Lightning Jump Algorithm for GOES-R Geostationary Lightning Mapper (GLM) Proxy Data

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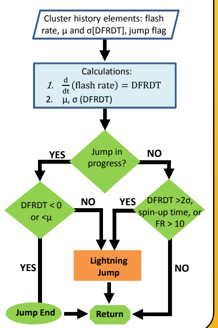
Introduction

- Schultz et al. (2011; MWR) presented strong results for the use of total lightning from lightning mapping arrays (LMAs) to aid in the prediction of severe and hazardous weather using an automated lightning jump algorithm (LJA) with semi automated.
- Project purpose: Develop automated, objective techniques for the GLM Proxy data set to continue to develop and refine the LJA to build towards as successful operational product.

Lightning Jump Process for each cluster



Data and Methods

- This study includes >90 events consisting of ~500-1000 storm clusters between 2002 and 2011 which covers a significant subset of Schultz et al. 2011's database. Events included are within range of the North Alabama Lightning Mapping Array.
- Database inclusion of the storm clusters is restricted to the time period (minimum of 30 minutes) that the cluster exists within a set radius from the LMA center, typically 125 km.

Table 1

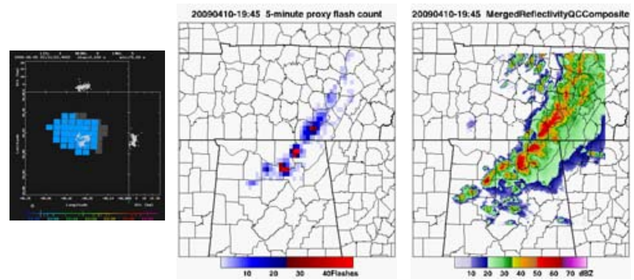
	Verification Schultz et al. 2011	Alternative Verification (Based on NWS, NWS-HUN personal communication)
Storm report grouping	Yes (6 minutes)	no
1 storm report verifies 2 overlapping forecasts	No (only first forecast, 1 hit)	Yes (1 hit)
Jump grouping	Yes (6 minutes)	Yes (6 minutes)
False alarm	• No report during forecast OR • For overlapping forecasts, no report in time period following first forecast expiration	No report during forecast

Table 2

	Tunable Parameter Defaults	Schultz et al. 2011	This study
Algorithm	**Sigma threshold** statistical jump threshold	2	2
Algorithm	**Flash rate threshold** Minimum flash rate (flashes/min[1]) required to activate the algorithm	10	10
Algorithm	**Algorithm Spin-up** Minute flash date required to determine a jump	5 DFRDT periods	5 DFRDT periods
Verification	**Storm report distance** Additional distance from cell boundary	0 (Only area within cell)	5 km
Verification	**Forecast period** Time following a jump	45 minutes	45 minutes
Database	**Domain range** From NALMA center	200 km (most within 150 km)	125 km
Database	**Spatial Scale** Based on WDSSII tracking parameters	-----	5 (storm area of ~160 km²)

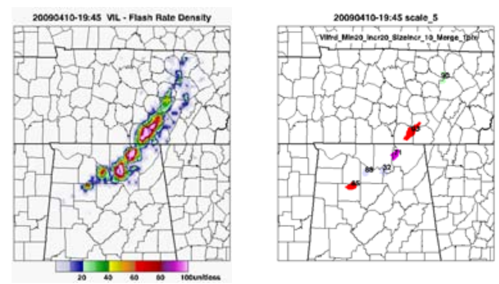
Automated Objective Tracking and Lightning Jump Algorithm Methodology

DATA



Above left: An example GLM Proxy flash. Each flash location is determined by an amplitude weighted centroid of the groups/events. These are then gridded to 0.08° x 0.08° at 1 min and 5 min running average every 1 minute (above center). **Above right:** Merged composite reflectivity from KHTX, KOHX, KGWX, KBMX, and KFFC.

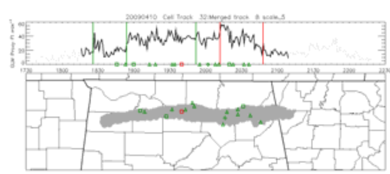
Combine lightning and radar for cell tracking



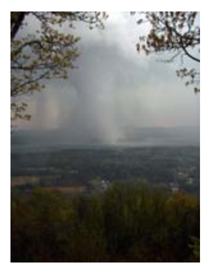
Unlike other tracking methods that use just reflectivity based measures, this study combines VIL and the 5-minute Proxy GLM flash rate density (FLCT5) into a new product, VILFRD. The WDSSII tracking algorithm tracks values where VILFRD ≥ 20, using increments of 20, with anything over 100 set to 100. Using VILFRD, builds clusters until a minimum size threshold is met. Several cluster sizes/scales are tested. A spatial/temporal threshold is used to merge cluster tracks that end prematurely.

$$VILFRD = 100\times\left[\left(\frac{VIL}{45}\le 1\right)+\sqrt{\frac{FLCT5}{45}}\le 1\right]$$

Algorithm and verification

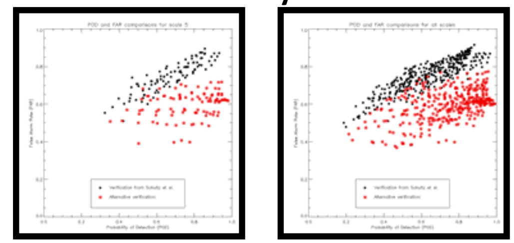


Above: **The lightning jump algorithm, automated tracking, and GLM proxy lightning data is applied to the individual cluster tracks using the same algorithm and verification methods as Schultz et al. (2009, 2011). The top panel depicts the lightning trend, lightning jumps, and severe storm reports. Color coded lines/symbols indicate hits (green) and false alarms/misses (red), using the default outline in Table 2. The bottom panel depicts the cluster areal coverage for the storm's lifetime within the domain (shaded gray) and severe storm report locations.**

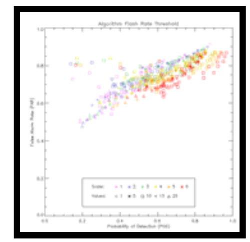


EF3 tornado crossing Lake Guntersville from storm highlighted to left just after 2005 UTC, April 10, 2009. A lightning jump was observed at 1948 UTC, 13 minutes prior to tornado touchdown. Photo credit: Martha Tellefsen

Sensitivity Tests

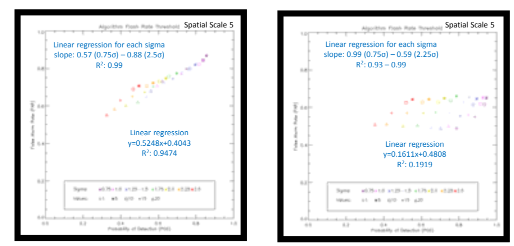


Probability of Detection (POD) and False Alarm Rate (FAR) show a strong quasi-linear relationship for the Schultz verification (*black*). For alternative verification (*red*), POD and FAR are more de-coupled and exhibits a weaker trend. The *upper left* figure shows the distribution for the spatial scale 5 (areal extent ~160 km²) database while the figure *upper right* shows the complete dataset distribution.



Left: **Colors represent the spatial scale (areal extent) at which storms are tracked and symbols represent flash rate thresholds for the Schultz verification method.**

- POD decreases steadily with increasing spatial scale
  - **0.19-0.88 at scale 1 (~32 km²)**
  - **0.44-0.97 at scale 6 (~243 km²)**
- There is less spread in the FAR with increasing spatial scale
  - **0.50-0.91 at scale 1**
  - **0.63-0.86 at scale 6**



The combined effect of the sigma and flash rate thresholds using the Schultz verification method (*above left*) and alternative verification method (*above right*).

- The relationship between POD and FAR are highly dependent upon sigma and flash rate threshold.
- For the Schultz verification, decreasing σ values and lowering the flash rate threshold results increases in the trend in POD more rapidly than in FAR (above left).
- For the alternative verification, sigma's impact is greater on the trend in POD and FAR values than in the flash rate threshold (above right).

Summary

- **This study reveals the impact of automated tracking and GLM Proxy data on the LJA as compared to the results in Schultz et al. 2011.**
  - Schultz: POD: 0.79, FAR: 0.36 vs. This Study: POD: 0.33-0.86, FAR: 0.55-0.87
  - Alternative verification: POD: 0.35-0.95, FAR: 0.48-0.66
- **Flash rate threshold and sigma have a greater impact on the LJA's performance than the other tunable parameters shown in Table 2.**
- **Flash rate and sigma are highly correlated (R^2=0.94) in the Schultz verification but not in the alternative verification (R^2=0.19) where sigma has a greater influence on the algorithm's performance.**

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