On the Relationship between Observations from the Lightning Imaging Sensor and Ground-based Lightning Observations at VLF, LF, and VHF Frequencies

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Background and Scope

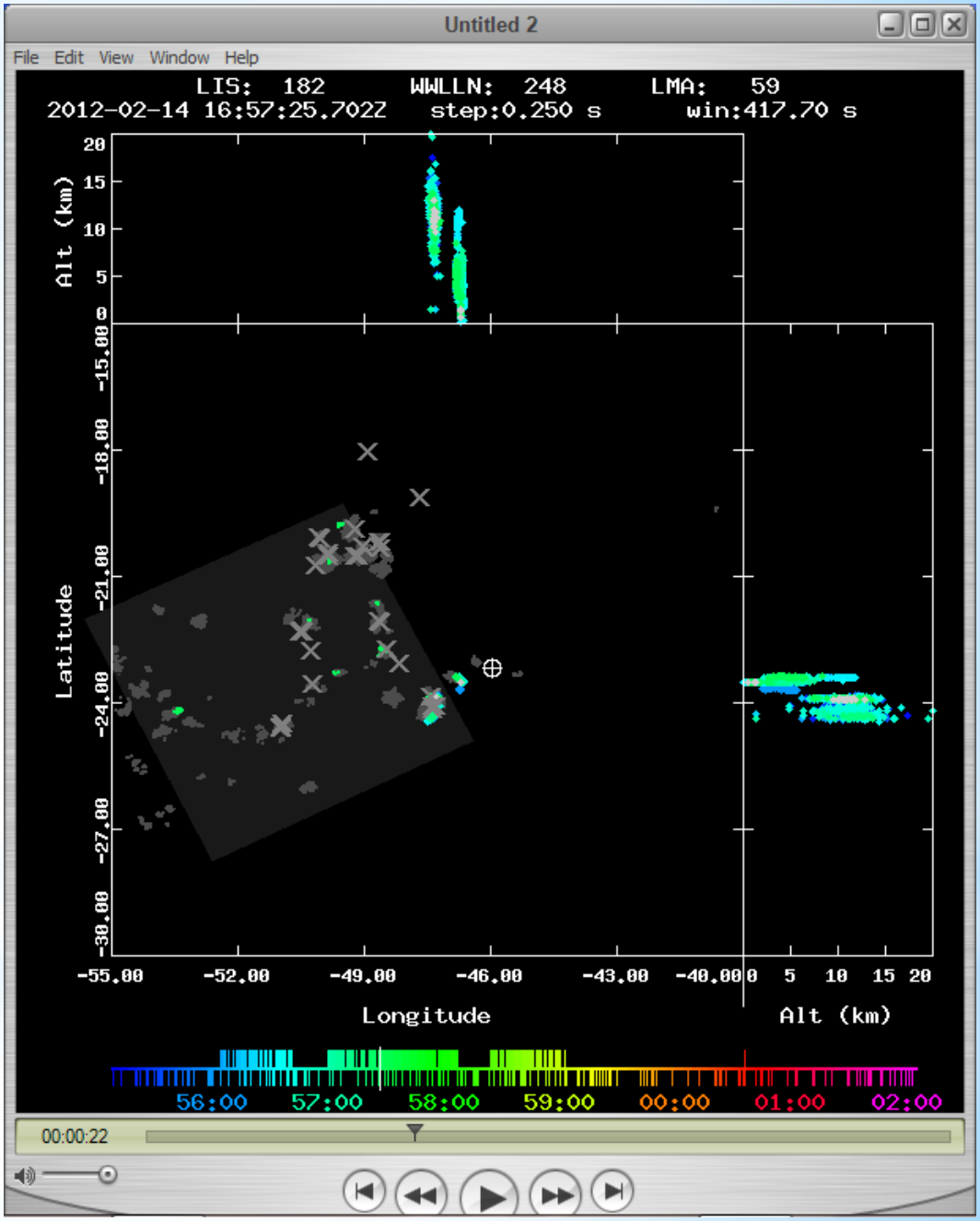
* GLM needs “all kinds of LLS data” for:
  * Proxy product generation
  * Post-launch validation

* For each candidate dataset we need to:
  * Quantify its relationship to LIS Events/Groups
  * Quantify the relative data quality related to LIS and the other datasets

* This Presentation:
  * Description / Demonstration of a LIS:LLS Space:Time exploration tool
  * Description / Demonstration of LLS inter-comparison tool

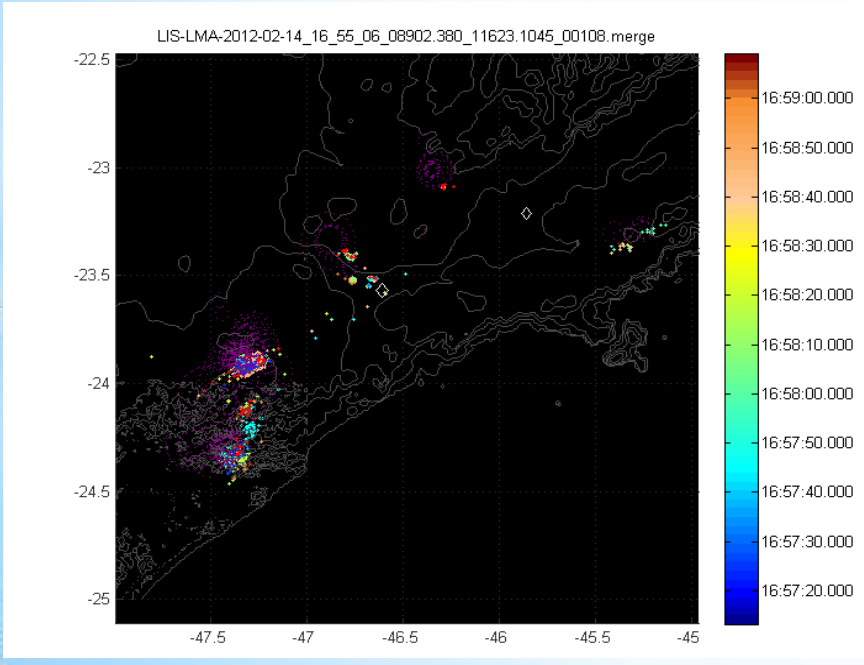
Monte's Movies

(no…, not Monty Python…)

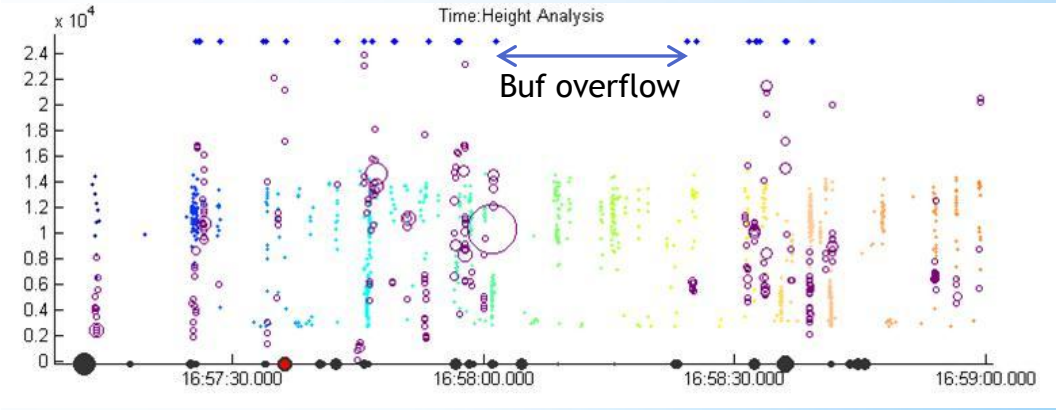


LIS Group Analysis Tool
Example: LIS, SPLMA, and TLS-CG

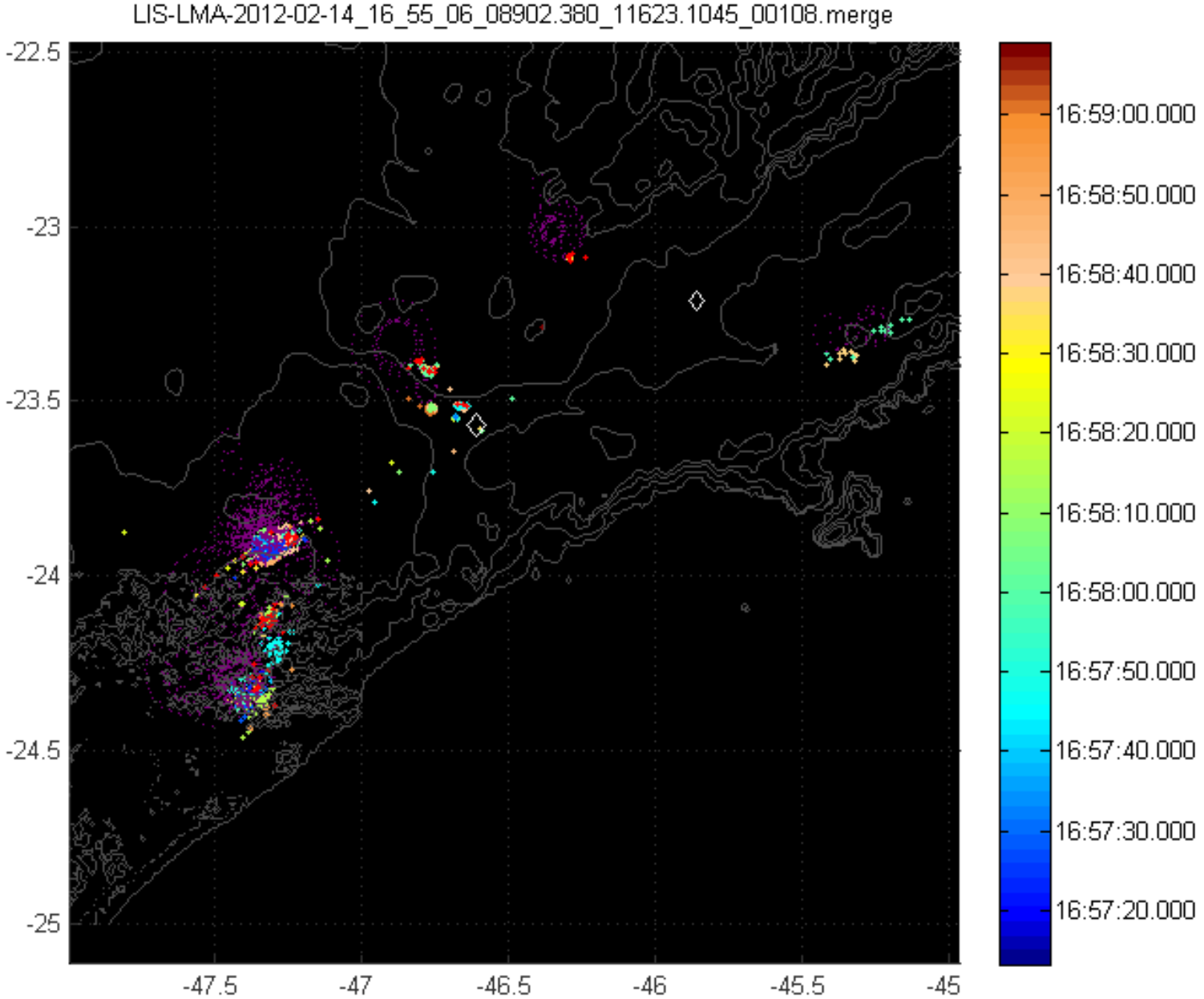
- Spatial Analysis
  - Limited to LIS swath coverage for each second
  - LIS Groups: Magenta circles w/ area = LIS group area
  - LMA: sources color-coded by time
  - TLS-CG: red "dots"



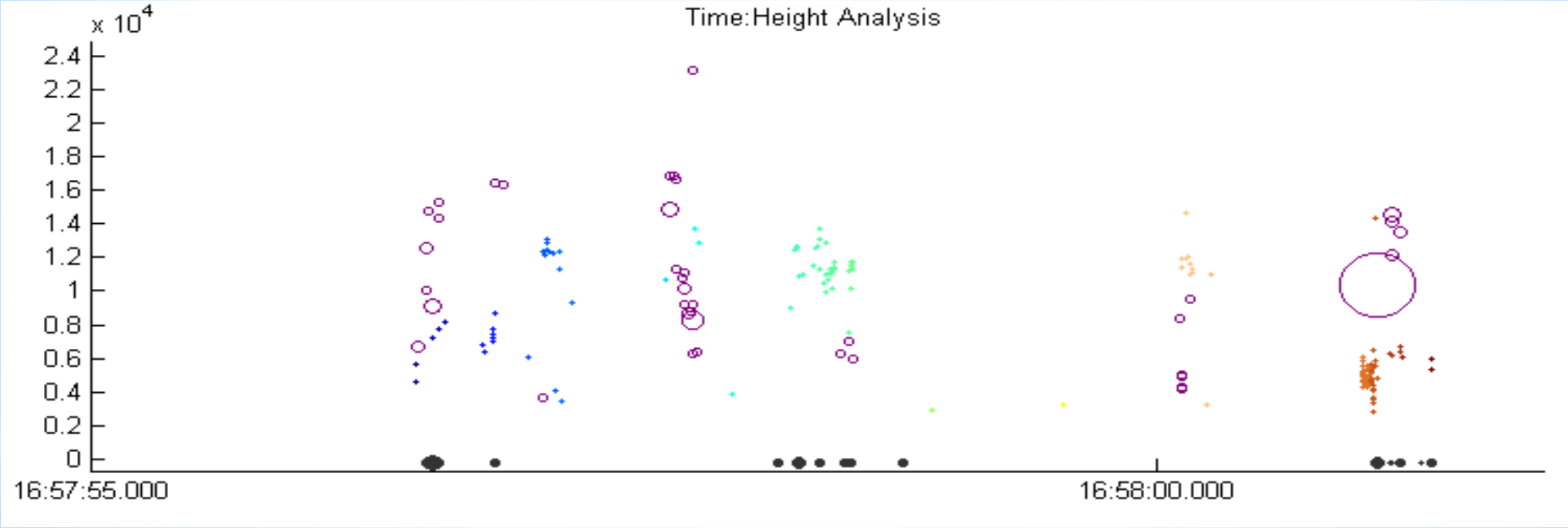
- Time:Height Analysis
  - LIS Groups:
    - area ∝ to radiance
    - "Height" ∝ distance from 7 closest LMA sources
  - LMA: same "time" color scale as spatial analysis
  - TLS-CG
    - Area ∝ peak current
    - Black: negative
    - Red: positive



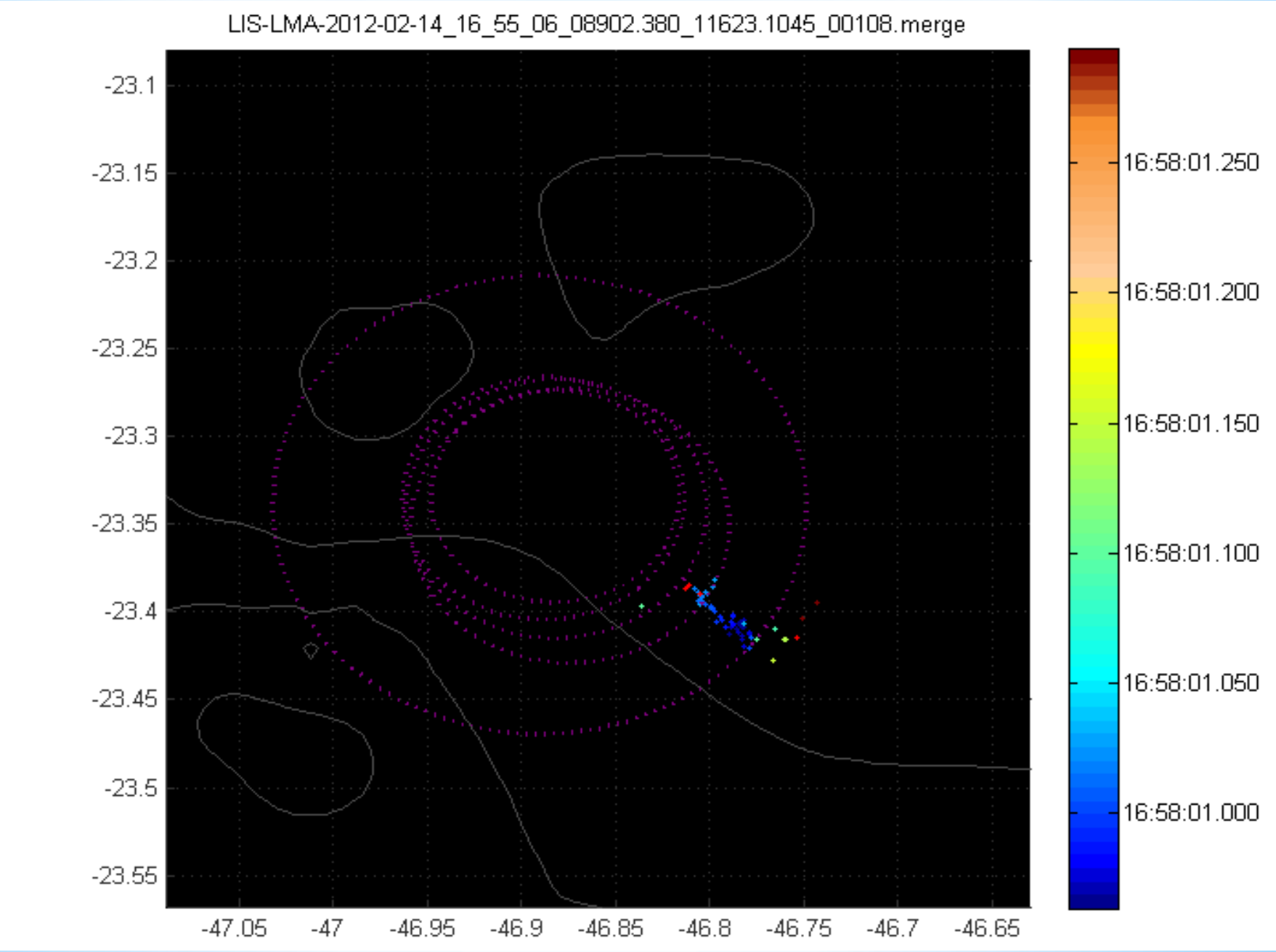
Spatial Analysis



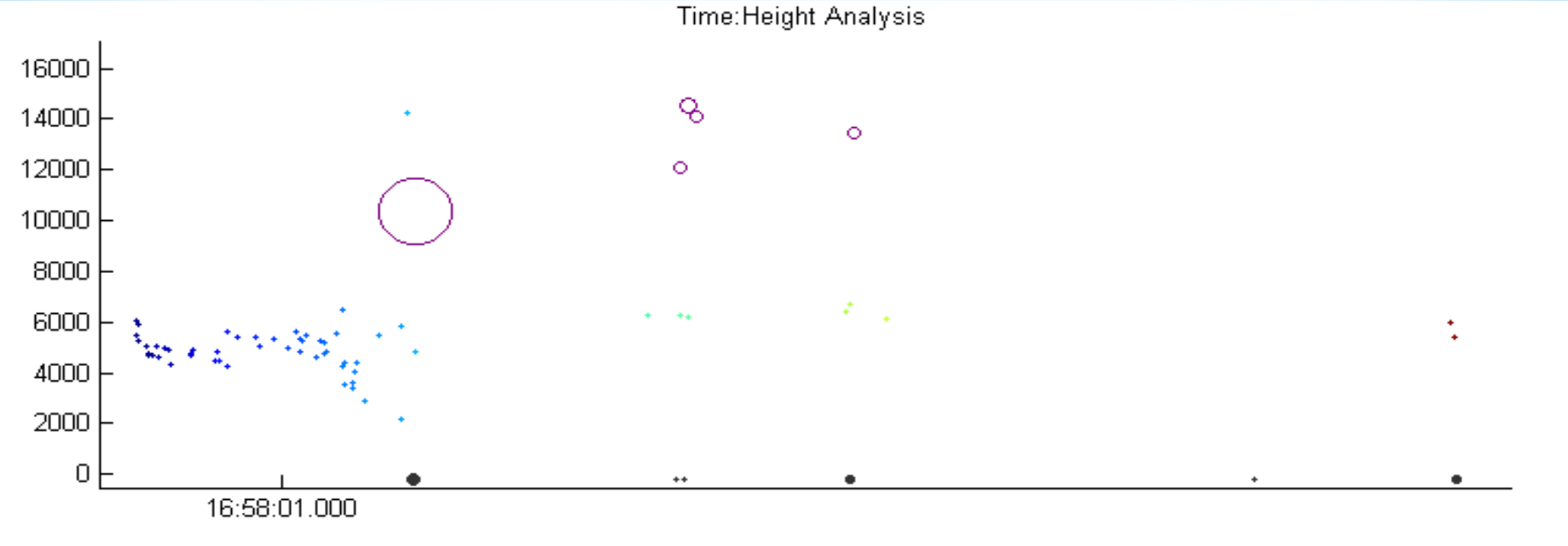
*Temporal Analysis



Spatial Analysis – single flash



*Temporal Analysis – single flash



LLS Inter-comparison Tool

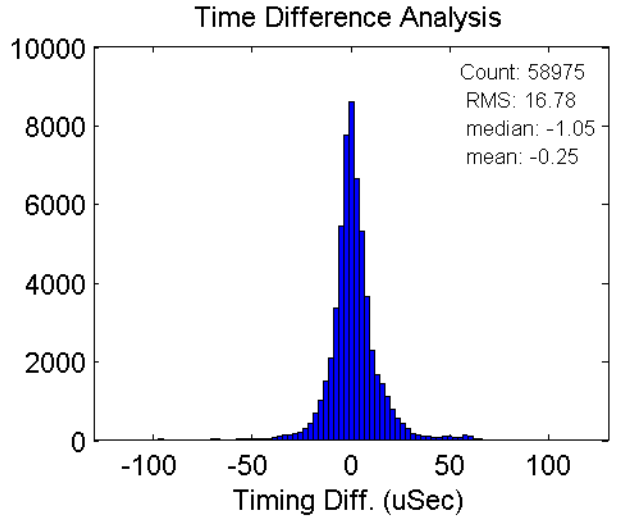
* Coded in Matlab
* Stand-alone executables can run on Unix, Linux, and Windows
* Can specify datasets and related parameters in a "cfg" file using a text editor…

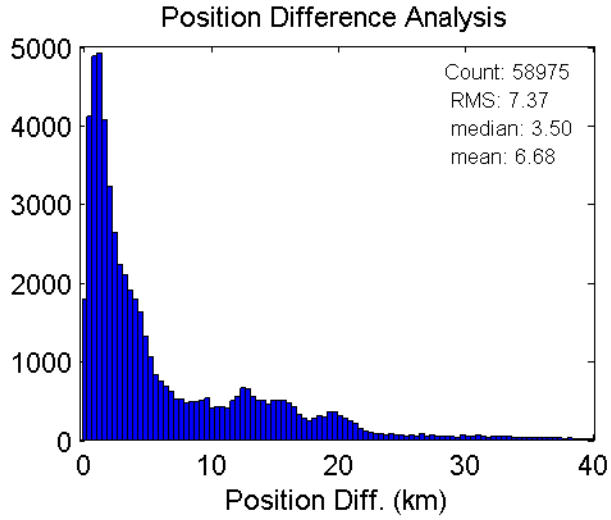
```
# sample Spec file for LLS comparison
# written by Ken Cummins,  July 2011

# Definition of possible fields in each data file
#    Date (D): date yyyy-mm-dd
#    Time (O): Occurrence time (hh:mm:ss.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) =
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.
```

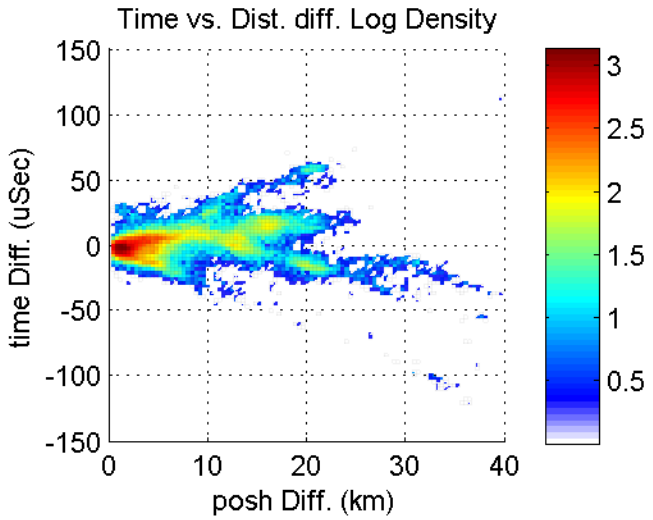
Tool "Outputs"

- 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
- Spatial Detection Efficiency
- Flash Analysis

* Sheet 1 - CHUVA TLS-CG vs. GLD360







GLD_TLS-LF.cfg 16-Mar-2013 20:34:00
Reference File: 20120105.asc
Test File: 2012.01.05.gld360.txt

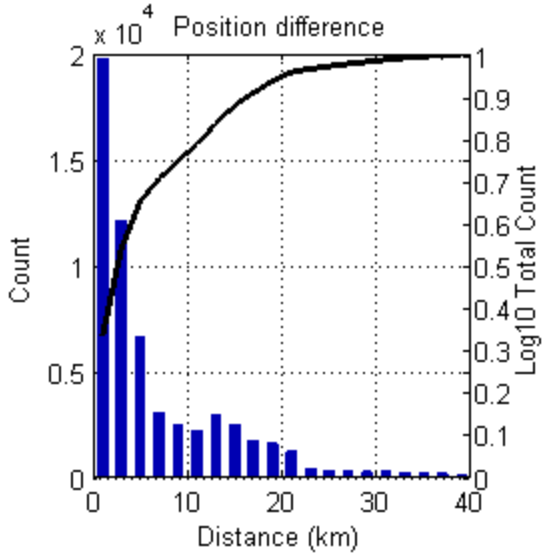
Network	#CG / DE	#CLD / DE	#Corr / DE
Ref:	137429 / (53.7)	0 / (NaN)	58975 / (53.7)
Test:	109861 / (42.9)	0 / (NaN)	58975 / (42.9)

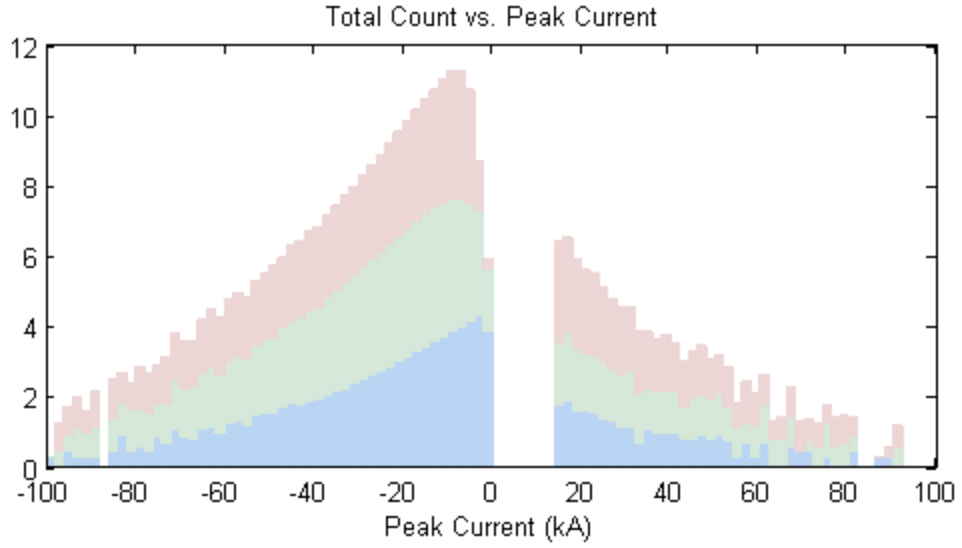
Classification Table:

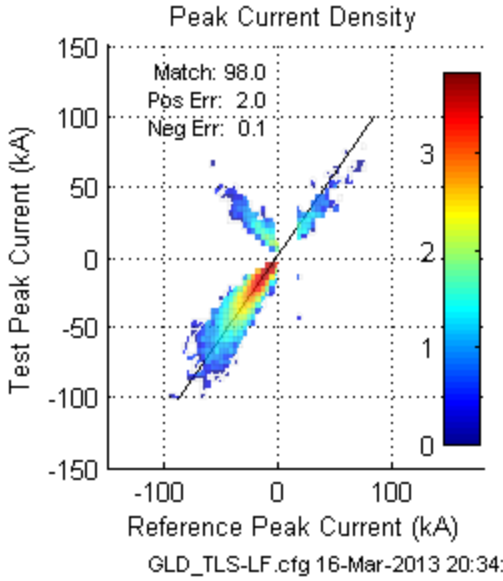
	Test CG	Test CLD
Ref. CG	058975	000000
Ref. CLD	000000	000000

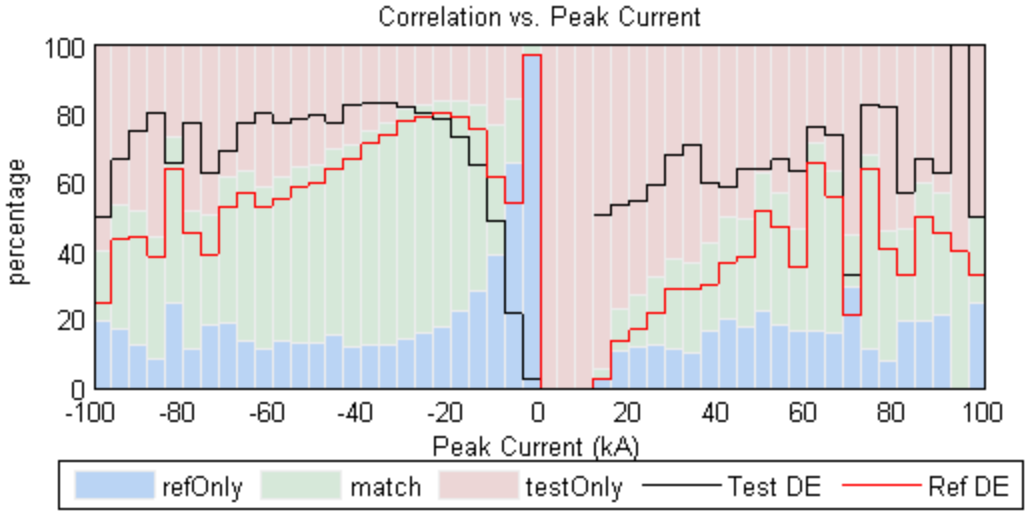
1128 rej. for separation distance 0 rej. for Type mis-match

* Sheet 2 - CHUVA TLS-CG vs. GLD360

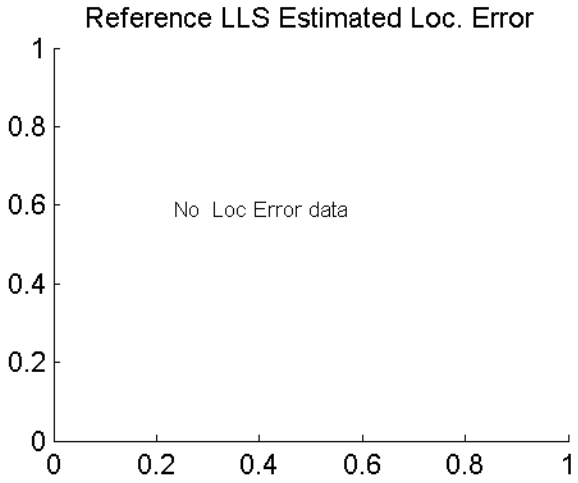


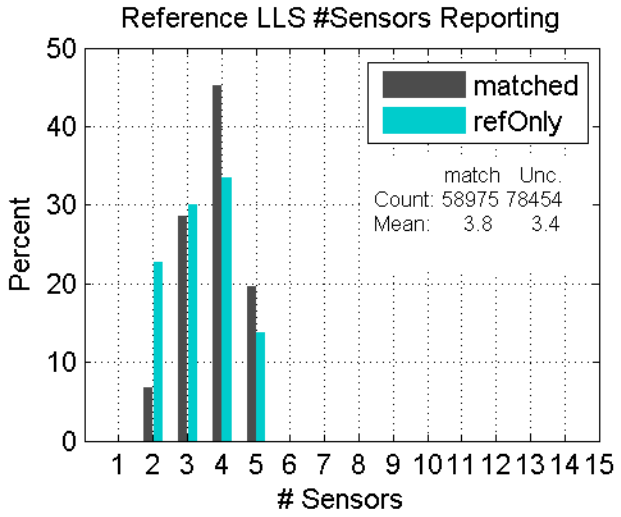


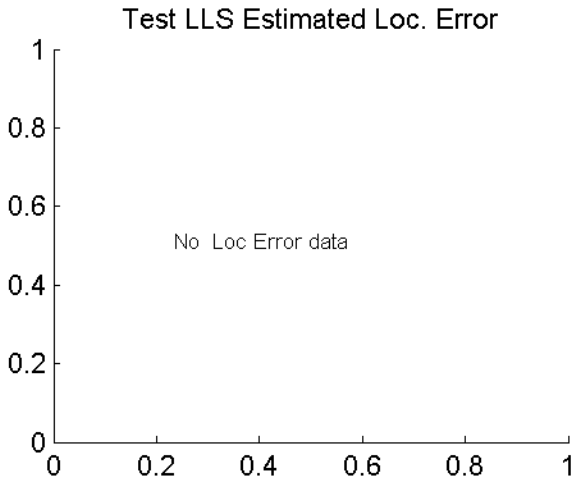


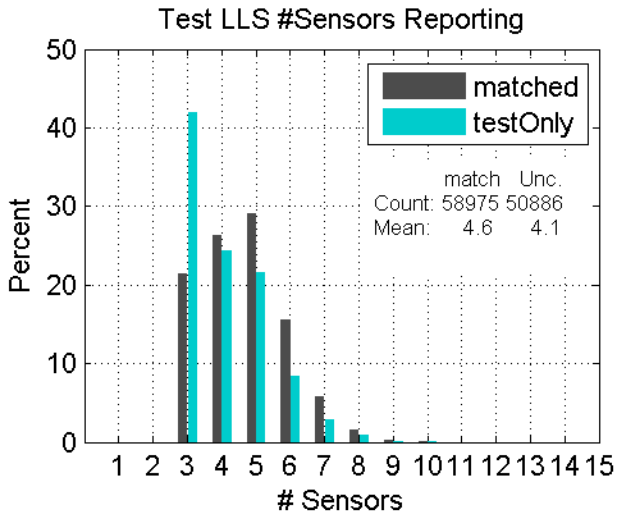


* Sheet 3 - CHUVA TLS-CG vs. GLD360



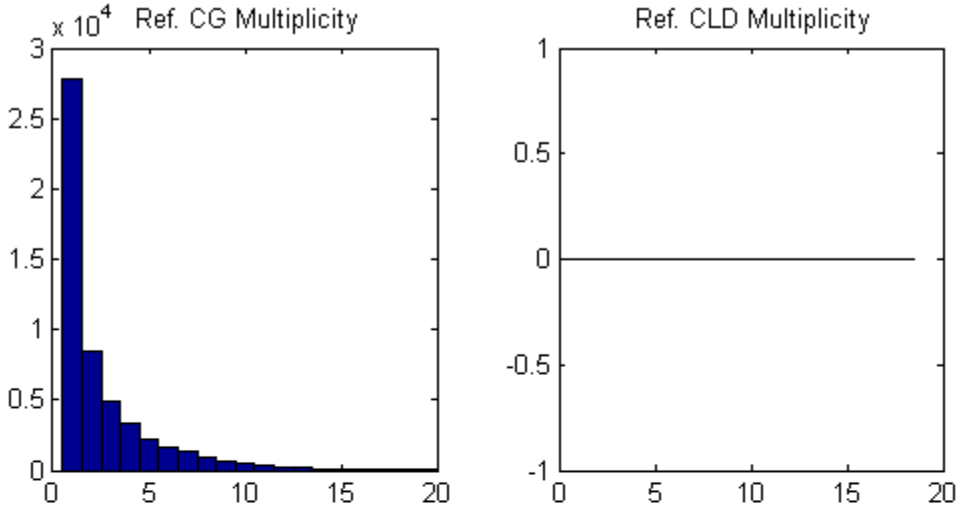






GLD_TLS-LF.cfg 16-Mar-2013 20:34:00 --
\\INTELMULTI-KEN\Users\Kens_shared\CHUVA_GLM_2012-13\TLS200LF-level_1b\20120327.asc - accum -

Flash - CHUVA TLS-CG vs. GLD360



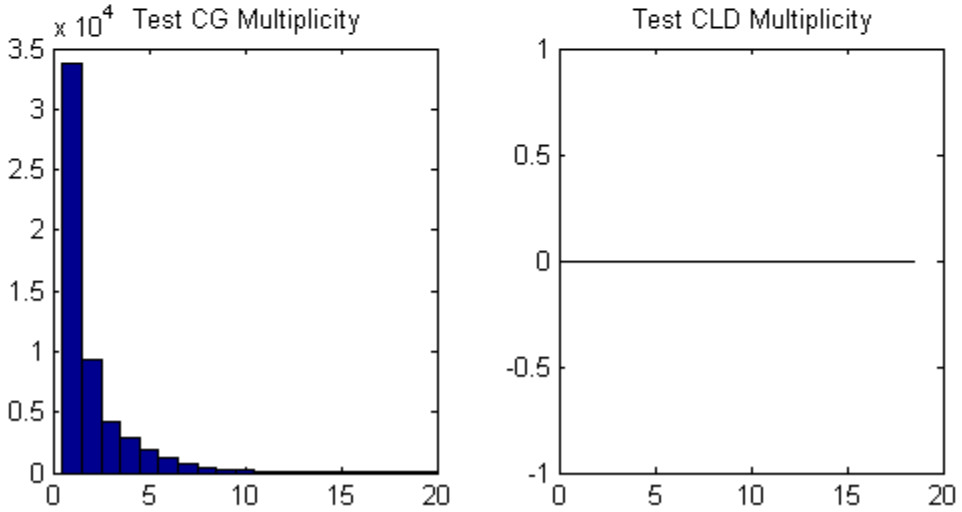
Flash Analysis

------ Reference Network ----

---Type---	Flashes	Mult
CG	053061	2.59
CLD	000000	NaN
CLD-in-CG	000000	0.00
PreCld	000000	

Flash Detection Efficiency

refCG	testCG	refCLD	testCLD
49.9	47.2	NaN	NaN

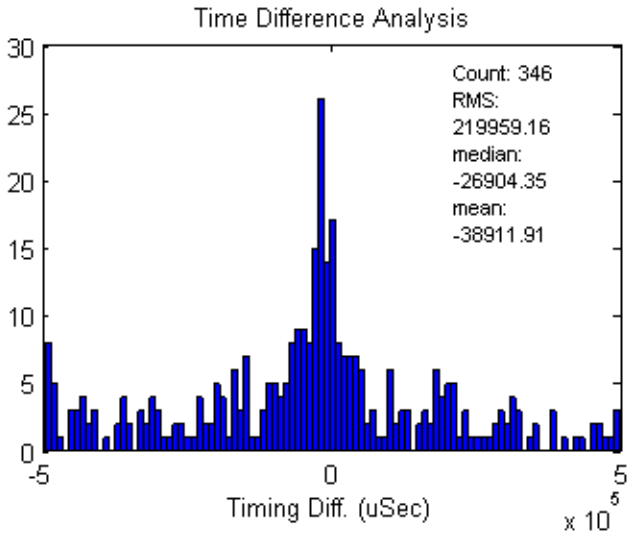


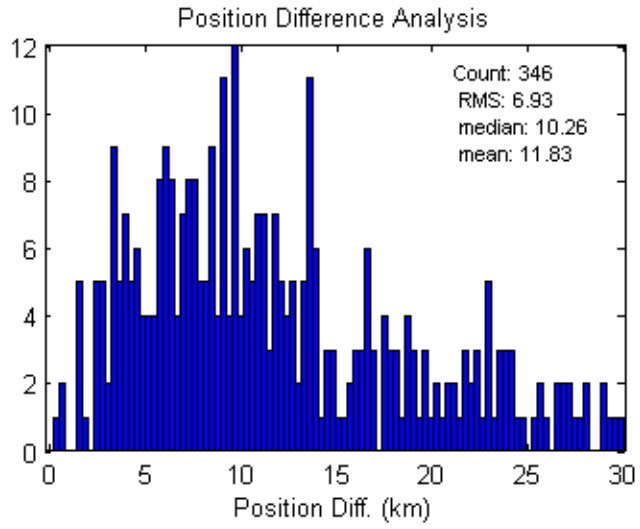
------ Test Network ----

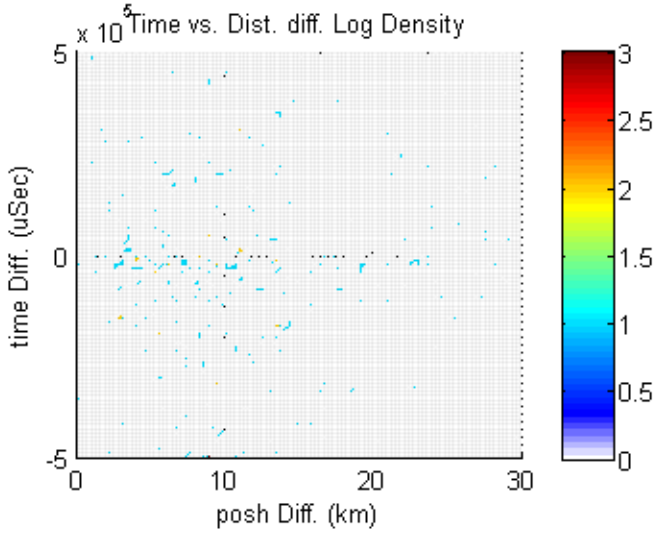
---Type---	Flashes	Mult
CG	055290	1.99
CLD	000000	NaN
CLD-in-CG	000000	0.00
PreCld	000000	

GLD_TLS-LF.cfg 16-Mar-2013 20:34:00 -- \\NTELMULTI-KEN\Users\Kens_shared\CHUVA_GLM_2012-13\TLS200LF-level_1b\20120327.asc - accum - \\NTELMULTI-KEN\Users\Kens_shared\CHUVA_GLM_2012-13\GLD360-level_1b\2012.03.27.gld360.txt

* Sheet 1 - LIS Groups vs. GLD360







LIS_GLD.cfg 09-May-2013 04:43:41
Reference File: LIS-LMA-2012-01-01_15_01_16_01330_LIS.txt
Test File: 2012.01.01.gld360.txt

Network	#CG / DE	#CLD / DE	#Corr / DE
Ref:	10262 / (0.3)	0 / (NaN)	346 / (0.3)
Test:	134431 / (3.4)	0 / (NaN)	346 / (3.4)

Classification Table:

	Test CG	Test CLD
Ref. CG	000346	000000
Ref. CLD	000000	000000

17276 rej. for separation distance 0 rej. for Type mis-match

Flash Summary Statistics

* METHOD:
  * Produced flashes from LIS Groups (30 km / 0.5 seconds clustering)
  * Determined mean groups/flash and strokes/flash
  * Identified LIS flashes with time-correlated LLS data
    * GLD360 “events” (CG strokes and cloud pulses)
    * TLS CG strokes
    * TLS CG strokes and cloud pulses (not in CHUVA dadaset)

LLS Network	# of LIS Flashes	Relative Group DE	Relative Flash DE	Mean Groups/fl.	Mean str./fl.
GLD360	1289	3.4	14.7	7.96	1.94
TLS-CG	433	4.1	20.1	7.05	2.85
TLS-LF ”all”	446	5.8	49.8	7.78	2.78

Summary / Comments

* LLS Correlation with LIS data must be done carefully
  * Must track the LIS "Swath" every second
  * Watch out for LIS buffer overruns
  * There may be small parallax issues with LIS data
  * LIS radiance may be a complicated function of peak current, channel geometry and path

* LLS Relative Performance vs. LIS Total Lightning
  * GLD < TLS CG < TLS(LF) CG+CLD < TLS VHF (studied elsewhere)
  * CG+ CLD data produced by the TLS LF "Short baseline" (~100 km) network was able to report ~ 50% of the LIS flashes
  * GLD might be sufficiently good to allow statistical up-scaling of the data for mid-oceanic LIS proxy data

Future Directions

* Analyze/compare other CHUVA LLS datasets
  * Relative to each other
  * Relative to LIS groups/flashes

* Try to use above results to allow statistical up-scaling of LLS data for proxy product generation and pre-calibration of post-launch validation systems

* Formalize correlation between LLS estimated peak current (CG and CLD pulses) and LIS group radiance and group area