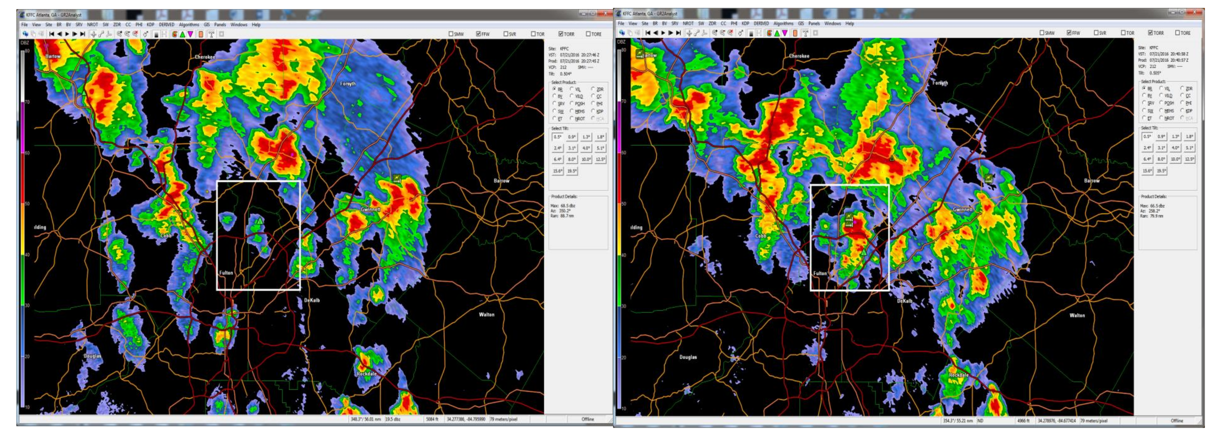

Figure 6: NEXRAD images with analysis boxes at 2023 and 2040 UTC

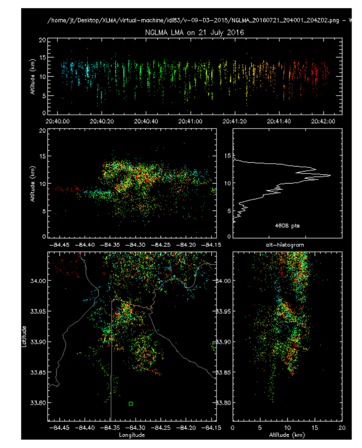

Figure 7: XLMA data at 2040 UTC

RESULTS

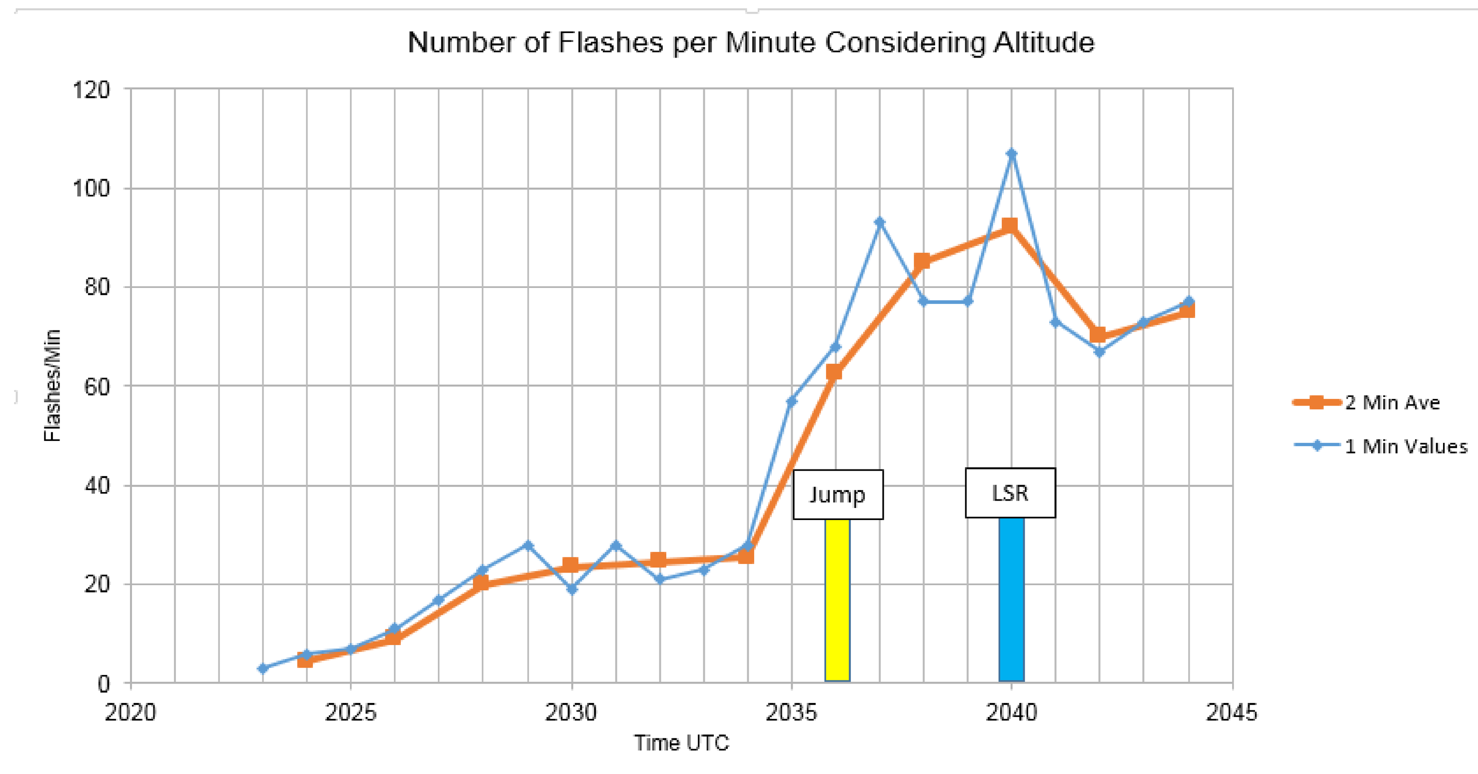

Figure 8: Flashes detected within the analysis area between 2023 and 2045 UTC with the LJA detected jump and LSR times

- Using both subjective visual analysis and the objective LJA, a lightning jump can be seen starting about 2034 UTC. Flashes/min increased from 28 at 2034 UTC to 93 at 2037 UTC.
- Two minute average flashes/min (used in the LJA) increased from 25.5 at 2034 UTC to 62.5 at 2036 UTC, when the LJA detected the jump.
- The lightning jump may have been helpful to NWS warning operators to confirm a warning was warranted, but it did not occur early enough to contribute to the warning decision
- The peak in the flash rate coincided with the wind event, rather than preceding it as seen in earlier studies. (Goodman, et al. 1998, 2005)
  - Goodman et al. had indicated that
  - Peak in total lightning may precede microburst by several minutes
  - An abrupt decrease in total flash rate occurred 3-5 minutes before maximum winds at surface. This was attributed to the collapse of the storm.

- Goodman, S., R. Blakeslee, H. Christian, W. Koshak, J. Bailey, J. Hall, and P. Gatlin (2005). The North Alabama Lightning Mapping Array: Recent severe storm observations and future prospects. Atmospheric Research, 76(1-4), 423-437.
- Goodman, S. J., D.E. Buechler, P.D. Wright, and W.D. Rust (1988). Lightning and precipitation history of a microburst-producing storm. Geophys. Res. Lett. Geophysical Research Letters, 15(11), 1185-1188.
- Schultz, C., W. Petersen, and L. Carey (2011). Lightning and Severe Weather: A Comparison between Total and Cloud-to-Ground Lightning Trends. Wea. Forecasting, 26, 744–755.