

\* **GLM Proxy Data Generation:  
Methods for Stroke/Pulse Level Inter-  
comparison of Ground-based Lightning  
Reference Networks**



Prepared by  
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Huntsville, AL Sept. 2011

# \* Context

## \* Requirement

- \* Ground-base lightning observations are needed to help create GLM proxy datasets over large continental and oceanic regions
- \* Observations will be provided by a variety of existing and emerging VLF/LF “LLS” datasets

## \* Approaches

- \* “bulk statistical analysis of datasets at the cell flash-rate level
- \* Detailed stroke/pulse inter-comparisons to understand what is seen uniquely and in-common by various data sources

## \* Issue

- \* LLS performance for CG strokes and cloud pulses must be characterized before it can be intelligently applied in quantitative proxy datasets
  - \* Location accuracy
  - \* Detection efficiency
  - \* Type classification (CLD/CG)
- \* Sub-context: CHUVA LLS inter-comparisons
- \* Note: Need help from modeling and independent validation where there are no comparison datasets

# \* Presentation Scope

- \* Description of the inter-comparison tool
- \* Case Study - Japan
- \* Case Study - GLD360
- \* GLD “show and tell”
- \* Next Steps

# \* What can you detect?

## \* VHF vs. VLF/LF Cloud Flash Detection

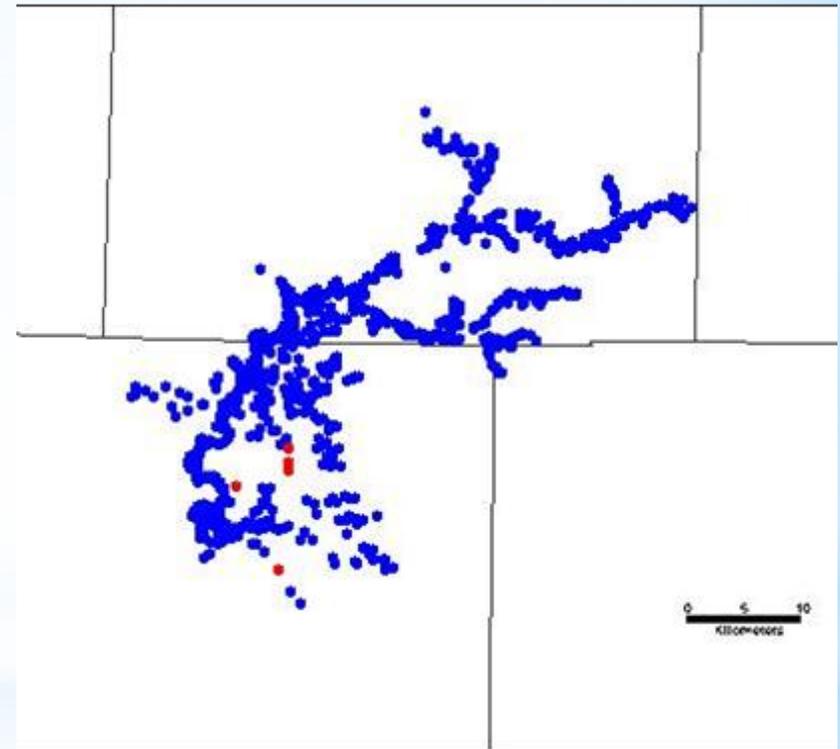
\* The pulses detected by a moderate baseline (~200-300 km) LF/VLF cloud detection system (red dots) generally cluster near the initial breakdown region shown in the 2-D flash depiction using a VHF mapping system (blue dots).

\* “Reasons” (2/3 - truths)

\* VHF emitted during breakdown (spark) and leader processes

\* Lower frequencies easily generated by “longer” (time duration and/or channel-length) processes

\* Channels must be “substantially vertical” for large EM fields to propagate 100’s of km => significant vertical orientation and depth of charge structure



# \* What can you detect?

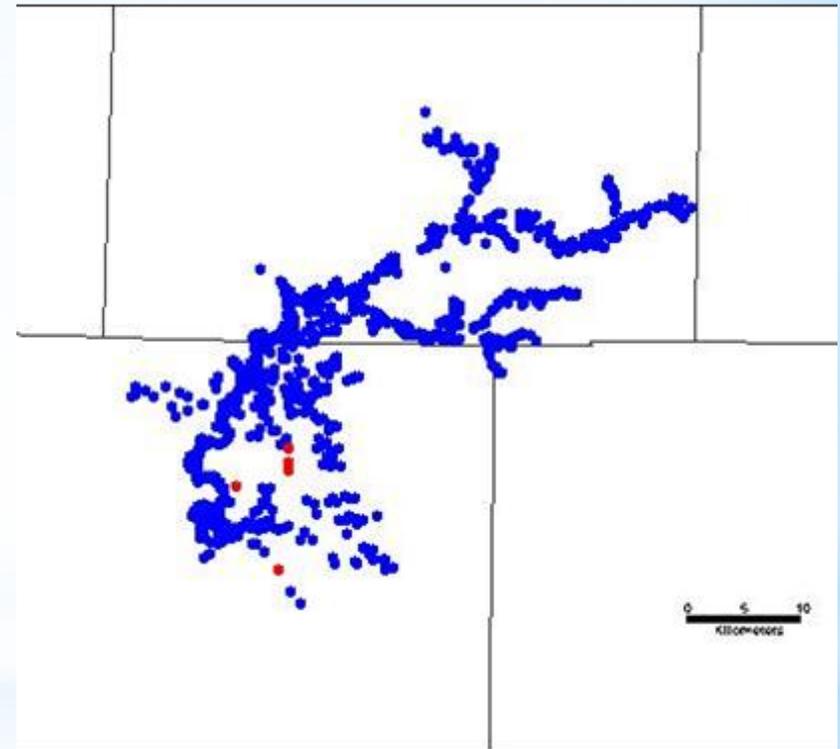
## \* VHF vs. VLF/LF Cloud Flash Detection

### \* Disadvantage of LF/VLF:

- \* Limited description of the spatial extent of a cloud flash (or the charged regions of a mature thunderstorm)

### \* Benefits:

- \* Ability to provide reasonable storm onset information
- \* Quantifiable flash-rate information
- \* EM signals propagate well through mountainous terrain (no line-of-sight constraint).
- \* EM signals will be better-correlated with optical emissions observed from space.



# \* Inter-comparison Tool

- \* Coded in Matlab
- \* Stand-alone executables can run on Unix, Linux, and Windows
- \* Can specify datasets and related parameters in a “cfg” file using a text editor...

```
# 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.mmmmmmm)
#   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) =
DT(uS)*0.3(km/uS)
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:

- \* Requires date, time, lat, lon, and (optionally) type (CG/CLD pulse)

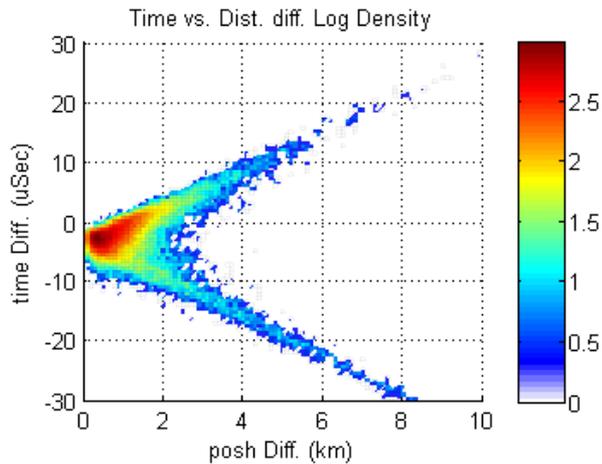
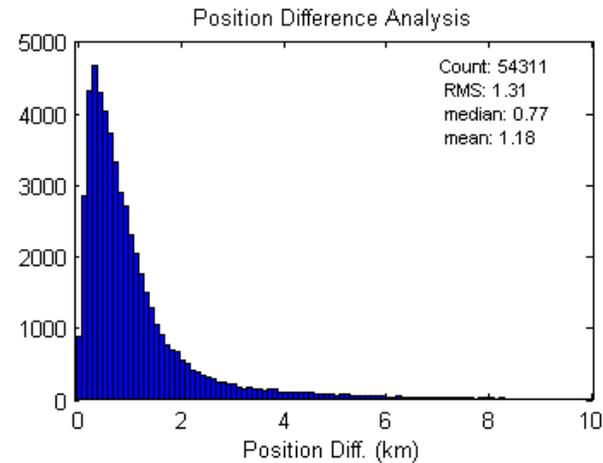
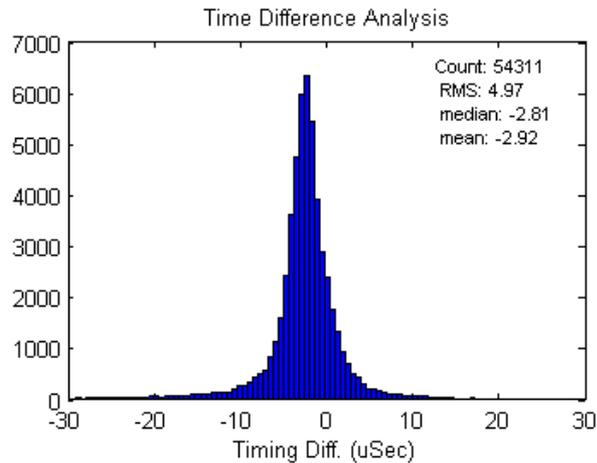
### \* Sheet 2:

- \* Requires peak current estimates

### \* Sheet 3:

- \* Requires quality-related parameters
  - \* location error estimate
  - \* # sensors reporting the stroke/pulse

# \* Sheet 1 - Japan Case



Tohoku\_imp\_LS.cfg 02-Sep-2011 11:41:49  
Reference File: data/Tohoku\_Jul2011.IMPACT.txt  
Test File: data/Tohoku\_Jul2011.LS.txt

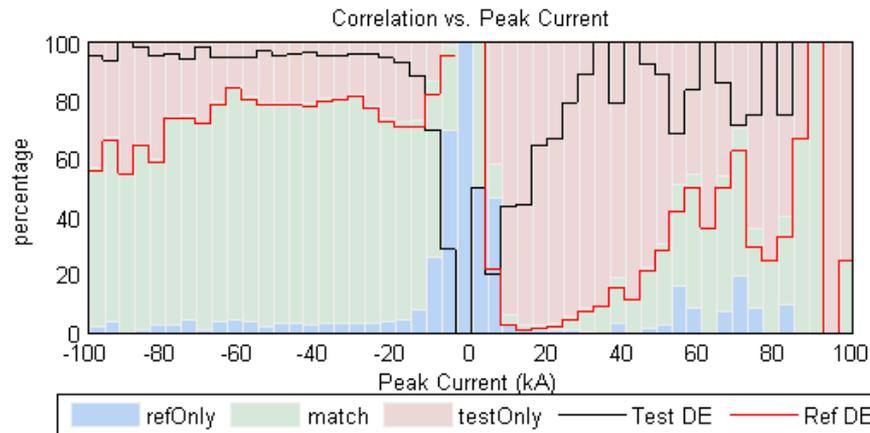
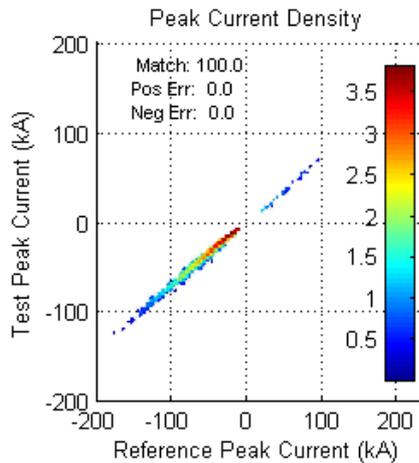
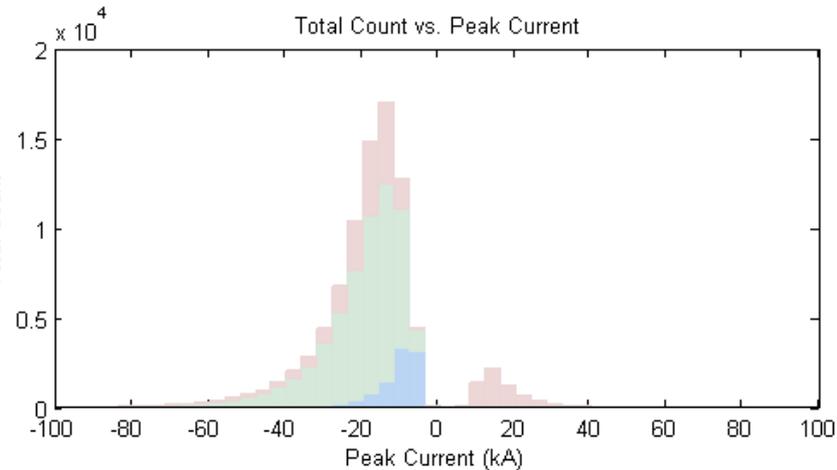
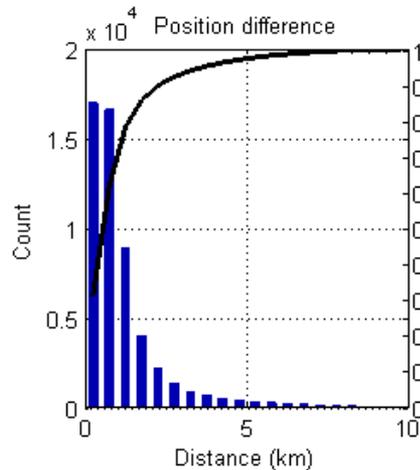
Network	#CG / DE	#CLD / DE	#Corr / DE
Ref:	62505 / (70.9)	2102 / (32.1)	54311 / (69.0)
Test:	74873 / (86.8)	3841 / (1.3)	54311 / (84.1)

Classification Table:

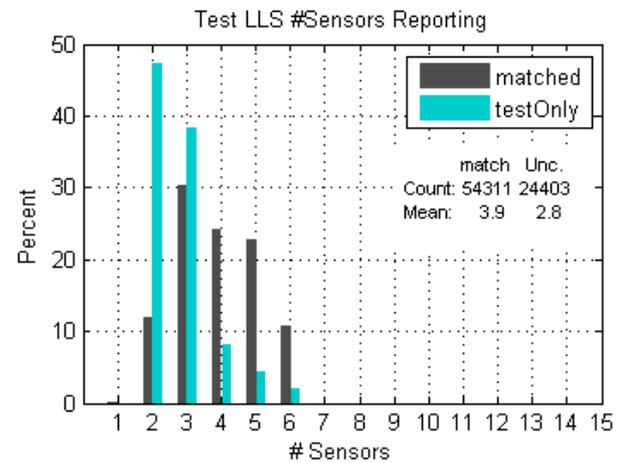
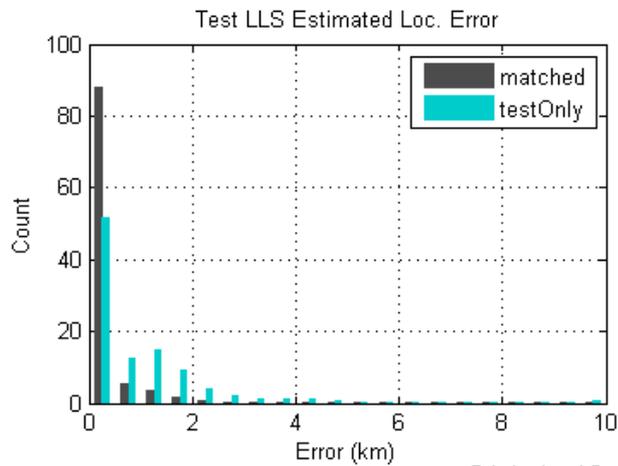
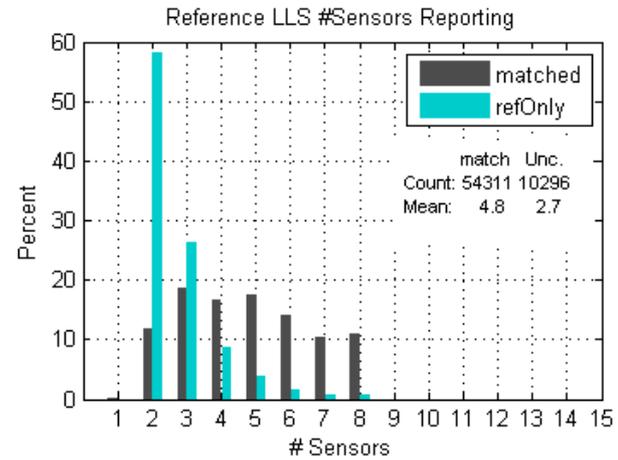
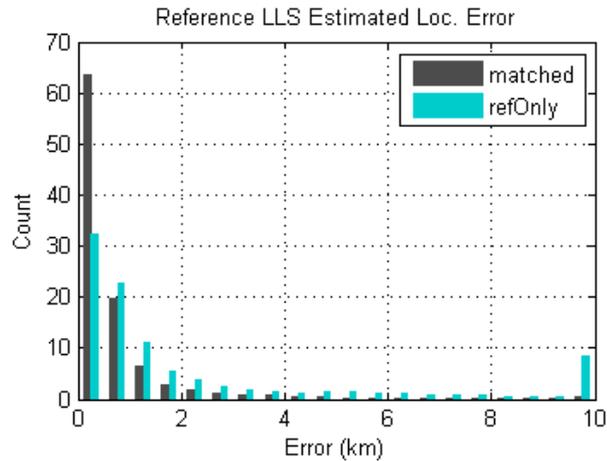
	Test	
	CG	CLD
Ref. CG	053073	000005
Ref. CLD	001210	000023

172 rej. for separation distance    0 rej. for Type mis-match

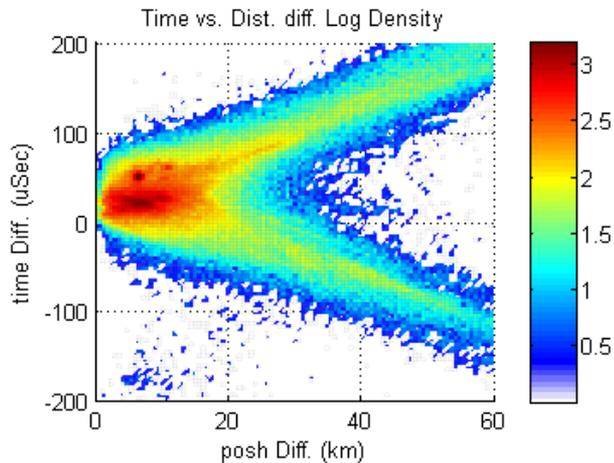
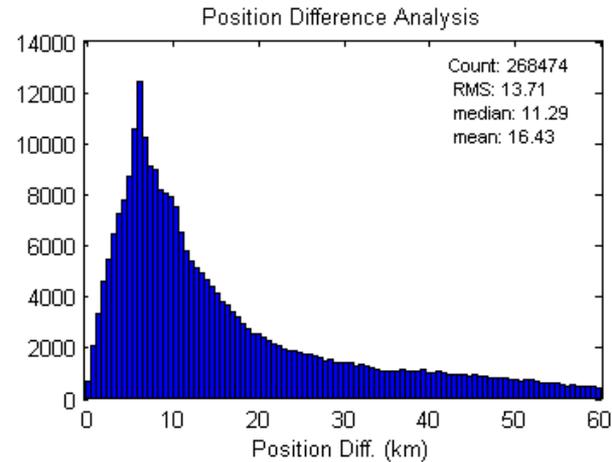
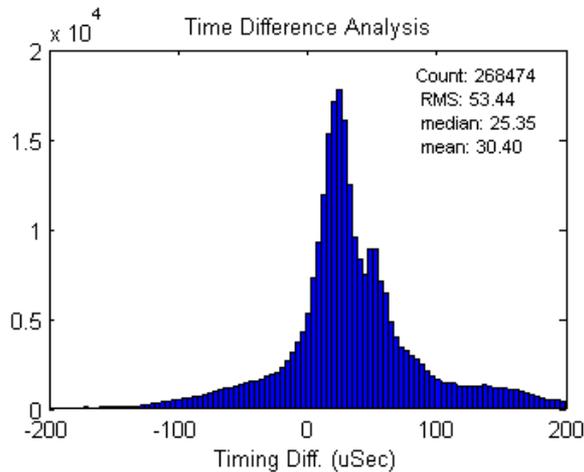
# \* Sheet 2 - Japan Case



# \* Sheet 3 - Japan Case



# \* Sheet 1 - GLD360 vs. NLDN (real-time operation)



NLDN\_GLDrt.cfg 15-Sep-2011 15:28:06  
Reference File: data/2011\_07\_27\_NALDN.asc  
Test File: data/2011\_07\_27\_gld\_RT.asc

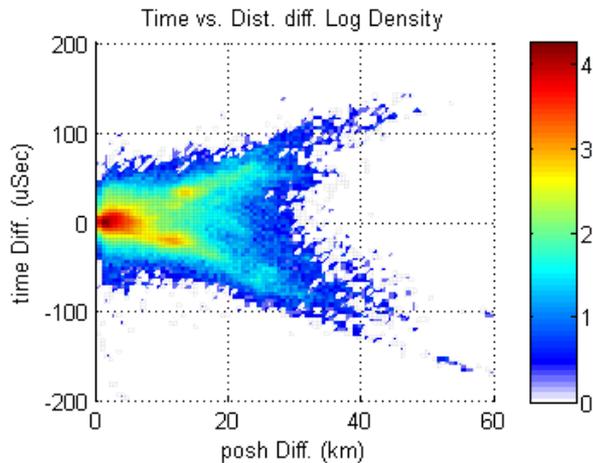
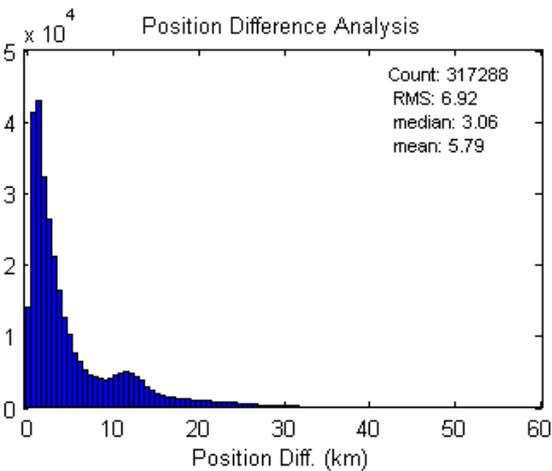
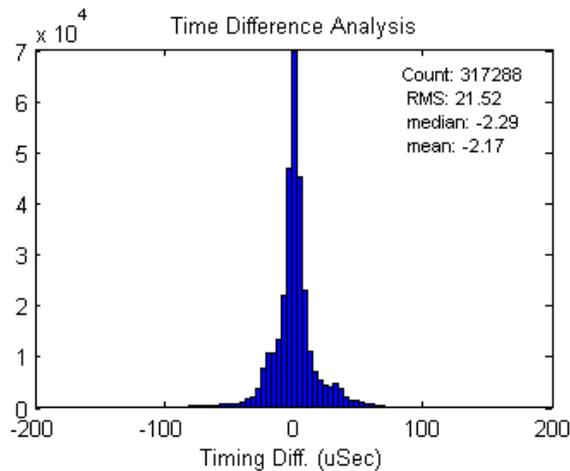
Network	#CG / DE	#CLD / DE	#Corr / DE
Ref:	391809 / (25.0)	171859 / ( NaN)	268474 / (32.8)
Test:	817727 / (52.2)	0 / ( 0.0)	268474 / (47.6)

Classification Table:

	Test	
	CG	CLD
Ref. CG	204599	000000
Ref. CLD	063875	000000

14408 rej. for separation distance      0 rej. for Type mis-match

# \* Sheet 1 - GLD360 vs. NLDN (Vaisala's upcoming algorithm release)



NLDN\_GLDrep.cfg 15-Sep-2011 10:51:29  
Reference File: data/2011\_07\_27\_NALDN.asc  
Test File: data/2011\_07\_27\_gld\_reproc.asc

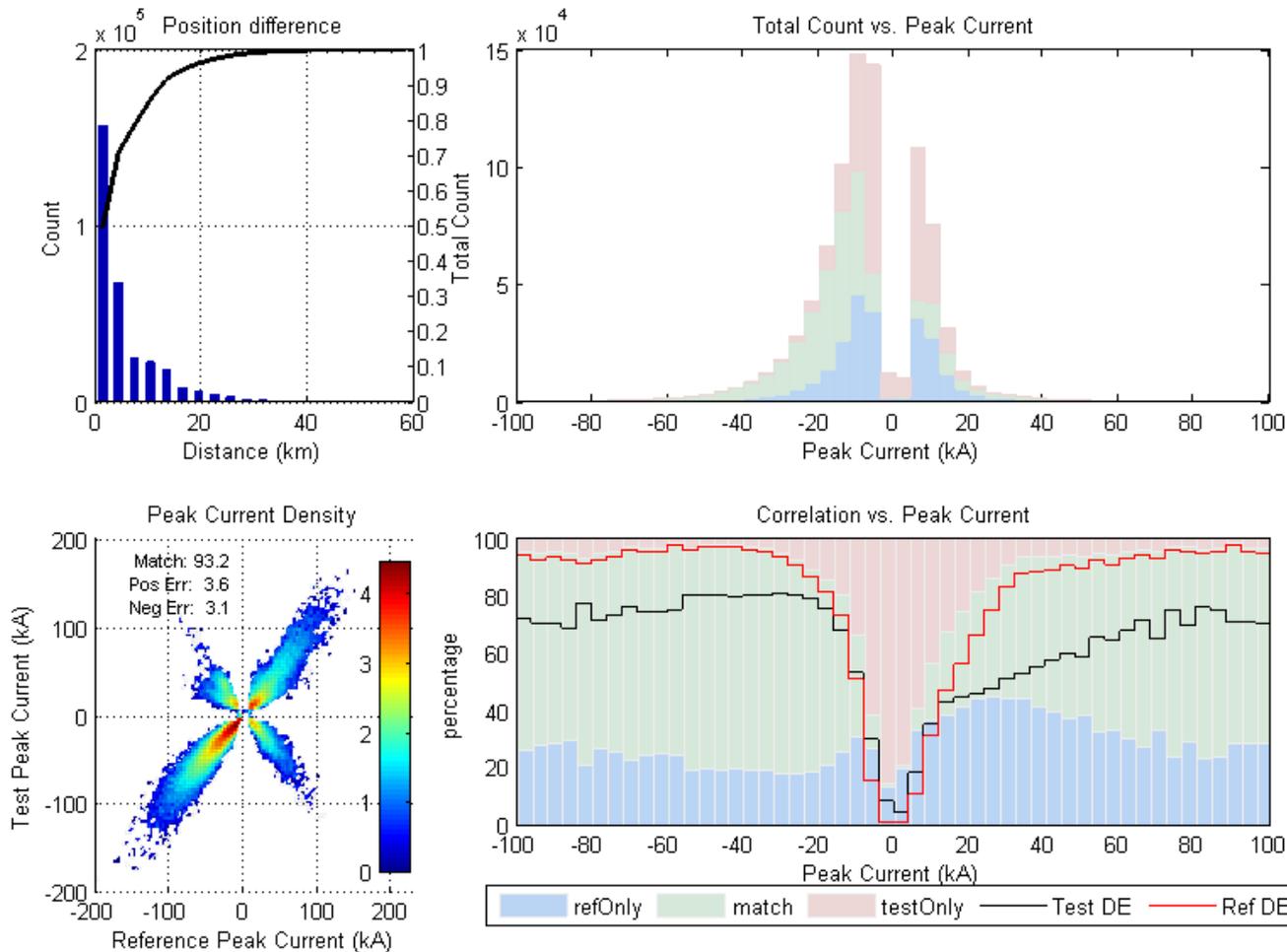
Network	#CG / DE	#CLD / DE	#Corr / DE
Ref:	391692 / (42.2)	171811 / ( NaN)	317288 / (50.6)
Test:	627174 / (67.6)	0 / ( 0.0)	317288 / (56.3)

Classification Table:

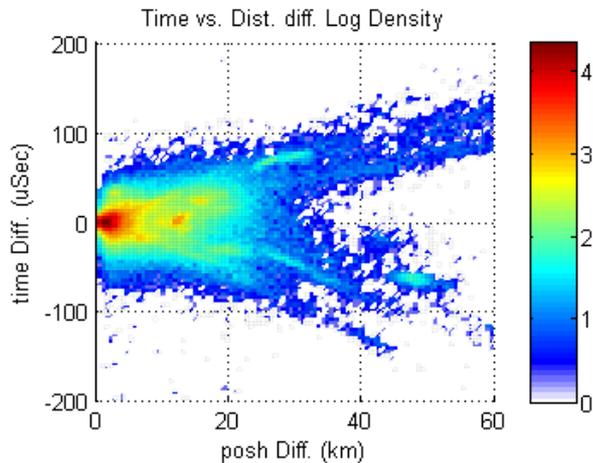
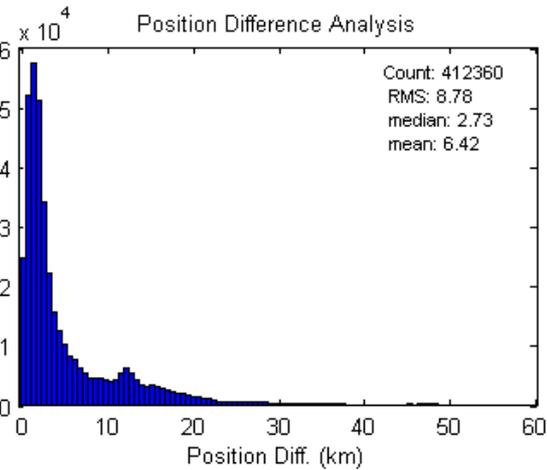
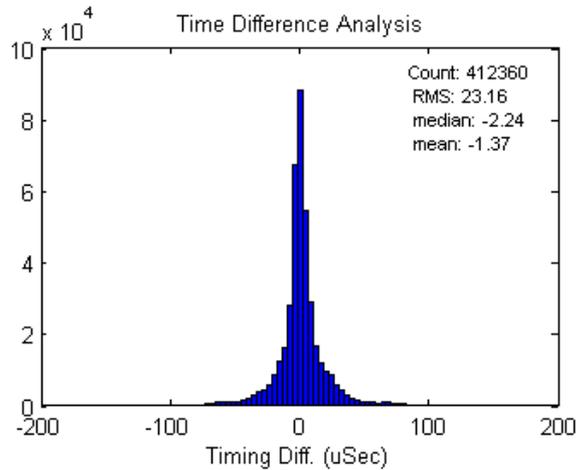
	Test	
	CG	CLD
Ref. CG	264968	000000
Ref. CLD	052320	000000

5559 rej. for separation distance      0 rej. for Type mis-match

# \*Sheet 2 - GLD360 vs. NLDN (Vaisala's upcoming algorithm release)



# \*Sheet 1 - GLD360 vs. NLDN ("bad day" operation - 2 local sensors)



NLDN\_GLDrep.cfg 15-Sep-2011 11:29:44  
Reference File: data/2011-08-04\_NALDN.txt  
Test File: data/2011\_08\_04\_gldCluster

Network	#CG / DE	#CLD / DE	#Corr / DE
Ref:	820524 / (47.6)	639464 / ( NaN)	412360 / (81.9)
Test:	665845 / (38.6)	0 / ( 0.0)	412360 / (28.2)

Classification Table:

	Test	
	CG	CLD
Ref. CG	316817	000000
Ref. CLD	095543	000000

13334 rej. for separation distance    0 rej. for Type mis-match

# \* Closing Comments/movies

- \* GLD Interpretation
  - \* Real-time data have
    - \* large location errors/scatter
    - \* Many duplicate solutions for the same events
    - \* Poor Ip estimates (not shown)
  - \* Future product generator has
    - \* 3-5 km median LA
    - \* ~50%/30% stroke DE over U.S. (good/bad days) => ~80%/60% flash DE)
    - \* Sees many events not reported by the NLDN (low-current strokes and cloud pulses?)
    - \* Good Ip estimates (>90% correct polarity)

# \* Future Directions

## \* Tool

- \* Spatial map of correlated and uncorrelated datasets
- \* Spatial DE map accumulated over many days
- \* Temporal DE curve
- \* Detailed flash analysis
  - \* Flash DE
  - \* Relative counts of flashes:
    - \* CLD, CG, and CG w/ CLD

## \* Analysis

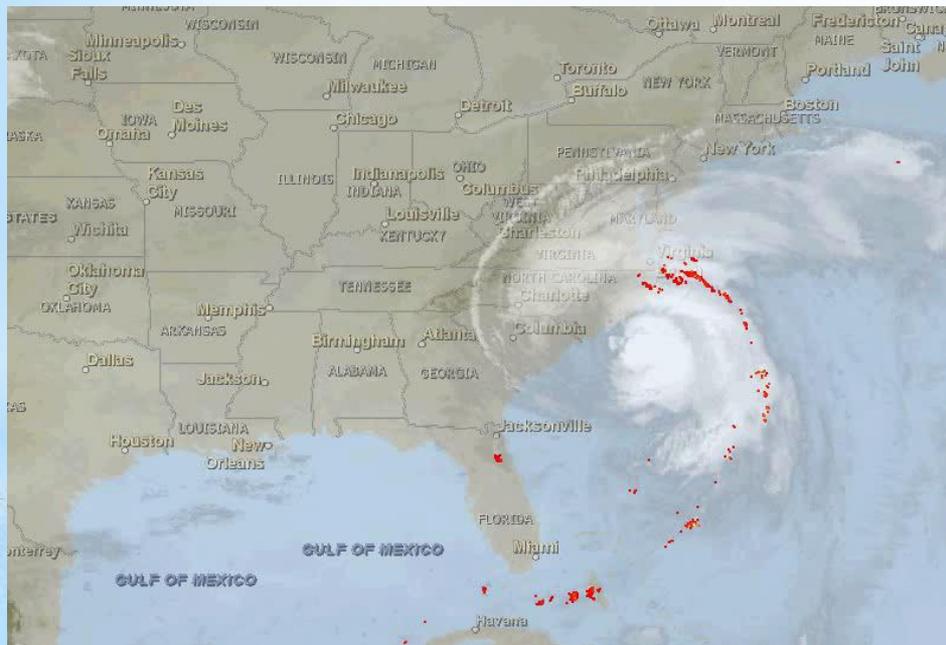
- \* Extensive GLD/NLDN comparisons
  - \* Land-only
  - \* Land-to-sea
- \* Other network inter-comparisons (directed or carried out by NASA/UAH)
- \* Employ performance values in proxy generator/products
  - \* “up-scale” LLS-based data
  - \* Help understand cell-based datasets and results

# \* Hurricane Irene

August 25-29, 2011

\* NLDN + IR

\* GLD360 + IR



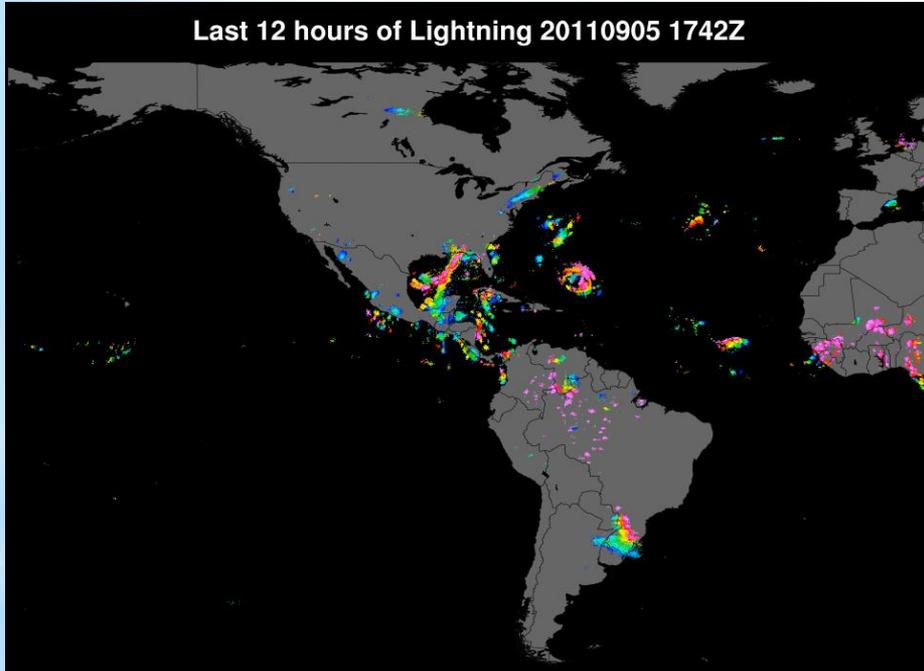
# \* Recent Data

(U-of-AZ display)

\* Western Hemisphere  
(Hurricane Katia)

\* Eastern Hemisphere

Last 12 hours of Lightning 20110905 1742Z



Last 12 hours of Lightning 20110919 1124Z

