Lightning Jump Evaluation

RITT Presentation

Tom Filiaggi (NWS – MDL)
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

<table>
<thead>
<tr>
<th>Person</th>
<th>Role</th>
<th>Affiliation</th>
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<tbody>
<tr>
<td>Tom Filiaggi</td>
<td>Co-Lead</td>
<td>OST - MDL</td>
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<td>Co-Lead</td>
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<td>University of Alabama: Huntsville</td>
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<td>Analyst</td>
<td>University of Alabama: Huntsville</td>
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<td>Consultant</td>
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<td>Geoffrey Stano</td>
<td>Consultant</td>
<td>NASA</td>
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<td>Daniel Melendez</td>
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<td>Consultant</td>
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<tr>
<td>Steve Zubrick</td>
<td>Consultant</td>
<td>WFO – Sterling, VA (LWX)</td>
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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.

<table>
<thead>
<tr>
<th>Algorithm</th>
<th>POD</th>
<th>FAR</th>
<th>CSI</th>
<th>HSS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gatlin</td>
<td>90%</td>
<td>66%</td>
<td>33%</td>
<td>0.49</td>
</tr>
<tr>
<td>Gatlin 45</td>
<td>97%</td>
<td>64%</td>
<td>35%</td>
<td>0.52</td>
</tr>
<tr>
<td><strong>2σ</strong></td>
<td>87%</td>
<td>33%</td>
<td>61%</td>
<td><strong>0.75</strong></td>
</tr>
<tr>
<td>3σ</td>
<td>56%</td>
<td>29%</td>
<td>45%</td>
<td>0.65</td>
</tr>
<tr>
<td>Threshold 10</td>
<td>72%</td>
<td>40%</td>
<td>49%</td>
<td>0.66</td>
</tr>
<tr>
<td>Threshold 8</td>
<td>83%</td>
<td>42%</td>
<td>50%</td>
<td>0.67</td>
</tr>
</tbody>
</table>

Thunderstorm breakdown:
- North Alabama – 83 storms
- Washington D.C. – 2 storms
- Houston TX – 13 storms
- Dallas – 9 storms
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)

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**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.

<table>
<thead>
<tr>
<th></th>
<th>POD</th>
<th>FAR</th>
<th>CSI</th>
<th>HSS</th>
<th>lead time (all)</th>
<th>lead time (tornado)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total lightning</td>
<td>79%</td>
<td><strong>36%</strong></td>
<td>55%</td>
<td>0.71</td>
<td>21.22 mins</td>
<td>20.94 mins</td>
</tr>
<tr>
<td>CG lightning</td>
<td>66%</td>
<td>53%</td>
<td>38%</td>
<td>0.55</td>
<td>13.54 mins</td>
<td>15.24 mins</td>
</tr>
</tbody>
</table>
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 how 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)

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
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” with 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.
Related to the Oklahoma tornado outbreak on May 31, 2013. **Blue** line is **LMA** flashes/min/km² (left y-axis), **red** line is the **NLDN** flashes/min/km². 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.)
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].