

# Characteristics of Lightning within Electrified Snowfall Events using Total Lightning Measurements

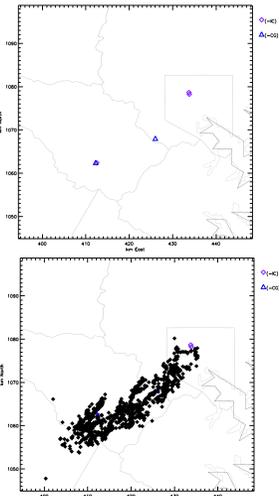
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## Motivation

Previous electrified snowfall studies (also known as “thundersnow”) have primarily used cloud to ground detection networks to understand the lightning component within these events [e.g., Schultz, 1999, Market and Becker, 2009, top right].

Very few studies have examined the spatial structure of these flashes or the correspondence between lightning measured by lightning mapping arrays (LMAs) and cloud to ground networks like the National Lightning Detection Network (NLDN) in order to understand the conditions in which these flashes develop [e.g., Schultz et al., 2011 (bottom right), AGU, Kumjian and Deierling 2015, MWR].



Above: A flash from an electrified snowfall event near Baltimore MD on 6 February 2010 from the perspective of the NLDN (top) and the Washington D.C. LMA (bottom).

## Goals

- To understand the spatial and temporal structure of lightning flashes and precipitation features in which these flashes develop.

- Intercompare traditional lightning measurements of thundersnow from the national lightning detection network with total lightning observations from lightning mapping arrays as a precursor to future measurements from the Geostationary Lightning Mapper (GLM).

## Data

Total Lightning Mapping Arrays

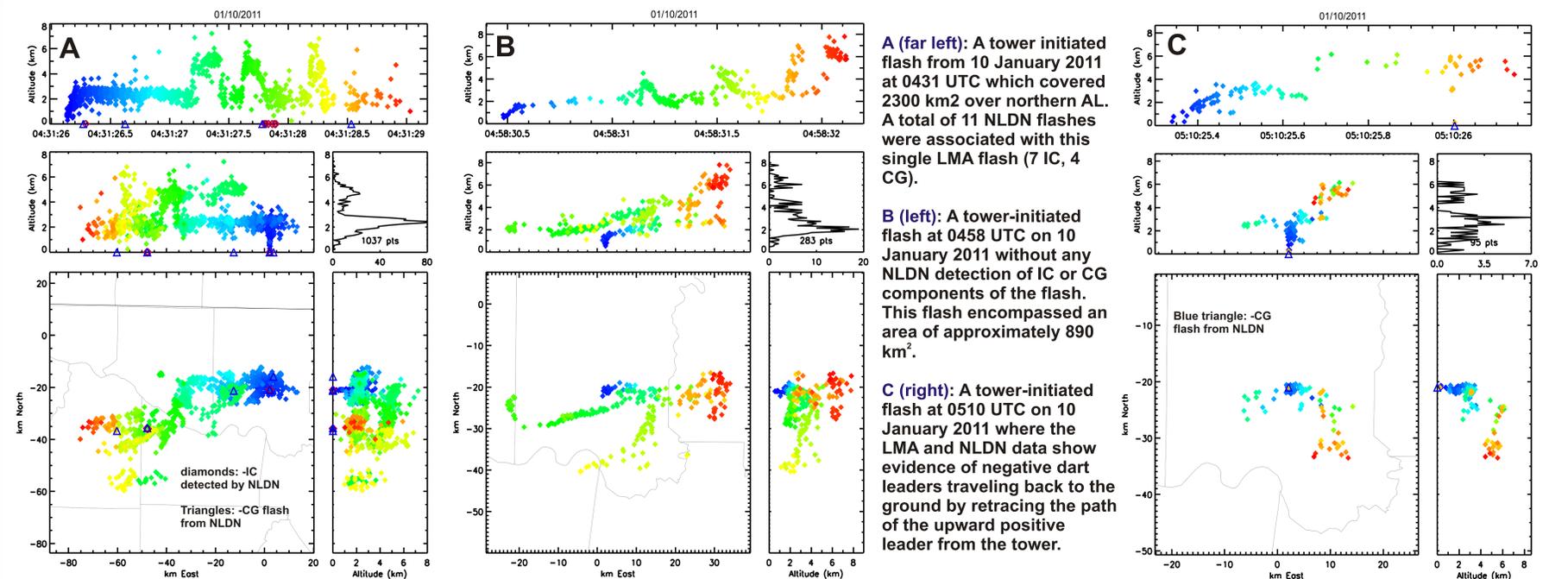
- Washington D.C.
- North Alabama
- Central Oklahoma

National Lightning Detection Network

## Events

- 24 December 2009 - Norman, OK (3 flashes)
- 6 February 2010 - Baltimore, MD (1 flash)
- 10 January 2011 - Huntsville, AL (6 flashes)
- 26-27 January 2011 - Washington D.C. (24 flashes)

A total of 34 flashes were examined

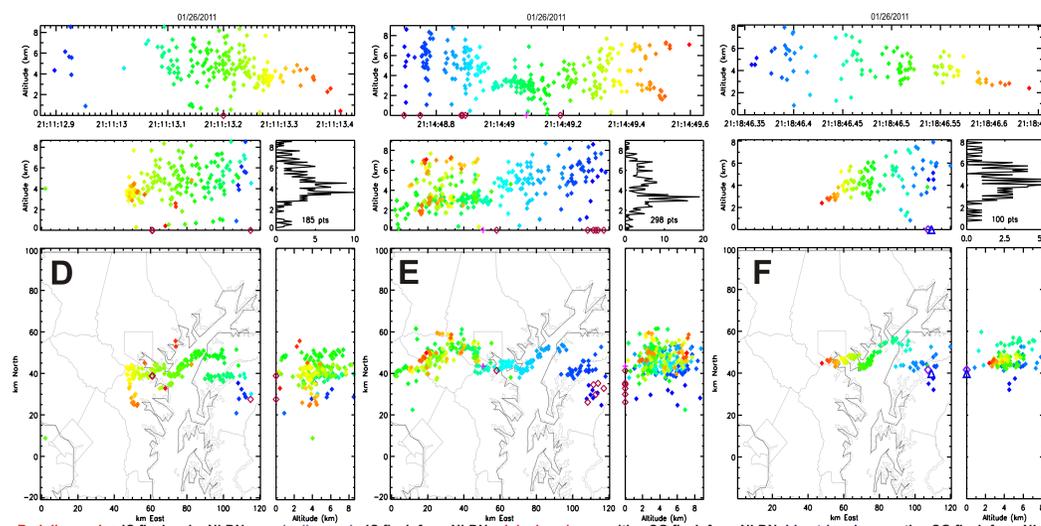


A (far left): A tower initiated flash from 10 January 2011 at 0431 UTC which covered 2300 km<sup>2</sup> over northern AL. A total of 11 NLDN flashes were associated with this single LMA flash (7 IC, 4 CG).

B (left): A tower-initiated flash at 0458 UTC on 10 January 2011 without any NLDN detection of IC or CG components of the flash. This flash encompassed an area of approximately 890 km<sup>2</sup>.

C (right): A tower-initiated flash at 0510 UTC on 10 January 2011 where the LMA and NLDN data show evidence of negative dart leaders traveling back to the ground by retracing the path of the upward positive leader from the tower.

Flashes D, E, F (below) represent a sequence of 3 flashes observed during the 26 January 2011 snowfall event near Washington D.C. Between 2111 UTC and 2119 UTC, LMA flashes producing opposite polarity ground strokes and both upward and downward directed IC components in the same region were observed in the same charge structure.



Red diamond: + IC flashes by NLDN; purple diamond: -IC flash from NLDN; pink plus sign: positive CG flash from NLDN; blue triangle: negative CG flash from NLDN

	Total NLDN Flashes	CG only Flashes	IC only Flashes
NLDN	77	31	46
NLDN:LMA ratio	2.26	0.94	1.39

Table 1: Number of NLDN flashes observed in conjunction with the 34 LMA derived flashes and the ratio of NLDN total flashes to LMA flashes, LMA to NLDN CG ratio, and LMA to NLDN IC ratio.

	Mean	Median	Maximum	Minimum
Flash Area (km <sup>2</sup> )	375	128	2300	3.3
Polarity/Peak Amplitude (kA)	89 -38	87 -19	185 -125	22 -5

Table 2: Flash area statistics for the 34 LMA flashes observed (top) and polarity and magnitude statistics for the 31 CG flashes observed in this set of LMA flashes. 7 LMA flashes had zero flash components observed by the NLDN.

## Conclusions/Findings

- 1) Flash areas in thundersnow events can exceed 1000 km<sup>2</sup>. The average area of this 34 flash dataset was 375 km<sup>2</sup>, with a median of 128 km<sup>2</sup>, a maximum of 2300 km<sup>2</sup> and a minimum of 3.3 km<sup>2</sup>.
- 2) Multiple NLDN based flash detections (IC and/or CG) were associated with a single LMA flash. On average 2.26 NLDN flashes per LMA flash was observed, with as many as 11 NLDN flashes to 1 LMA flash. Also 7 of the 34 LMA flashes in this study were not detected by the NLDN.
- 3) Evidence of negative dart leaders traveling back to the ground as the flash retraces the path of the upward positive leader from tower initiated flashes was observed.
- 4) The peak positive (negative) amplitude of CG flashes in this sample was +185 kA (-125 kA) with a mean of +89 kA (-39 kA) and a median of 87 kA (-17 kA).

## Future Work

- Understand the microphysical and kinematic structure of the precipitation in which these flashes develop.
- Develop conceptual models for operational forecasting applications of convective snow using total lightning.

