GLM Performance Assessment Using Ground-based Lightning Network Data

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with help from:

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LI/GLM Workshop 2015
Topics

* Proposed GLM Verification Approach *(beyond the instrument...)*
  * Hierarchical assessment of RTEPS=>Regions => GLM pixels
    * Location Accuracy using CG strokes
    * “Strokes” => GLM group DE
    * Channel mapping => GLM spatial extent
  * Continuous, recursive statistics
  * Findings used to initiate lower-level assessment (deep dive)
  * Choice of reference network(s) depends on both availability and applicability
    * Must also maintain current performance statistics
      * Multi-network
      * Self-referenced

* Tools (thus far)
  * 2-Network Inter-comparison
    * Un-attended use (batch)
    * LA, DE, Type classification, field/current calibration
  * DE Analysis Options
    * Stroke and flash
    * Spatial Map, and overall avg.
  * CHUVA Examples
  * 3-network DE
    * Multiple 2-network analyses
  * Multi-system Exploration
    * LIS Groups, LMA, And LF networks
    * Interactive use
    * Time-height
    * Spatial plan view
* Data-driven Performance Assessment

* Analysis Resolution
  * Depend on viewing domain
  * Statistical aggregation of lower-level (single pixel) statistics

* Possible Realizations
  * Dedicated mapping tool
  * Overlay placed over any data map
    * Enable/Disable
    * Adjustable transparency
### Performance Metrics and Reference datasets

<table>
<thead>
<tr>
<th>Performance Parameter</th>
<th>Preferred Reference</th>
<th>“Good” Values</th>
<th>“Poor” Values</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Location Accuracy</td>
<td>CG Return Strokes</td>
<td>1 nearest neighbor?</td>
<td>&gt;1 nearest Neighbor &gt; 50% of the time</td>
<td>Brightest or closest event in +/- 2 ms (?)</td>
</tr>
<tr>
<td>Group/CG Detection Eff.</td>
<td>&gt;80% CG Stroke DE VLF/LF Network</td>
<td>&gt;60%</td>
<td>&lt; 50%</td>
<td>Lower-performance networks could be used with modified performance thresholds</td>
</tr>
<tr>
<td>TL Flash Detection. Eff. (required?)</td>
<td>&gt;80% cloud Flash DE</td>
<td>&gt;60%</td>
<td>&lt; 50%</td>
<td>Lower-performance networks can be used with modified performance thresholds</td>
</tr>
<tr>
<td>Per-minute Spatial Extent (desired)</td>
<td>VLF or LF Mapping systems</td>
<td>&gt;xx% of flash area</td>
<td>&lt; yy% of flash area</td>
<td>LF system will need to be able to map horizontal channels in extensive flashes</td>
</tr>
</tbody>
</table>

Can we agree that CG strokes are as hard to detect as anything?
**LIS Group Exploration Tool**

**Example: LIS, SPLMA, and TLS-CG**

* Spatial Analysis
  * Limited to LIS swath coverage for each second
  * LIS Groups: Magenta circles w/ area = LIS group area
  * LMA: sources color-coded by time
  * TLS-CG: red “dots”

* Time:Height Analysis
  * LIS Groups:
    * area $\propto$ to radiance
    * “Height” $\propto$ distance from 7 closest LMA sources
  * LMA: same “time” color scale as spatial analysis
  * TLS-CG
    * Area $\propto$ peak current
    * Black: negative
    * Red: positive

---

[Map of LIS-LMA data with color-coded points and legend for area and peak current.]
* Spatial Analysis - single flash for LIS Groups, LINET, and LMA
*Temporal Analysis - single flash got LIS Groups, LINET, and LMA

(no consistent relationships with LIS, other than occurrence time)
Spatial Analysis Examples - what correlates?

Generally reasonable spatial correlation between LF stroke/pulses and some of the LIS Events constituting a group

LIS Group Area and “accumulated” Group Radiance have reasonable correlation
# sample Spec file for LLS comparison
# written by Ken Cummins, July 2011

# Definition of possible fields in each data file
# Date (D): date yyyy-mm-dd
# Time (O): Occurrence time (hh:mm:ss.mmmmmm)
# Lat (L): decimal degrees
# Lon (G): decimal degrees
# Ip (I): Peak Current (kA)
# LocErr (E): position error (km)
# ChiSq (C): Chi-square or consistency parameter
# NSR (N): integer number of sensors reports
# Type (T): G or C
# Skip (S): field to skip

Ref_file: data/sampleRef.asc  
Ref_fmt: DOLGIECTN

Test_file: data/sampleTest.asc  
Ref_fmt: DOLGIECTN

# DT is the nominal correlation time in microseconds
DT: 100.

# DD is the nominal spatial correlation distance in km
# (should be at least DT*c = DT(sec) * 3*10^8(m/sec) =
# DD = 30.0

# MATCH is a true/false requirement for type-matching
MATCH: false

# START is the start data/time
# If not defined, starts at the beginnig of the later-start file
START: 2011-07-01@00:00:00

# STOP is the stop date/time
# If not defined, stops at the end of the earlier-stop file
STOP: 2011-07-30@23:59:59

# LATLON is the lat-lon rectangular boundry for analysis region
# in decimal degrees ( LL_lat LL_lon UR_lat UR_lon )
# If not defined, the whole region is used
LATLON: 36.,137.,41.,142.
* **Tool “Outputs”**

* **Analysis “Sheets”**
  * **Sheet 1:** (overall timing, LA, and DE statistics)
    * Requires date, time, lat, lon, and (optionally) type (CG/CLD pulse)
  * **Sheet 2:** (peak current (Ip) calibration and DE vs. Ip)
    * Requires peak current estimates
  * **Sheet 3:** (data quality parameters)
    * Requires quality-related parameters
      * location error estimate
      * # sensors reporting the stroke/pulse

* **Spatial Detection Efficiency**

* **Flash Analysis**
* **Spatial Detection Efficiency**

* Observe spatial variation in DE
  * Combined for cloud pulses and CG strokes
* Helpful for selecting LLS comparison regions
* Automatic global country/coastline
* Example: CHUVA TLS200cg (ref) and GLD360 (test)
* Flash Analysis Overview

* Definition of flash DE

* This is complicated by the fact that LLS’s frequently disagree about the discharge type (cloud vs. CG)

Examples:

\[
\text{DE}_{\text{TestCGF}} = 100 \times (\text{Test}_{\text{CG}} \text{FmatchRef}_{\text{CLD}} + \text{Test}_{\text{CLD}} \text{FmatchRef}_{\text{CG}}) / (\text{Ref}_{\text{CG}} F);
\]

\[
\text{DE}_{\text{TestAll}} = 100 \times \text{allMatchTest} / (\text{Ref}_{\text{CG}} F + \text{Ref}_{\text{CLD}} F);
\]
Flash - CHUVA LINET vs. GLD360

Flash Analysis
max. ISI: 3.000000e-01   max. Rng: 30.0

Reference Network
--- Type:--- Flashes Mult PctFl
CG  114774  2.73  58.2
CLD  082542  2.87  41.8

*** IC:CG Flash Ratio 0.72

--- Type:--- Events Mult PctCLD
CLD-in-CG  210471  1.83  37.2
PreCG  118640  1.03  21.0

Flash Detection Efficiency
refCG  testCG  refCLD  testCLD  refAll  testAll
82.9  31.2  NaN  14.9  82.9  24.4

Test Network
--- Type:--- Flashes Mult PctFl
CG  060043  1.95  100.0
CLD  000000  NaN  0.0

*** IC:CG Flash Ratio 0.00

--- Type:--- Events Mult PctCLD
CLD-in-CG  000000  0.00  NaN
PreCG  000000  0.00  NaN

LINET/GLD360.cfg -- accum -- 20-May-2014 23:48:25 -- 20120327_LINET_level1b.txt - accum - 2012.03.27.gl360.txt
The Flash Analysis includes a temporal analysis for each network:

- Are they part of a cloud flash?
- Are they part of a CG flash?
- What part of a CG flash?
Temporal Analysis

- Limited to LLS’s with both CLD and CG stroke detection
  - LINET, BrasilDat, and TLS-LF-all
- Large variation among the networks in terms of the types of reported discharges
  - LINET sees 83% of its cloud pulses associated with CG flashes
  - These findings are very dependent on the accuracy of type-classification

![Discharge Type Distribution (IPI / Distance = 200 ms / 20 km)](chart1)

![Discharge Type Distribution (IPI / Distance = 500 ms / 30 km)](chart2)
* Example Use: LINET-referenced Comparison

**METHOD:**

* Selected a “common” (small) region and time period
  * Region determined by LINET
  * Time period limit defined by TLS200
    * 16 high-activity days between January 5 through March 27, 2012
      * Note: LINET is compromised during some of these times
Selection of the Analysis Domain: LINET Comparison

* The domain was selected to be optimal for LINET (Blue box)

* Does not necessarily provide a representative spatial sample for the long-range networks
* Comments from data contributors

* WWLLN
  * The small domain and small number of flashes result in uncertainty in the WWLLN findings. Analysis over a larger domain should be done.

* LINET
  * During much of this time, only 5 of the 7 sensors were operational.
  * Leap-second issue with LIS data?

* BrasilDat
  * Typically, only 1-2 of the 7 “special” sites were operational, and the network was just being calibrated. The network is now working much better than it was during the CHUVA campaign. (the ~100 km baseline in the previous slide reflected the “functional” baseline during this study)
## Comparison Table

<table>
<thead>
<tr>
<th>Network</th>
<th>#TL Events</th>
<th>#Flash</th>
<th>Flash IC:CG</th>
<th>Rel FDE</th>
<th>mean DT</th>
<th>RMS DT</th>
<th>mean Dist.</th>
<th>median Dist</th>
<th>5% +IC Ip</th>
<th>50% +IC Ip</th>
<th>Ip slope</th>
<th>% pol. Match</th>
<th>Sensor baseline dist. (km)</th>
</tr>
</thead>
<tbody>
<tr>
<td>LINET</td>
<td>882926</td>
<td>198405</td>
<td>0.72</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1.5</td>
<td>3</td>
<td></td>
<td></td>
<td>22-45</td>
</tr>
<tr>
<td>TLS-LF &quot;all&quot;</td>
<td>538028</td>
<td>170418</td>
<td>2.03</td>
<td>65.4</td>
<td>18.3</td>
<td>16.56</td>
<td>3.21</td>
<td>1.46</td>
<td>1.5</td>
<td>3.5</td>
<td>1.22</td>
<td>89.4</td>
<td>55-125</td>
</tr>
<tr>
<td>BrasilDat</td>
<td>447098</td>
<td>189094</td>
<td>5.83</td>
<td>69.8</td>
<td>17.6</td>
<td>19.4</td>
<td>3.44</td>
<td>1.84</td>
<td>2</td>
<td>4.5</td>
<td>1.05</td>
<td>78.3</td>
<td>~100</td>
</tr>
<tr>
<td>TLS-LF CG</td>
<td>151094</td>
<td>55833</td>
<td>N/A</td>
<td>32.6</td>
<td>17.86</td>
<td>13</td>
<td>2.23</td>
<td>1.08</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>97.6</td>
<td>55-125</td>
</tr>
<tr>
<td>GLD360</td>
<td>117221</td>
<td>60043</td>
<td>N/A</td>
<td>24.2</td>
<td>20.2</td>
<td>18.61</td>
<td>7.1</td>
<td>4.61</td>
<td>N/A</td>
<td>N/A</td>
<td>1.07</td>
<td>88.7</td>
<td>big</td>
</tr>
<tr>
<td>StarNet*</td>
<td>51608</td>
<td>36676</td>
<td>N/A</td>
<td>19.1</td>
<td>-64.74</td>
<td>70.2</td>
<td>16.34</td>
<td>14.86</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>big</td>
</tr>
<tr>
<td>WWLLN*</td>
<td>15264</td>
<td>11463</td>
<td>N/A</td>
<td>6.2</td>
<td>14.14</td>
<td>26.53</td>
<td>7.12</td>
<td>5.68</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>big</td>
</tr>
</tbody>
</table>

*Note: Flash grouping parameters were relaxed to 500 ms and 50 km for these networks, due to low DE (both) and larger location errors (StarNet)*

The flash grouping parameters for the other networks was 300 ms and 30 km
Comparison Table: DE & IC:CG

<table>
<thead>
<tr>
<th>Netwrk</th>
<th>#TL Events</th>
<th>#Flash</th>
<th>Flash IC:CG</th>
<th>Rel FDE</th>
<th>Sensor baseline dist. (km)</th>
</tr>
</thead>
<tbody>
<tr>
<td>LINET</td>
<td>882926</td>
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<td>0.72</td>
<td></td>
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<td>2.03</td>
<td>65.4</td>
<td>55-125</td>
</tr>
<tr>
<td>BrasilDat</td>
<td>447098</td>
<td>189094</td>
<td>5.83</td>
<td>69.8</td>
<td>~100</td>
</tr>
<tr>
<td>TLS-LF CG</td>
<td>151094</td>
<td>55833</td>
<td>N/A</td>
<td>32.6</td>
<td>55-125</td>
</tr>
<tr>
<td>GLD360</td>
<td>117221</td>
<td>60043</td>
<td>N/A</td>
<td>24.2</td>
<td>big</td>
</tr>
<tr>
<td>StarNet*</td>
<td>51608</td>
<td>36676</td>
<td>N/A</td>
<td>19.1</td>
<td>big</td>
</tr>
<tr>
<td>WWLLN*</td>
<td>15264</td>
<td>11463</td>
<td>N/A</td>
<td>6.2</td>
<td>big</td>
</tr>
</tbody>
</table>

* Factor-of-50 variation in reported events
* Factor-of-20 variation in FDE
* “top 3” Networks:
  * event counts are inversely related to sensor baseline
  * nearly-equal flash counts
  * extremely different IC:CG ratios (=> classification issues)

Note: LINET only reported 75-80% of the flashes reported by TLS and BrasilDat => all networks “see” some things that others do not
Network mean DT RMS DT mean Dist. median Dist.
Sensor baseline dist. (km)
LINET 22-45 TLS - LF "all" 18.3 16.56 3.21 1.46 55-125
BrasilDat 17.6 19.4 3.44 1.84 ~100
TLS - LF CG 17.86 13 2.23 1.08 55-125
GLD360 20.2 18.61 7.1 4.61 big
StarNet* - 64.74 70.2 16.34 14.86 big
WWLLN* 14.14 26.53 7.12 5.68 big

Mean timing difference (DT) only reflects differences in arrival-time calculation.

Smallest RMS timing and median location differences is for return strokes (TLS CG).

ALL larger than expected, even considering √2

Tails on DT histograms due to GDOP for LINET (small baselines and few sensors).

Reference File: 20120327_LINET_level1b.txt
Test File: 20120327.asc

Network | #CG / DE | #CLD / DE | #Crr / DE
Ref: 312851 / (50.5) 566095 / (NaN) 110713 / (73.3)
Test: 151094 / (24.4) 0 / (0.0) 110713 / (12.6)

Classification Table:

<table>
<thead>
<tr>
<th>Test</th>
<th>CG</th>
<th>CLD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ref. CG</td>
<td>076312</td>
<td>000000</td>
</tr>
<tr>
<td>Ref. CLD</td>
<td>034401</td>
<td>000000</td>
</tr>
</tbody>
</table>

161 rej. for separation distance 0 rej. for Type mis-match
* Example Use: LIS-referenced DE

* Simple question: When LIS saw something, did others see it?

* METHOD:
  * Selected a “common” (small) region and time period
    * Region determined by LINET
  * Time period limit defined by TLS200
    * January 1 through March 27, 2012
      * Note: LINET is compromised during these times
  * Total Groups/Flashes were ~2900/300 in 13 overpasses

* Use tools to compute group-referenced and Flash-referenced DE

* Produce flashes from LIS Groups and LLS “events”
  * Multiple IPI/Distance Criteria for flash grouping: (200 ms/20 km; 500 ms/30 km; 500 ms /50 km for some long-range networks)
* Selection of the Analysis Domain

* Smaller domain would not have enough LIS flashes ( < 300)
* The domain is quite large for LINET
* confirmed that the LINET pulse/stroke DE, relative to TLS-LF-all, was not compromised over this domain
Negative values indicate that TLS arrives later.

**Time Difference Analysis**
- Count: 553
- RMS: 6850.65
- Median: 189.72
- Mean: -2605.03

**Position Difference Analysis**
- Count: 553
- RMS: 6.14
- Median: 8.27
- Mean: 10.06

**Time vs. Dist. diff. Log Density**

---

LIS_TLSf_all.cfg -- accum -- 20-May-2015 23:26:44
Reference File: LIS-LMA-2012-03-27_19_01_11_03152_LIS.txt
Test File: 2012.03.27_TLSall.asc

Network | #CG / DE | #CLD / DE | #Corr / DE
---|---|---|---
Ref: 2888 / (0.2) | 0 / (0.0) | 553 / (0.4)
Test: 44230 / (3.8) | 87718 / (NaN) | 553 / (19.1)

Classification Table:

<table>
<thead>
<tr>
<th>Test</th>
<th>CG</th>
<th>CLD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ref. CG</td>
<td>000109</td>
<td>000444</td>
</tr>
<tr>
<td>Ref. CLD</td>
<td>000000</td>
<td>000000</td>
</tr>
</tbody>
</table>

921 rej. for separation distance 0 rej. for Type mis-match
Negative values indicate that TLS arrives later.

**Time Difference Analysis**
- Count: 118
- RMS: 6004.04
- Median: 844.52
- Mean: -1485.29

**Position Difference Analysis**
- Count: 118
- RMS: 6.98
- Median: 10.30
- Mean: 12.27

**Time vs. Dist. diff. Log Density**

**Classification Table:**

<table>
<thead>
<tr>
<th>Classification</th>
<th>Test</th>
</tr>
</thead>
<tbody>
<tr>
<td>CG</td>
<td>CLD</td>
</tr>
<tr>
<td>Ref. CG</td>
<td>000118</td>
</tr>
<tr>
<td>Ref. CLD</td>
<td>000000</td>
</tr>
</tbody>
</table>

363 rejs for separation distance 0 rejs for Type mis-match
## Flash Summary Statistics

<table>
<thead>
<tr>
<th>Flash Grouping (IPI/Dist)</th>
<th>LLS Network</th>
<th>Relative Group DE</th>
<th>Relative Flash DE</th>
<th>Mean Groups/fl</th>
<th>Mean Mult. (G/C)</th>
<th>Nominal Sensor Baseline in test region</th>
</tr>
</thead>
<tbody>
<tr>
<td>200/20</td>
<td>LINET</td>
<td>32.0</td>
<td>61</td>
<td>8.4</td>
<td>3.3/3.2</td>
<td>22-45 km</td>
</tr>
<tr>
<td>200/20</td>
<td>TLS-LF “all”</td>
<td>23</td>
<td>56</td>
<td>8.4</td>
<td>2.4/1.9</td>
<td>55-125 km</td>
</tr>
<tr>
<td>200/20</td>
<td>BrasilDat</td>
<td>15</td>
<td>45</td>
<td>8.4</td>
<td>1.8/3.3</td>
<td>~100 km</td>
</tr>
<tr>
<td>200/20</td>
<td>GLD360</td>
<td>5</td>
<td>17</td>
<td>8.4</td>
<td>2.4/0.0</td>
<td>&gt;big</td>
</tr>
<tr>
<td>200/20</td>
<td>TLS-LF CG</td>
<td>6</td>
<td>13</td>
<td>8.4</td>
<td>3.3/0.0</td>
<td>55-125 km</td>
</tr>
<tr>
<td>200/20</td>
<td>StarNet</td>
<td>2</td>
<td>8</td>
<td>8.4</td>
<td>1.6/0.0</td>
<td>&gt;big</td>
</tr>
<tr>
<td>200/20</td>
<td>WWLLN</td>
<td>1</td>
<td>2</td>
<td>8.4</td>
<td>1.7/0.0</td>
<td>&gt;big</td>
</tr>
</tbody>
</table>

(estimated uncertainty of about +/-2%)

| 500/30                   | LINET       | 32                | 67                | 9.2           | 3.5/3.4         | 22-45 km                              |
| 500/30                   | TLS-LF “all”| 23                | 67                | 9.2           | 3.0/2.8         | 55-125 km                             |
| 500/30                   | BrasilDat   | 15                | 53                | 9.2           | 1.8/3.6         | ~100 km                               |
| 500/30                   | GLD360      | 5                 | 24                | 9.2           | 2.8/0.0         | >big                                  |
| 500/30                   | TLS-LF CG   | 6                 | 19                | 9.2           | 3.5/0.0         | 55-125 km                             |
| 500/50                   | StarNet     | 2                 | 14                | 10.3          | 2.0/0.0         | >big                                  |
| 500/50                   | WWLLN       | 1                 | 5                 | 10.4          | 2.0/0.0         | >big                                  |
LLS Relative Performance vs. LIS Total Lightning

- Wide variation in TL flash DE (few percent => ~70%)

- Short-baseline VLF/LF networks CAN detect a majority of TL flashes (but do not represent the spatial extent of big flashes)
  - Note: Hartmut indicates that for days with all LINET sensors working, they would detect almost all LIS flashes that were within the network, as well as some flashes not reported by LIS

- Some long-range LF networks MIGHT be sufficiently good to allow statistical up-scaling of the data for mid-oceanic LIS proxy and validation activities
End of talk...

Thanks!
Sheet 1 - two networks in Japan

- Time Difference Analysis
  - Count: 55718
  - RMS: 9.65
  - Median: -2.85
  - Mean: -3.58

- Position Difference Analysis
  - Count: 55718
  - RMS: 2.67
  - Median: 0.79
  - Mean: 1.53

- Time vs. Dist. diff. Log Density

SampleSpec.cfg  03-Nov-2013 15:09:11
Reference File: data/sampleRef.asc
Test File: data/sampleTest.asc

<table>
<thead>
<tr>
<th>Network</th>
<th>#CG / DE</th>
<th>#CLD / DE</th>
<th>#Corr / DE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ref.</td>
<td>62594 / (72.7)</td>
<td>2102 / (0.6)</td>
<td>55718 / (70.8)</td>
</tr>
<tr>
<td>Test</td>
<td>74002 / (87.0)</td>
<td>3841 / (1.1)</td>
<td>55718 / (86.1)</td>
</tr>
</tbody>
</table>

Classification Table:

<table>
<thead>
<tr>
<th></th>
<th>Test</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ref. CG</td>
<td>054461</td>
</tr>
<tr>
<td></td>
<td>0000006</td>
</tr>
<tr>
<td>Ref. CLD</td>
<td>001228</td>
</tr>
<tr>
<td></td>
<td>000023</td>
</tr>
</tbody>
</table>

57 rej. for separation distance  0 rej. for Type mis-match
Sheet 1 - GLD360 vs. NALDN

Time Difference Analysis
- Count: 412360
- RMS: 23.16
- Median: -2.24
- Mean: -1.37

Position Difference Analysis
- Count: 412360
- RMS: 8.78
- Median: 2.73
- Mean: 6.42

Time vs. Dist. diff. Log Density

Classification Table:
- Test
  - CG
  - CLD

Network | #CG / DE | #CLD / DE | #Corr / DE
--- | --- | --- | ---
Ref:   | 820524 / (47.6) | 639464 / (NaN) | 412360 / (61.9)
Test:  | 605645 / (36.6) | 0 / (0.0) | 412360 / (26.2)

13334 rej. for separation distance  0 rej. for Type mis-match
Sheet 2 - two networks in Japan

![Graphs showing different data distributions and correlations.](image)
Sheet 3 - two networks in Japan
Sheet 3 - GLD360 vs. NALDN

Reference LLS Estimated Loc. Error

- Count vs. Error (km)
- Matched and refOnly

Reference LLS #Sensors Reporting

- Percent vs. # Sensors
- Match and Unc.
- Count: 412360 1047628
- Mean: 8.0 4.7

Test LLS Estimated Loc. Error

- Count vs. Error (km)
- Matched and testOnly

Test LLS #Sensors Reporting

- Percent vs. # Sensors
- Match and Unc.
- Count: 412360 253485
- Mean: 3.9 3.5

NLDN_GLDrepNew.cfg 04-Nov-2013 07:03:18 -- 2011-08-04_NALDN.txt 2011_08_04_gldCluster
Flash Analysis Overview

* Flash Grouping (within an individual LLS dataset)
  * New flash is initiated if there are no “active” flashes within the max inter-pulse interval (IPI) and within the max separation distance (*typically 200 mS and 10 km for “accurate” LLS’s*)

* If there is a match with more than one active flash, then the new pulse is added to the flash with the spatially-closest pulse

* A flash is “closed” if the time between the most-recent pulse and the first pulse in the flash is greater then the max flash duration (*typically 1 second*)
**Flash Analysis Overview**

*Flash / Pulse “Typing”*

* Pulses within a CG flash are categorized as one of three types:
  * “pre” cloud: likely preliminary breakdown or leader pulse
  * “during” cloud: k-changes etc.
  * “CG” stroke: we think we knew what this is...
* Any flash containing a CG stroke is a CG flash

*A flash is detected in-common by two LLS’s if:*

* Any pulse in the flash is matched using the tight requirements employed by the Inter-comparison Tool
* Any “unmatched” pulses in the flash meet the max IPI/Distance requirements when compared to any pulse from the other LLS
Additional Flash Analysis: where (in time) are the LLS cloud pulses detected?

- The Flash Analysis includes a temporal analysis for each network
  - Are they part of a cloud flash?
  - Are they part of a CG flash?
  - What part of a CG flash?

Back
Extra Slides
How to get the stuff...

Observed CG strokes

Statistical Up-scaling Model (SUM)
August 11, 2011

Up-scaled strokes

Select one

Stroke-to-Optical Generator

Observed CG flashes

Up-scaled flashes

Climate/Weather:
- Multiplicity
- Inter-stroke interval

Observed CLD pulses

Up-scaled CLD flashes

Climate/Weather:
- “Pulse” Multiplicity
- Pulse separation Distr.

Flash Count Up-scaling

Stroke Count Up-scaling

Stroke Count Up-scaling

Pulse Count Up-scaling

CLD map-to-Optical Generator

LLS Performance:
- stroke DE
- Flash DE

CLD Performance:
- CLD Flash DE

Up-scaling Methods:
- distribution Matching
- Spatial Interpolation
- Spatial Convolution

alternate input:
LMA/LDAR

GLM Proxy Data