Lightning Jump Evaluation RITT Presentation

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12/18/13

Reduction of FAR?

Agenda

- Team Members
- Total Lightning
- Lightning Mapping Arrays (LMAs)
- Previous Research Summary
- Current Project
- Analysis & Results
- Future Work

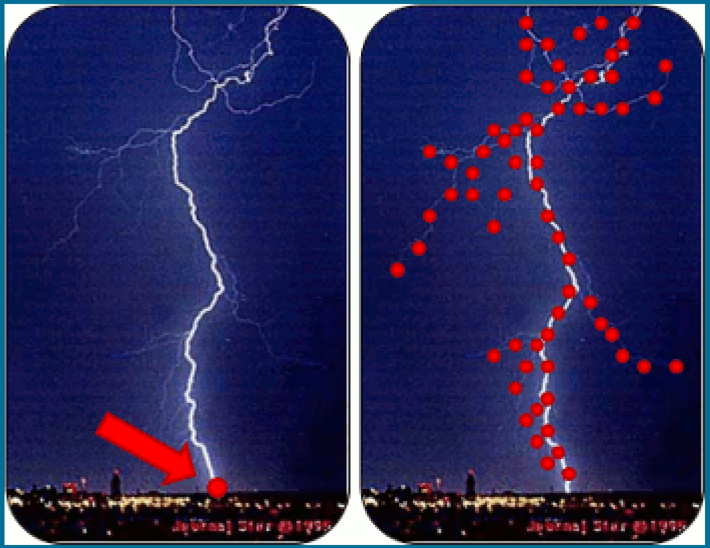
Team Primary Members

Person	Role	Affiliation
Tom Filiaggi	Co-Lead	OST - MDL
Steve Goodman	Co-Lead	NASA
Larry Carey	PI	University of Alabama: Hunstville
Themis Chronis	Analyst	University of Alabama: Hunstville
Chris Schultz	Consultant	University of Alabama: Hunstville / NASA
Kristin Calhoun	PI	National Severe Storms Laboratory
Greg Stumpf	Consultant	OST - MDL
Geoffrey Stano	Consultant	NASA
Daniel Melendez	Consultant	OST - SPB
Scott Rudlosky	Consultant	NESDIS
Steve Zubrick	Consultant	WFO – Sterling, VA (LWX)

About 15 additional people from a handful of *additional* agencies participated in various discussions.

"Total Lightning"

- Most familiar is Cloud-to-ground (CG):
  - point locations at ground level
  - Uses certain types of electromagnetic field sensors
  - Can directly impact more people



- Total Lightning:
  - uses a different kind of sensor to obtain step charge release locations for all flashes (not just CG)
  - Location is in full 3 dimensions
  - More difficult to sense with 'sufficient' accuracy – need more sensors
  - Less direct societal impact to people, but can be used indirectly, perhaps with significant value

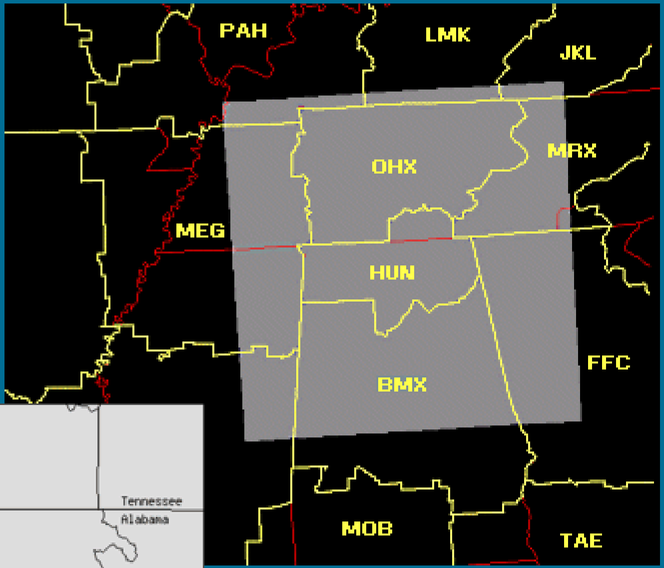
(Image borrowed from http://weather.msfc.nasa.gov/sport/lma/)

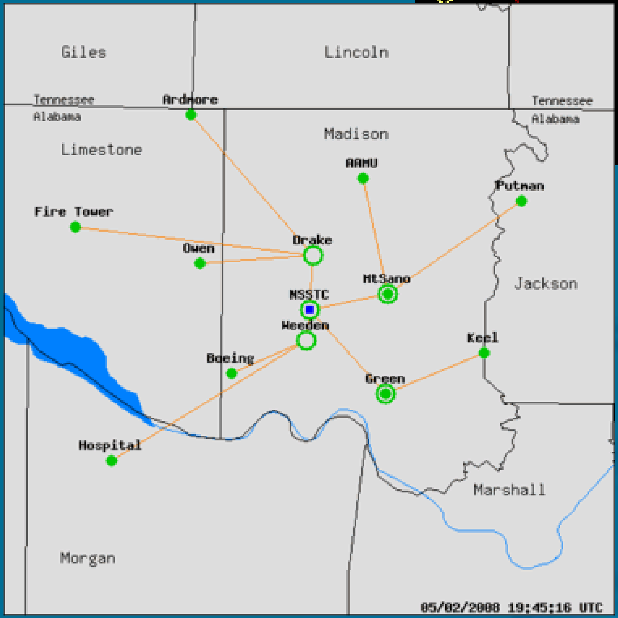
Sensors:
Lightning Mapping Array

- Predominant sensor array type used by this project
- Uses time of arrival and multilateration to locate step charges

Sensors: Lightning Mapping Array

- NALMA example
- Sensor distribution and 'effective' domain





(Images borrowed from http://weather.msfc.nasa.gov/sport/lma/)

Summary of Previous Research

- **Schultz et al. (2009), JAMC**
- Six separate lightning jump configurations tested
- Case study expansion:
  - 107 T-storms analyzed
    - 38 severe
    - 69 non-severe
- The "2σ" configuration yielded best results
  - **FAR even better i.e.,15% lower (Barnes et al. 2007)**
    - Caveat: Large difference in sample sizes, more cases are needed to finalize result.

Thunderstorm breakdown:

North Alabama – 83 storms

Washington D.C. – 2 storms

Houston TX – 13 storms

Dallas – 9 storms

Algorithm	POD	FAR	CSI	HSS
Gatlin	90%	66%	33%	0.49
Gatlin 45	97%	64%	35%	0.52
2σ	87%	33%	61%	0.75
3σ	56%	29%	45%	0.65
Threshold 10	72%	40%	49%	0.66
Threshold 8	83%	42%	50%	0.67

Slide contents borrowed from Schultz (UofAH) presentation.

Summary of Previous Research

- **Schultz et al. 2011, WAF**
- Expanded to 711 thunderstorms
  – 255 severe, 456 non severe
  – Primarily from N. Alabama (555)
  – Also included
    - Washington D.C. (109)
    - Oklahoma (25)
    - STEPS (22)

TABLE 3. Skill scores and average lead times using the sample set of 711 thunderstorms for both total lightning and CG lightning, correlating trends in lightning to severe weather.

	POD	FAR	CSI	HSS	lead time (all)	lead time (tornado)
Total lightning	79%	36%	55%	0.71	21.22 mins	20.94 mins
CG lightning	66%	53%	38%	0.55	13.54 mins	15.24 mins

Slide contents borrowed from Schultz (UofAH) presentation.

Summary of Previous Research

- The performance of using a 2σ Lightning Jump as an indicator of severe weather looked **very** promising (looking at POD, FAR, CSI)! ***But*** . . .
- The Schultz studies were significantly *manually* QCed, for things like consistent and meteorologically sound storm cell identifications.
- The Schultz studies also did not do a direct comparison to hoe NWS warnings performed **for the same storms**.
- How would this approach fare in an operational environment, where forecasters do not have the luxury of baby-sitting the algorithms?

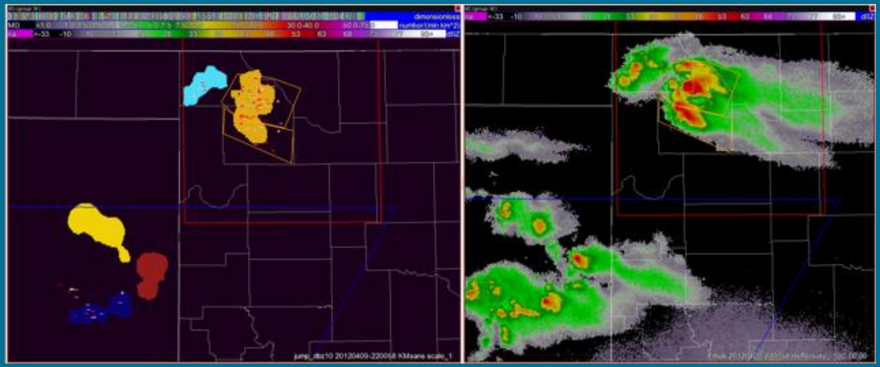
Current Project

- **Primary Goal:**
  - Remove the burden of manual intervention via automation then compare results to previous studies to see if an *operational* Lightning Jump will have *operational* value.
- **Secondary Goals:**
  - Use & evaluate a more "reliable" storm tracker (SegMotion (NSSL) over TITAN (NCAR) and SCIT (NSSL)).
  - Provide an opportunity to conduct improved verification techniques, which require some high-resolution observations.

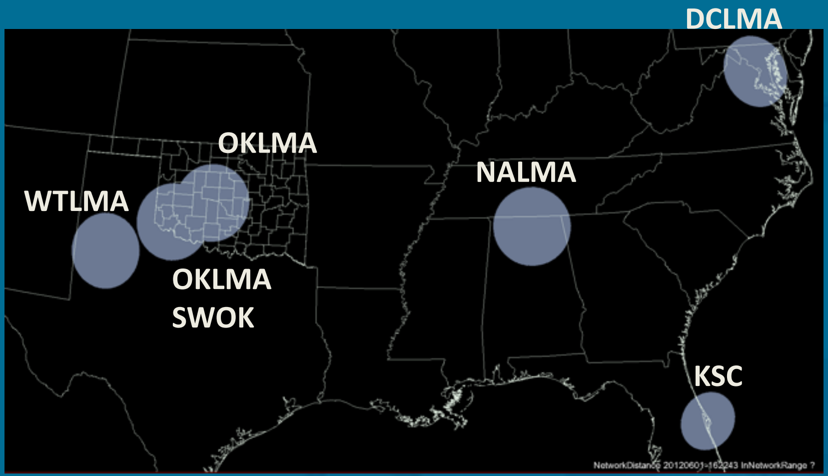
Current Project

- Purpose: Evaluate potential for Schultz et al. (2009, 2011) LJA to improve NWS warning statistics, especially False Alarm Ratio (FAR).
  - Objective, real-time SegMotion cell tracking (radar-based example upper right)
  - LMA-based total flash rates (native LMA, **not GLM proxy**).
  - Increased sample size over variety of meteorological regimes (LMA test domains bottom right)

Storm Objects WSR-88D



WDSSII K-means storm tracker.



LMA Test Domains

Slide contents borrowed from L. Carey (UofAH) presentation.

Analysis

- Data
  - Data from 2012 was not usable due to integrity issues. Would need to re-process in order to use.
  - Collected from 3/29/13 through 8/14/13, includes:
    - 131 storm days
    - 3400+ tracked storm clusters
    - Nearly 600 of which experienced Lightning Jumps
    - Nearly 675 Storm Reports recorded
- Results of variational analyses:
  - POD = 64-81%
  - FAR = 75-84%
  - Lead Time = ~25 minutes (but with standard deviation of 12-13 minutes)
  - Best Sigma = 1.2-1.7
  - Best Threshold = 9-12 flash/minute

Analysis

- FAR values much higher than previous studies. (POD was *essentially* the same.)
- FAR could improve to 55-60%, if we can account for:
  - Storm Tracking imperfections
  - Low-population storm report degradation
  - Application of a 50 flash/minute severe weather proxy
  - Change in verification methodology (allow double counting of severe reports)
- But, FAR still significantly higher than previous studies - !?

Analysis: FAR Differences

What could explain the different results of FAR?

- Geography
  - differing climatology (predominant severe weather types: hail in OK)
  - population density (storm reports: OK less dense)
- Methodology
  - subjective storm track extension
  - Different Storm Tracker behaviors
- Data Integrity
  - Some unexplained data drops were noted, but not analyzed

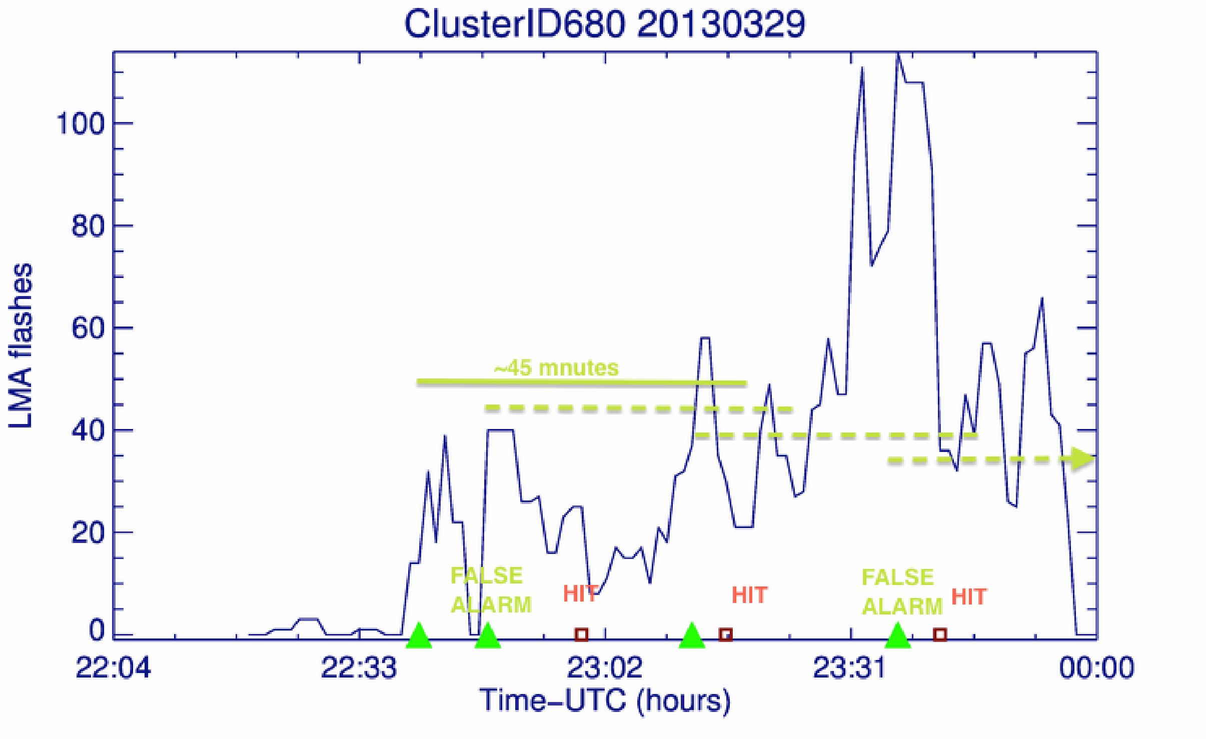
Future Work

- Explore enhanced verification techniques using extensive SHAVE data (already gathered) and funded by the GOES-R program.
- Explore refined methodologies (to compensate for the removal of manual QC care and attention).

The End

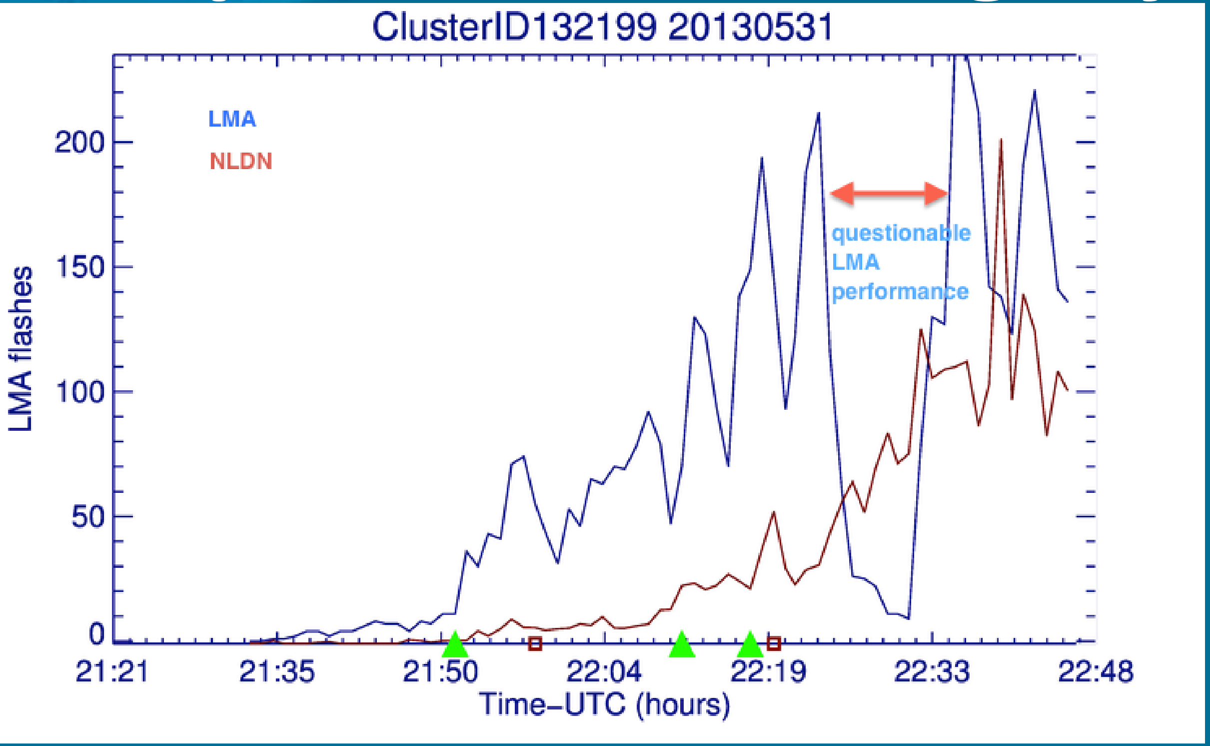
- Questions?
- Tom.Filiaggi@noaa.gov
- VLab Community:
  https://nws.weather.gov/innovate/group/lightning/home
- Email listserver:
  total_lightning@infolist.nws.noaa.gov

Graphics: Methodology



Example of POD and FAR calculation for a multi-jump and multi-report cluster. Green triangles represent the issued jumps while brown squares represent the “matched” SPC severe weather reports. Each jump is “valid” for 45 minutes. For the first jump’s time window, 2 severe weather reports are present. These are counted as 2 hits. For the second there are no ***additional*** SPC reports beyond the first two which are already accounted for by the first jump. The second jump constitutes a “false alarm”. The third jump counts as a “hit” 9with 3rd report). For the fourth there are no additional reports other than the third report which is already accounted for by the previous jump. This counts as an additional “false alarm”. From this particular cluster, a total of 3 hits, 2 false alarms and 0 misses are counted.

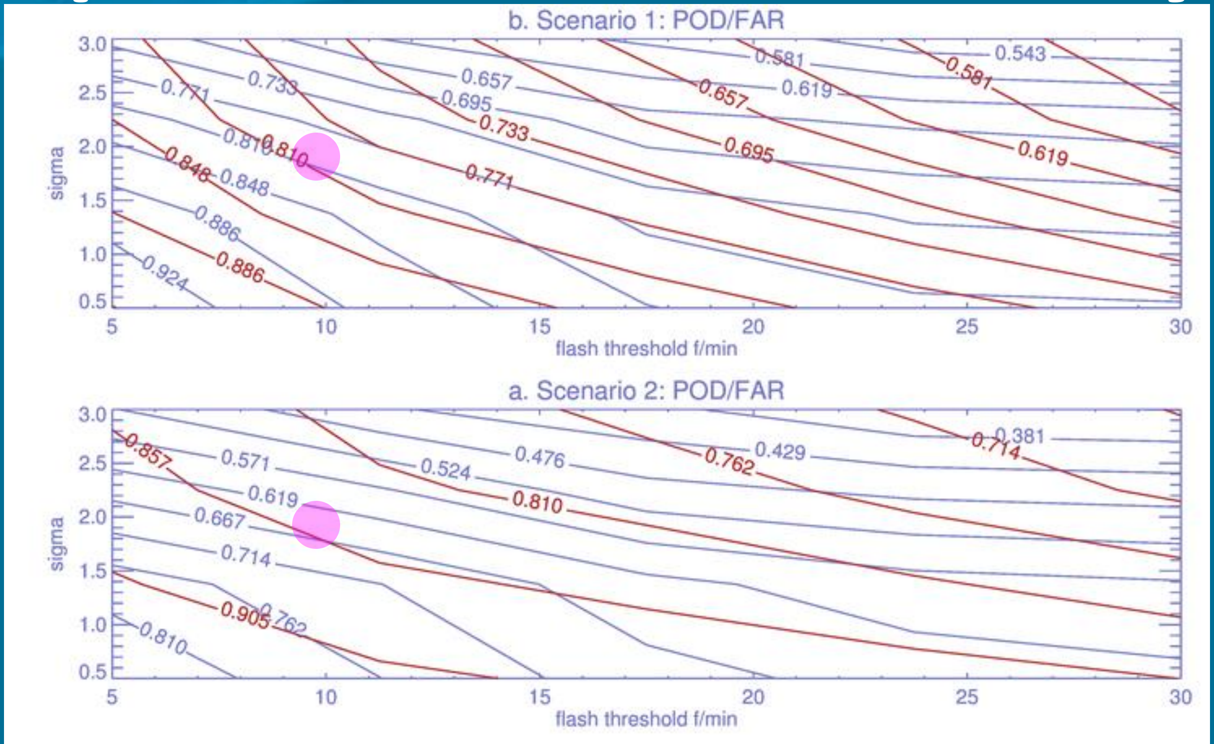
Graphics: Data Integrity



Related to the Oklahoma tornado outbreak on May 31, 2013. **Blue** line is **LMA** flashes/min/km^2 (left y-axis), **red** line is the **NLDN** flashes/min/km^2. Note the discrepancy around 22:20 - 22:33 between the two lightning detection systems.

(Green triangles represent the issued jumps while brown squares represent the "matched" SPC reports.)

Graphics: Variational Analysis



Calculation of POD (blue) and FAR (red) as a function of LJA **sigma** (y-axis, flashes/min) and lightning **flash rate** (x-axis, flashes/min) for both Scenarios and imposing the “stricter” SPC-SWR spatial/temporal matching criteria [i.e. 5 km/20 minutes and considering for clusters that have a life span of at least 30 minutes].