Earth Networks Total Lightning Network (ENTLN) Detection Efficiency versus LIS for 2011-2013 in North America

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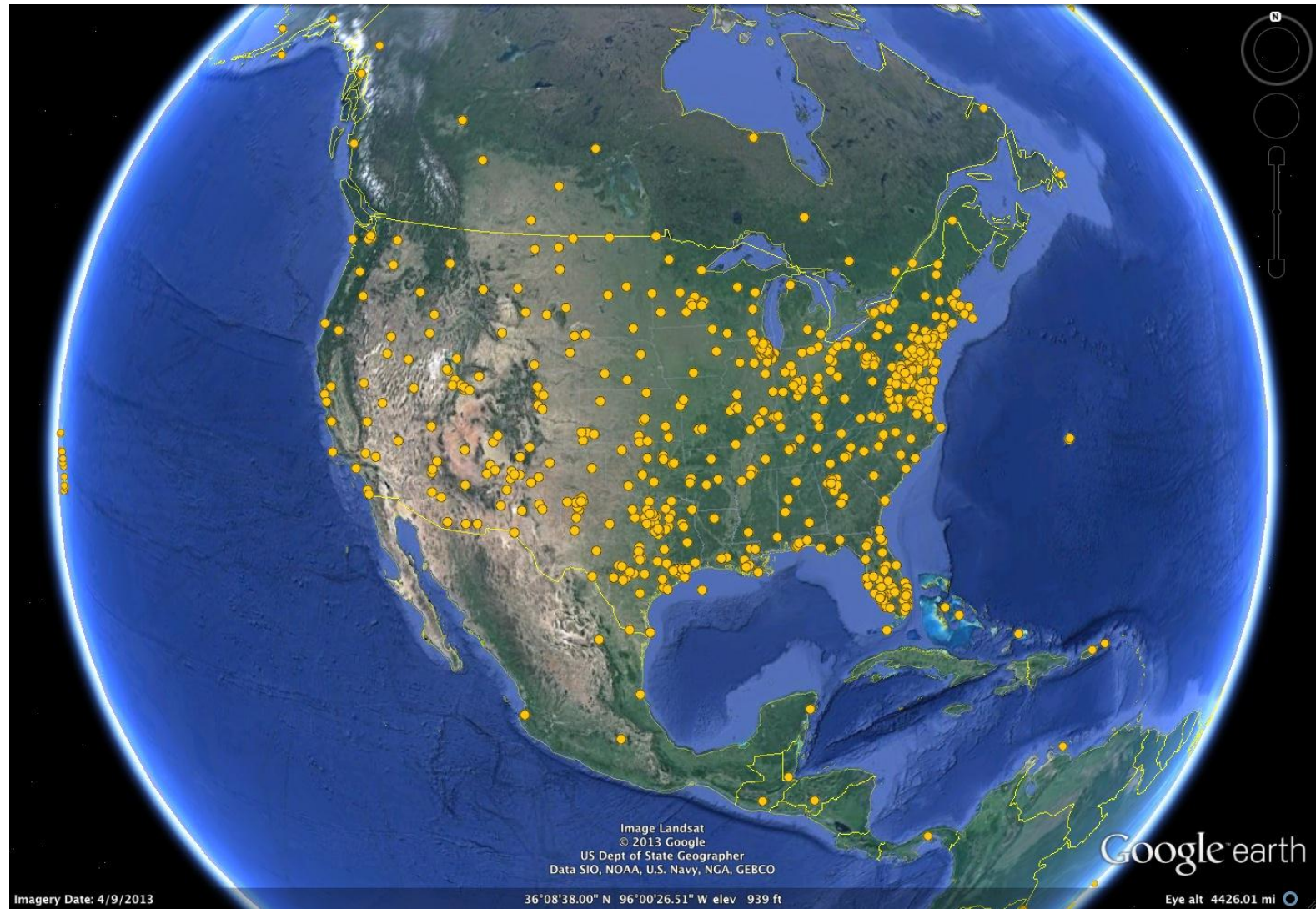
02/04/2014

Introduction

- Use of ENTLN data for research is a priority for Earth Networks.

- Comparison of ENTLN to the Lightning Imaging Sensor (LIS) on the TRMM Satellite using LIS as truth.

- Comparison of LIS to ENTLN using ENTLN as truth.

- Earth Networks Dangerous Thunderstorm Alert and detection efficiency improvements.

# Earth Networks Total Lightning Network

Earth Networks Total Lightning Sensor

- Total Lightning from a Single, Compact Sensor

- Wideband Electrical Field Recorders (1 Hz to 12 MHz)

- Designed to detect cloud flashes beyond the line of sight with high efficiency

- Nano-second GPS timing
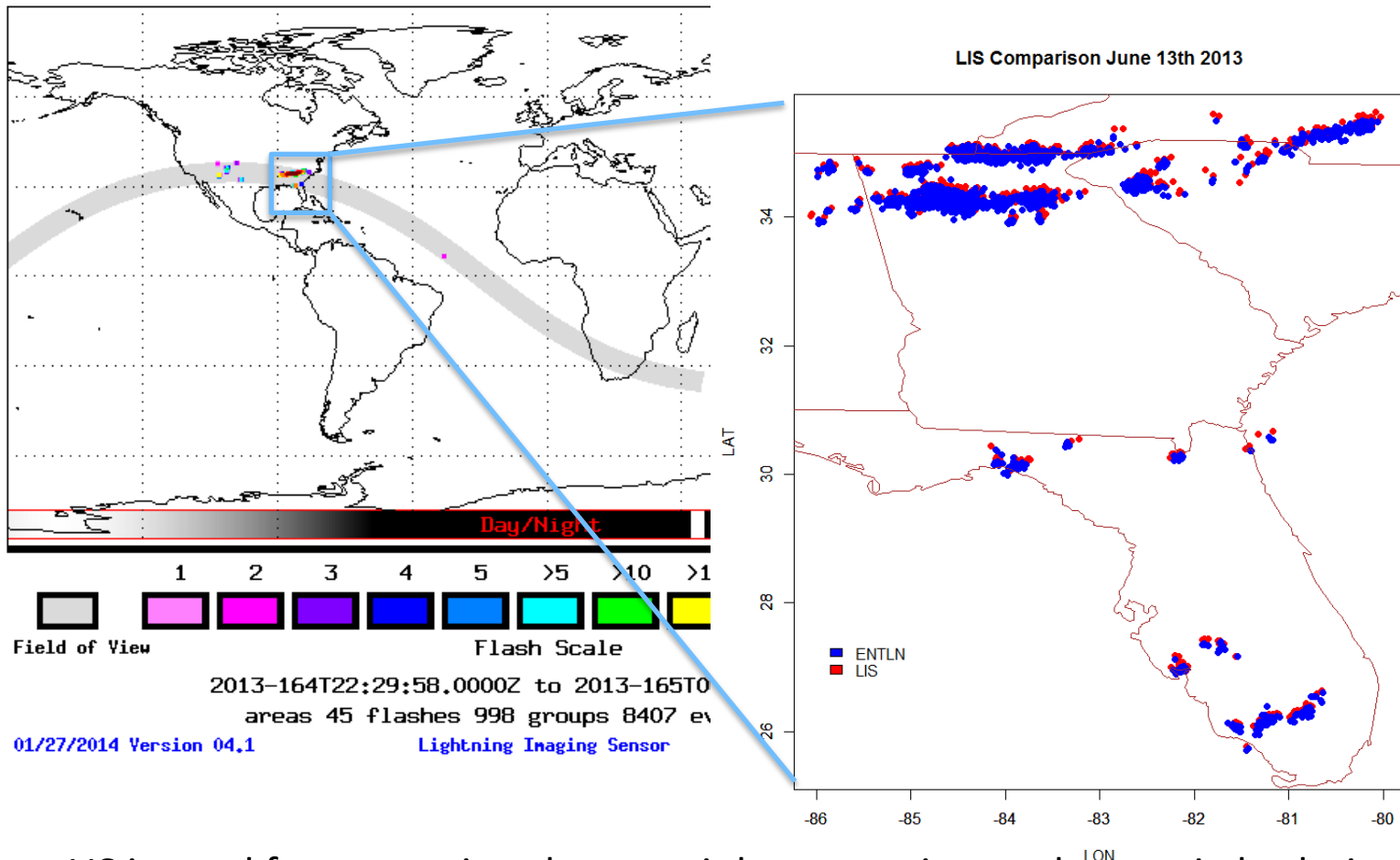
- Dual digital signal processors

Earth Networks Total Lightning Waveform Data

2013-08-14T00:00:01.2175 to 01.2225   500 microseconds / division   (150 km/div)

KNDIA
FRIAA
MAMOU
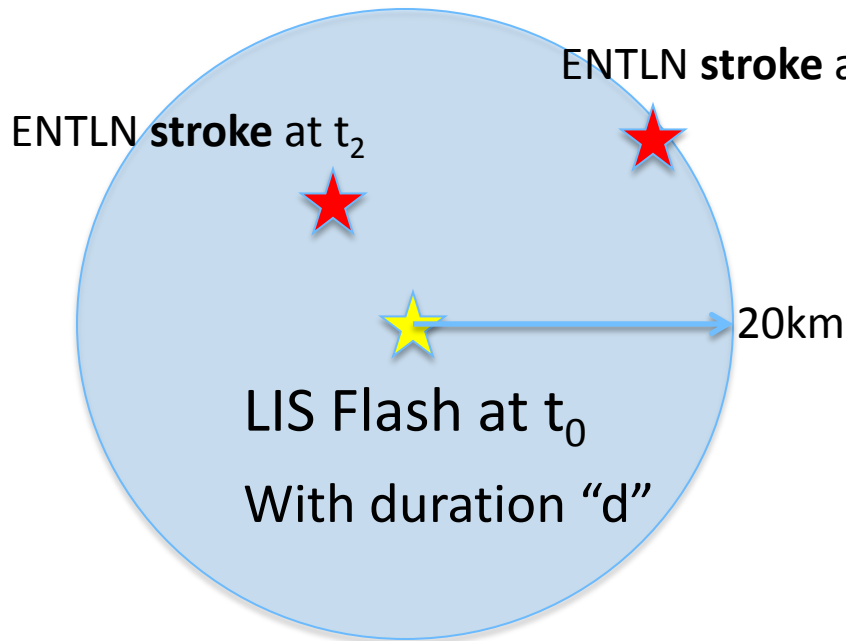LABEA
BOKEE
KMSRR
DABLA
MALIG
NZRKR
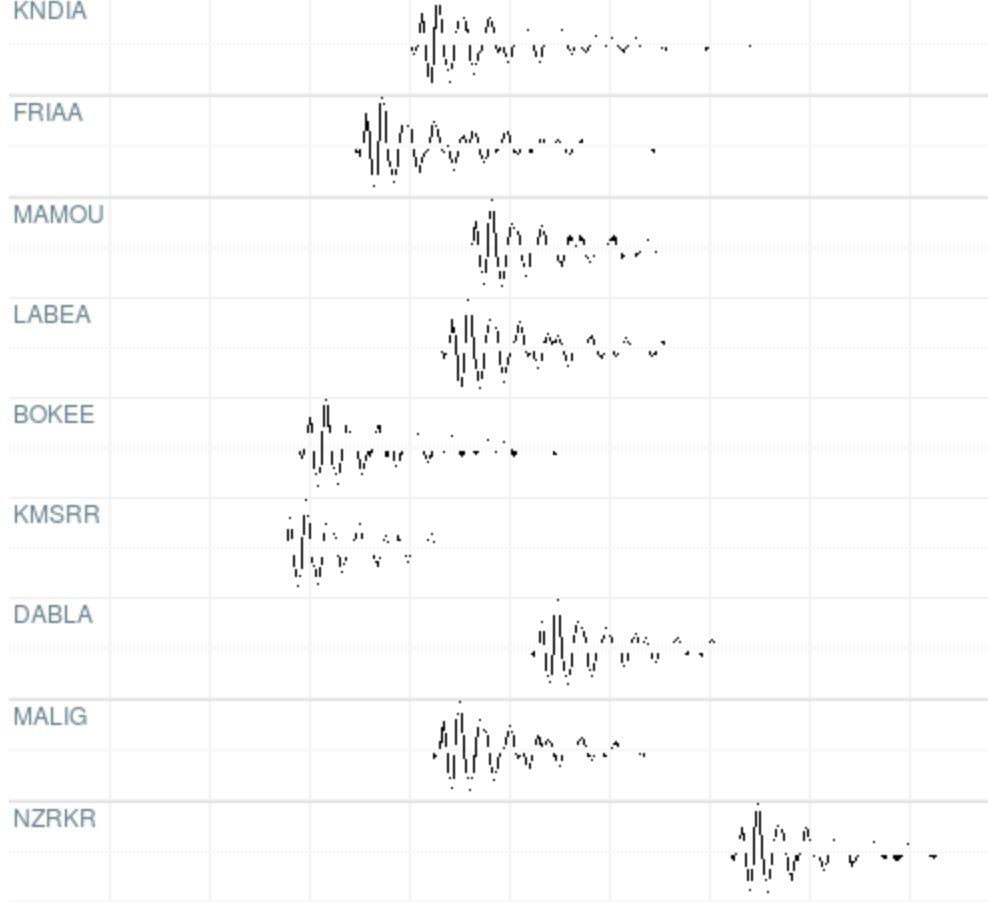
- Full waveform data transmitted to servers.

- Terabytes of waveforms archived from ~Feb. 2009 to present.

- Currently ~1GB data every 10 minutes.

LIS Satellite Data

- LIS is good for comparison because it has a consistent data set in both time and geography.

Methodology Overview

ENTLN **stroke** at t_2

ENTLN **stroke** at t_1

20km

LIS Flash at t_0

With duration "d"

- ENTLN Stroke is coincident with LIS FLASH if it occurs within 100 milliseconds before flash through to 100 milliseconds after the duration of the flash.
- Stroke at t_2 is coincident, stroke at t_1 is not.

t_2

t_1

100 ms

100 ms

d

t_0
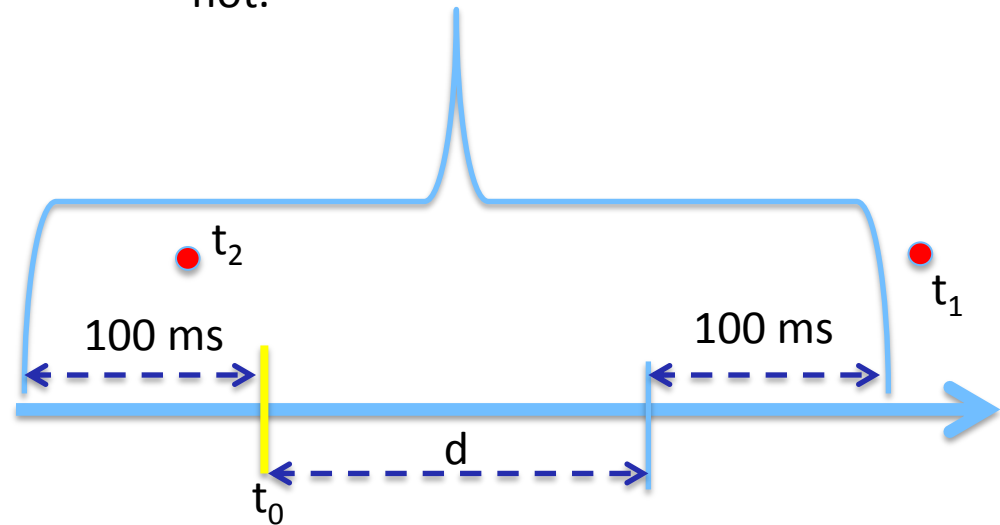
Intermediate Data Sets

LISID	LISFlashTimeString	Lightning_Time	Latitude	Longitude	Radiance	Duration	Groups	Events	LISYear	LISDayOfYear	LISGranule
6822042	2013-164T23:20:53.7826Z	2013-06-13 23:20:51.783	34.264	-84.977	156123	173	6	22	2013	164	14
6822045	2013-164T23:20:54.7494Z	2013-06-13 23:20:52.750	34.399	-84.815	178812	143	8	13	2013	164	14
6822048	2013-164T23:20:55.9173Z	2013-06-13 23:20:53.917	34.227	-84.789	192062	286	7	19	2013	164	14
6822054	2013-164T23:20:56.2484Z	2013-06-13 23:20:54.247	34.466	-84.669	17999	26	2	2	2013	164	14
6822055	2013-164T23:20:56.4454Z	2013-06-13 23:20:54.447	34.437	-84.786	128170	370	7	11	2013	164	14
6822057	2013-164T23:20:56.8479Z	2013-06-13 23:20:54.847	34.231	-84.95	512828	487	20	57	2013	164	14
6822058	2013-164T23:20:57.4997Z	2013-06-13 23:20:55.500	34.368	-84.706	211193	671	11	26	2013	164	14
6822068	2013-164T23:20:59.6609Z	2013-06-13 23:20:57.660	34.318	-84.806	45057	107	4	6	2013	164	14
6822071	2013-164T23:21:00.5433Z	2013-06-13 23:20:58.543	34.231	-84.808	26873	94	2	3	2013	164	14
6822072	2013-164T23:21:00.5670Z	2013-06-13 23:20:58.567	34.205	-84.753	45885	75	2	5	2013	164	14

All LIS Flashes

For each LIS Flash, database all **strokes** within +- 1 second and 80 km

LISID	ENID	Distance	TimeDiff	Lightning_Time	Latitude	Longitude	Amplitude	Stroke_Type
6822057	893345759	4.68328394180678	100	2013-06-13 23:20:54.947	34.17176	-84.9898167	5929	1
6822057	893345760	5.81131852597037	113	2013-06-13 23:20:54.960	34.1652659	-85.01343	7823	1
6822057	893345761	7.80446389871067	126	2013-06-13 23:20:54.973	34.1220595	-84.9860462	-11197	1
6822057	893345563	3.34441937524874	363	2013-06-13 23:20:55.210	34.1956639	-84.9899982	7519	1
6822057	893345646	2.38280090851111	390	2013-06-13 23:20:55.237	34.2011122	-84.9708023	6993	1
6822057	893345647	2.18878189127997	420	2013-06-13 23:20:55.267	34.2015608	-84.9641414	5221	1

Aggregate Data into 1x1 degree bins by day

Total count of LIS "Hits" for June 13th 2013 in the 34, -84 lat/lon bin

TheMonth	TheDay	TheYear	Latitude	Longitude	TheCount
6	13	2013	34	-84	445

"Hit" only if ENTLN Stroke within 100 milliseconds before or after the flash duration AND within a distance of 20km

Total count of LIS Flashes for June 13th 2013 in the 34, -84 lat/lon bin

TheMonth	TheDay	TheYear	Latitude	Longitude	TheCount
6	13	2013	34	-84	495

For this case the detection efficiency vs LIS is 445/495 or 90%

ENTLN vs LIS 2011

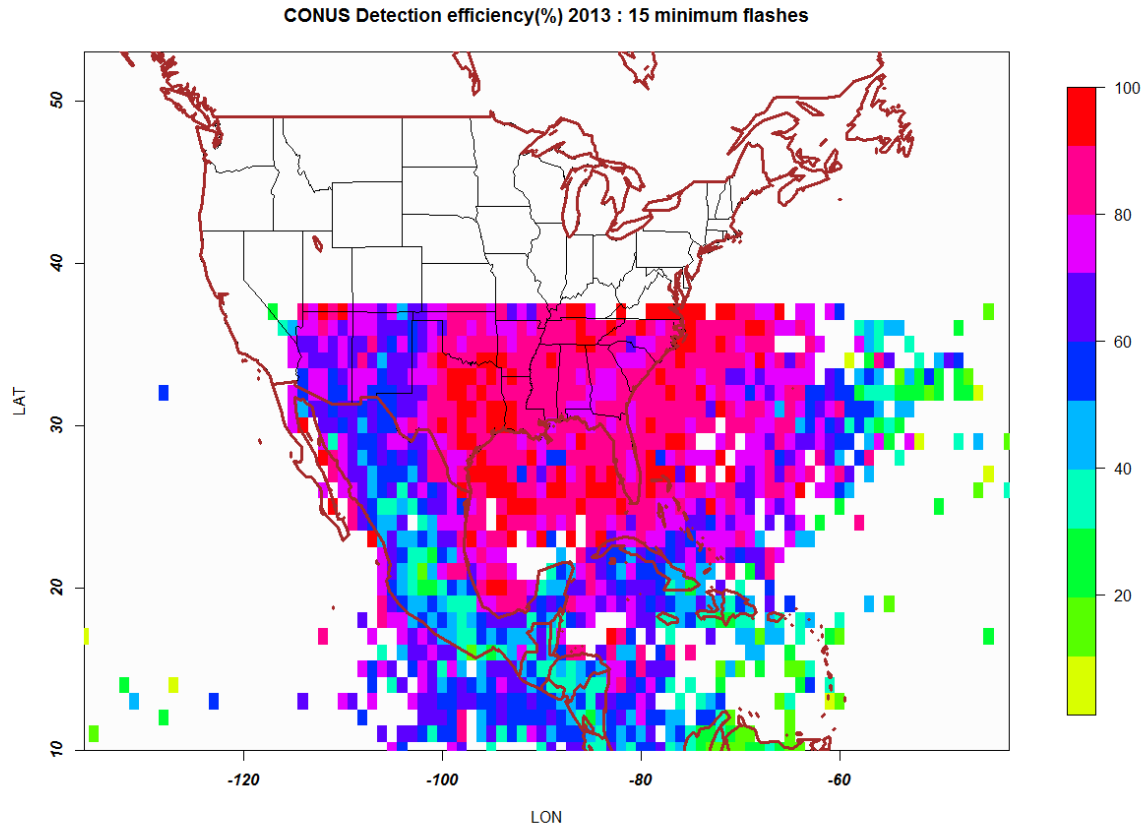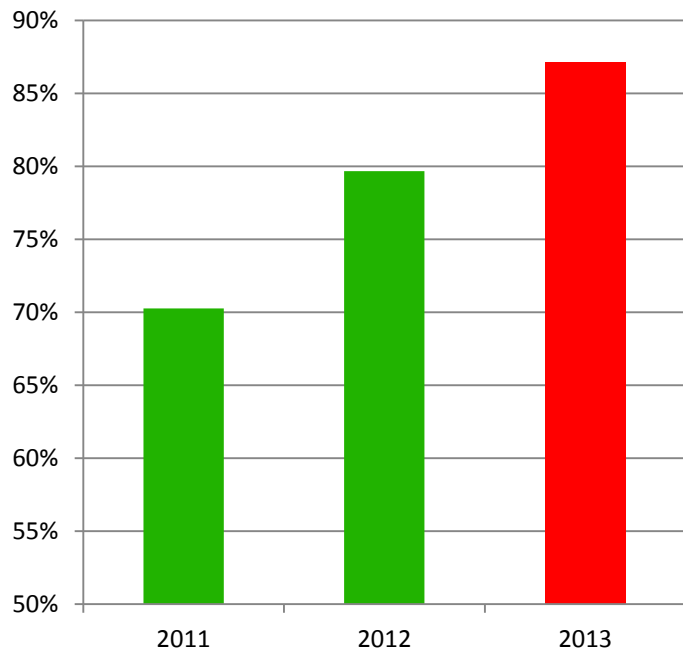**Average CONUS Detection Efficiency by Year**

CONUS Detection efficiency(%) 2011 : 15 minimum flashes
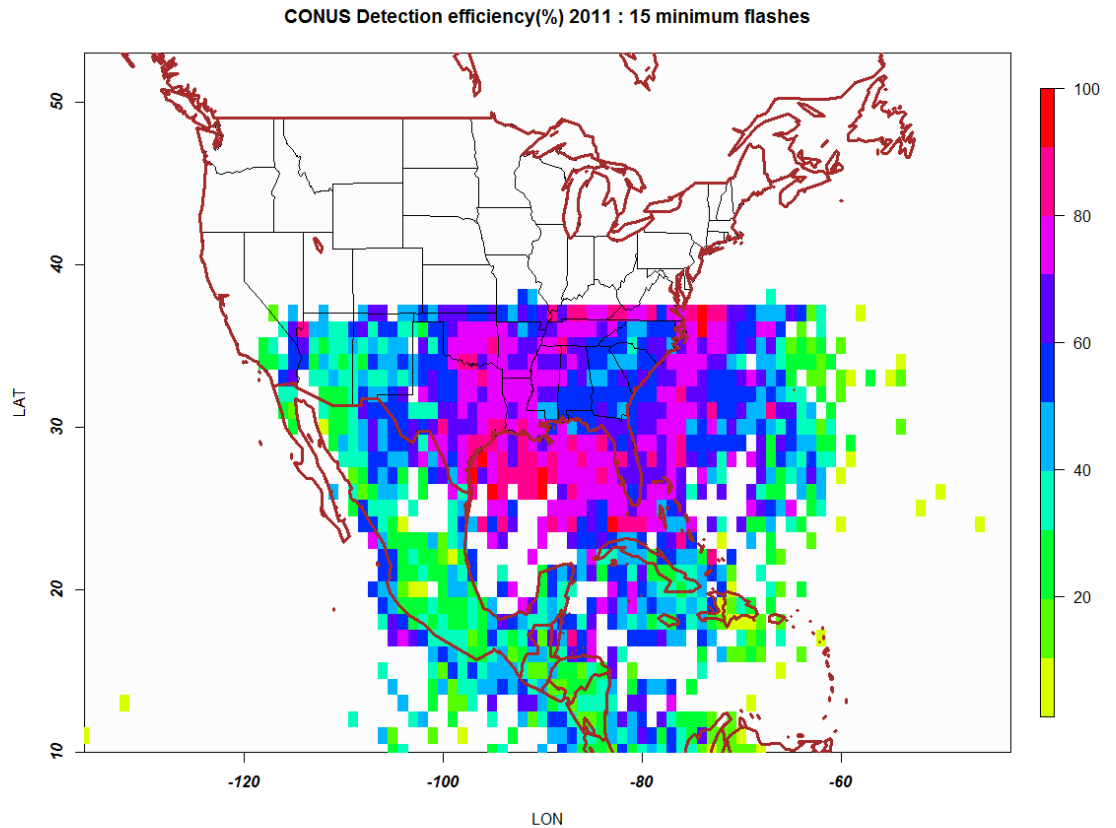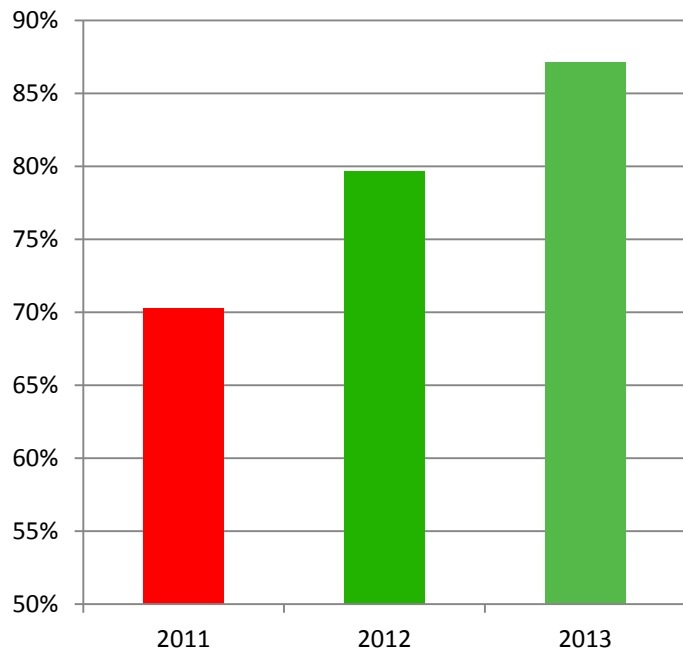
ENTLN vs LIS 2012

Average CONUS Detection Efficiency by Year

CONUS Detection efficiency(%) 2012 : 15 minimum flashes
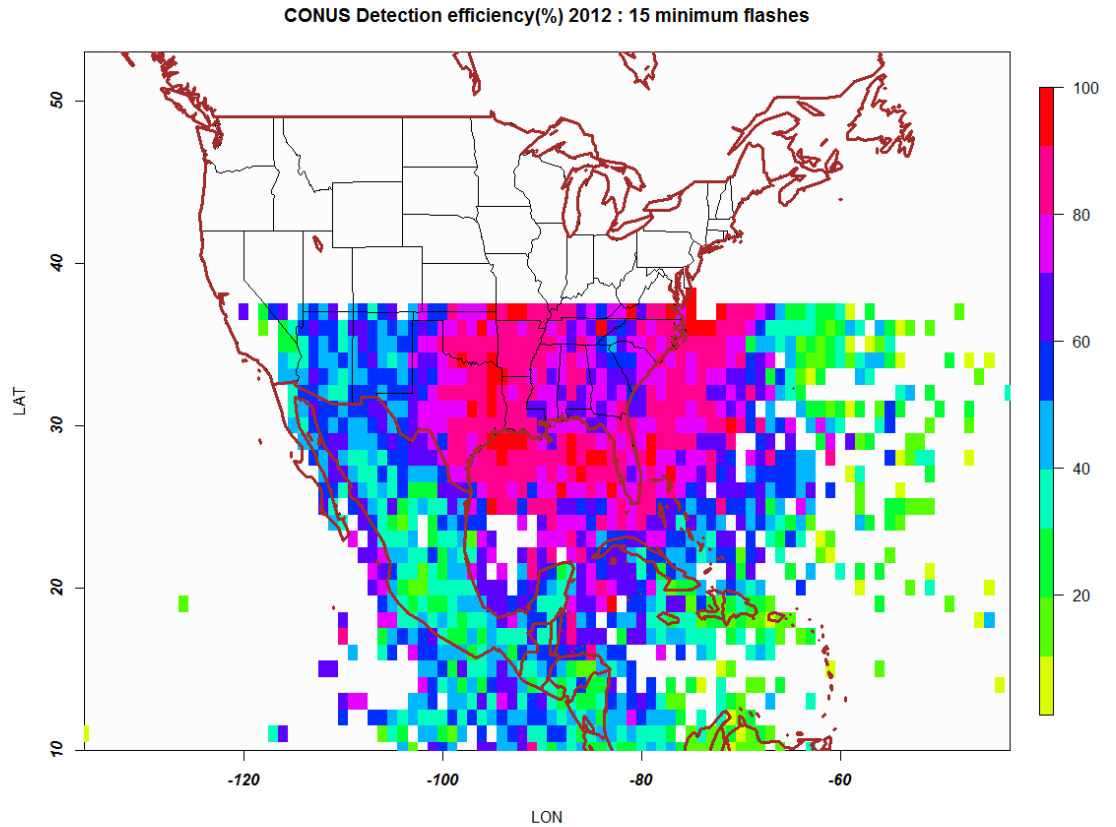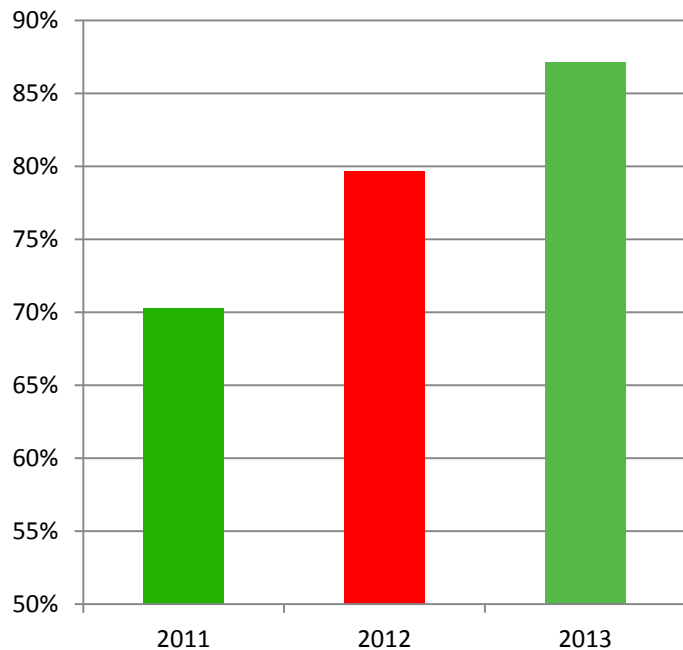
ENTLN vs LIS 2013

Average CONUS Detection Efficiency by Year

CONUS Detection efficiency(%) 2013 : 15 minimum flashes

Average Detection Efficiency By State By Year
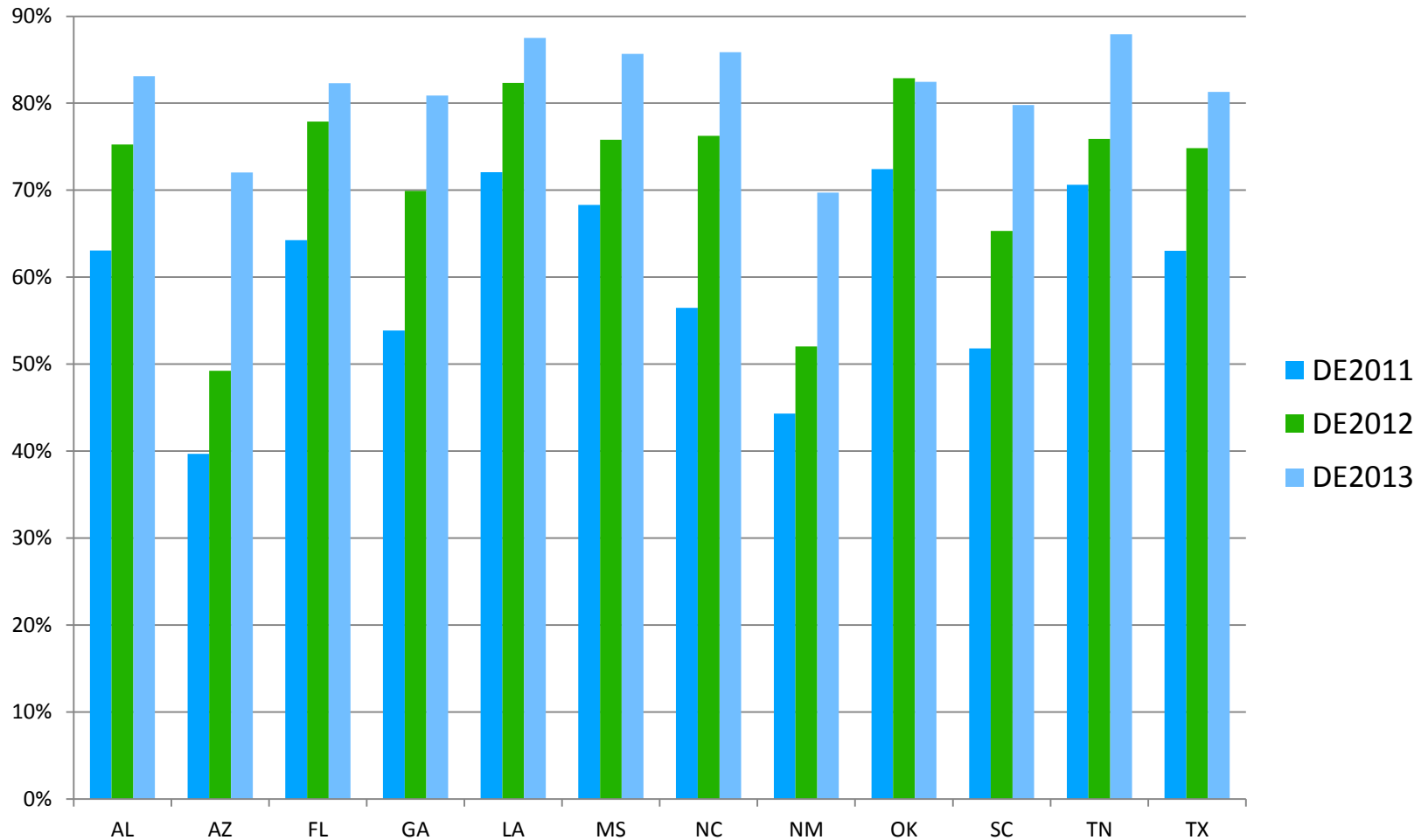
How does DE vs LIS change with sensor density?

$$\text{"baseline"} = (d_{1} + d_{2} + d_{3} + d_{4} + d_{5}) / 5$$
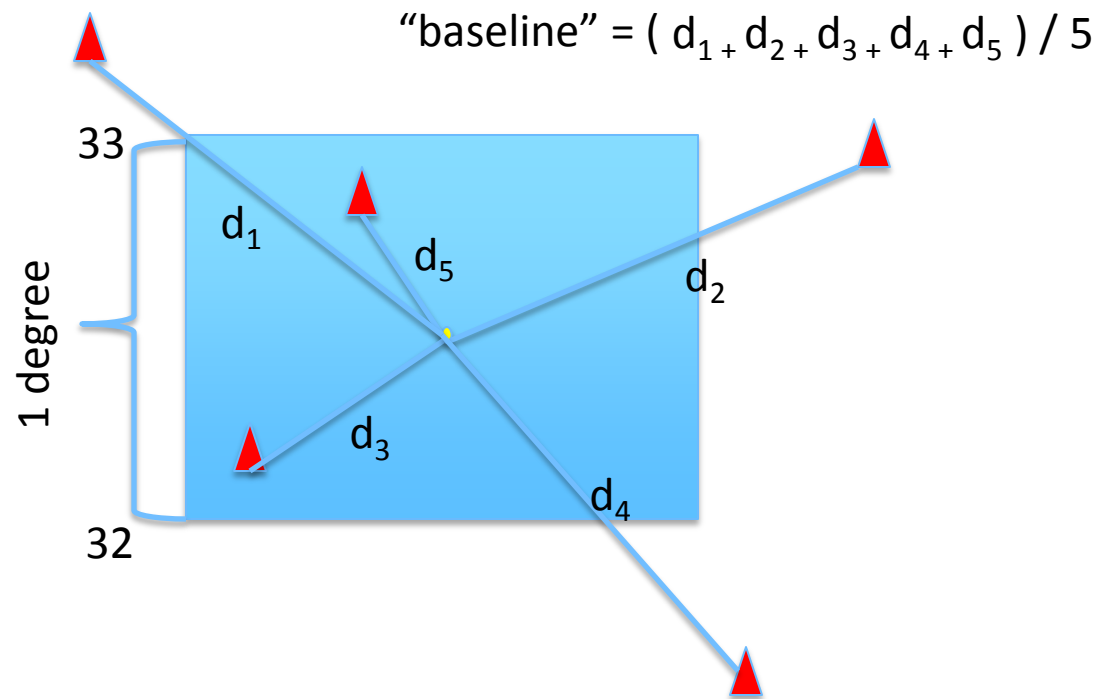
For each 1x1 degree grid, calculate the average distance to the 5 closest sensors
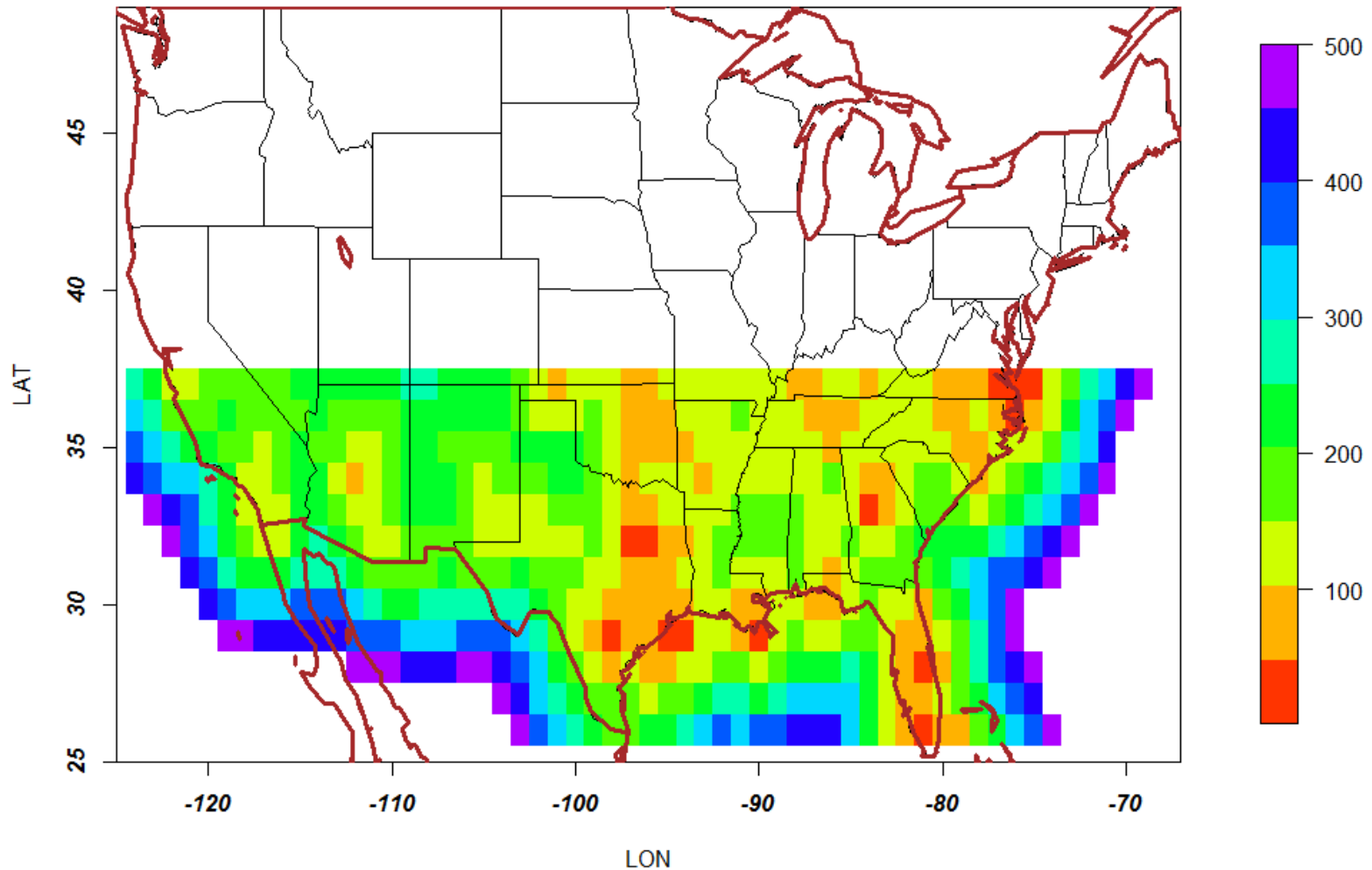
Average Distance to first 5 sensors ("baseline")
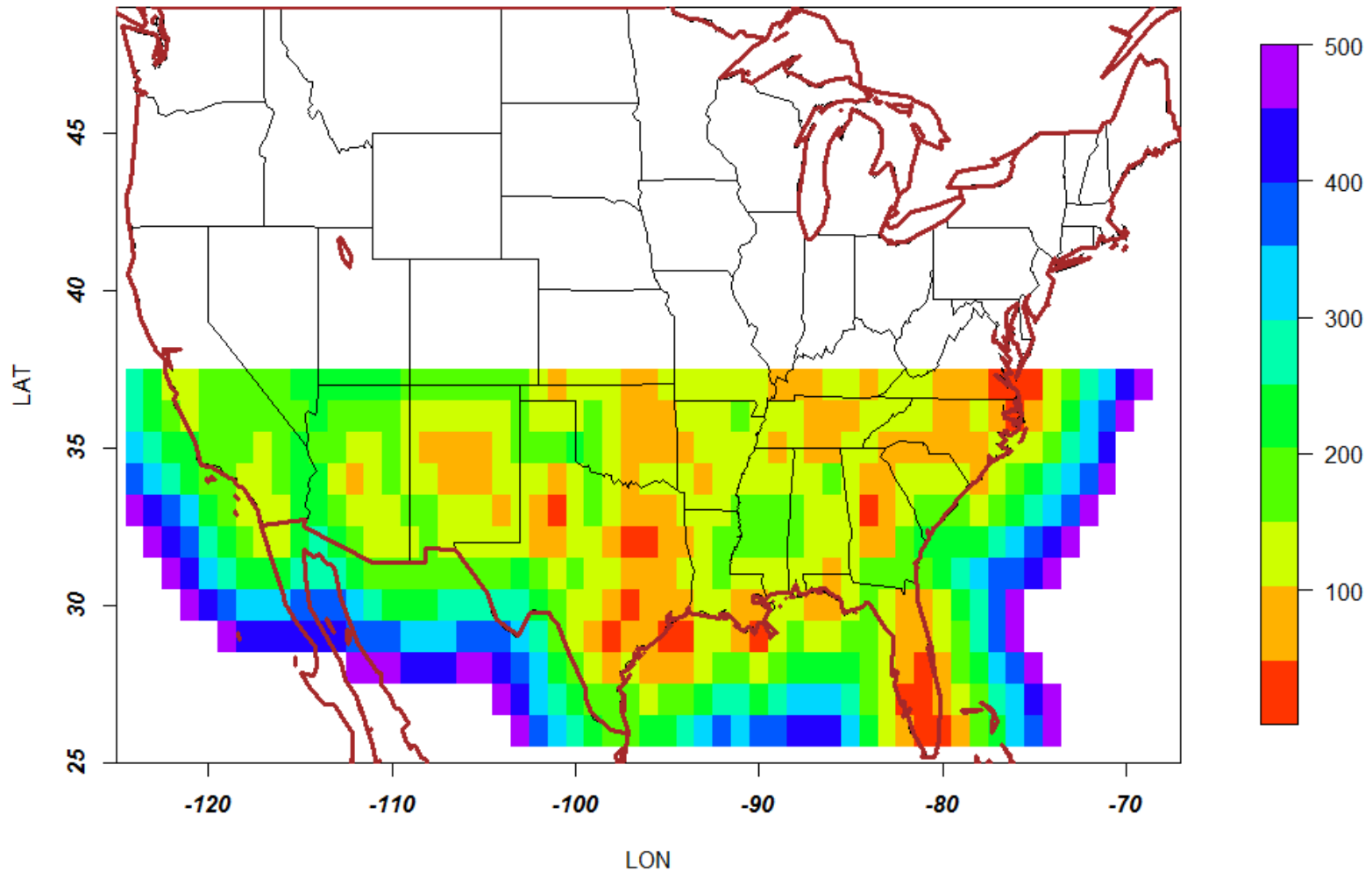

Sensor Baselines(km) 2011
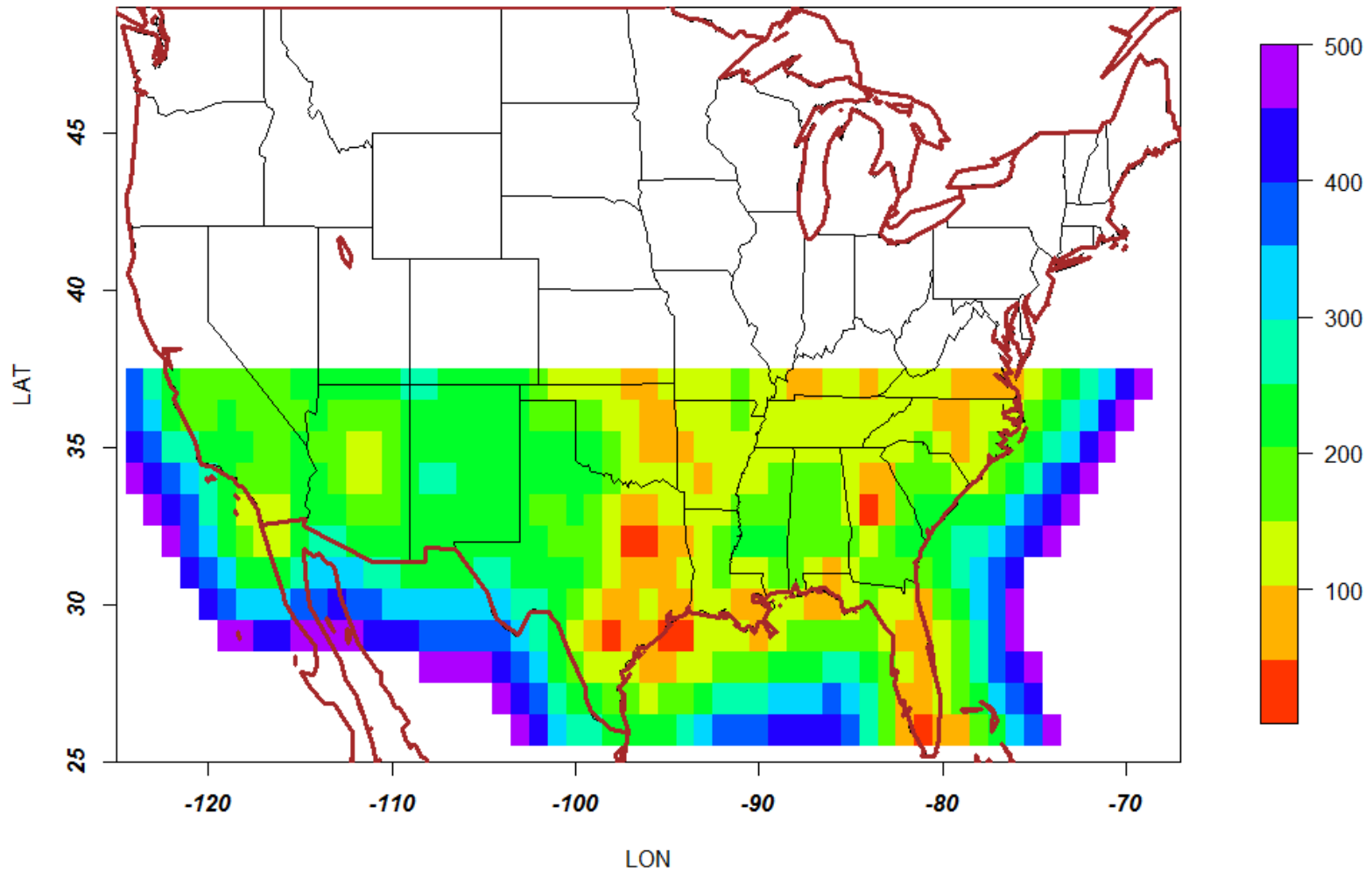
Average Distance to first 5 sensors ("baseline")
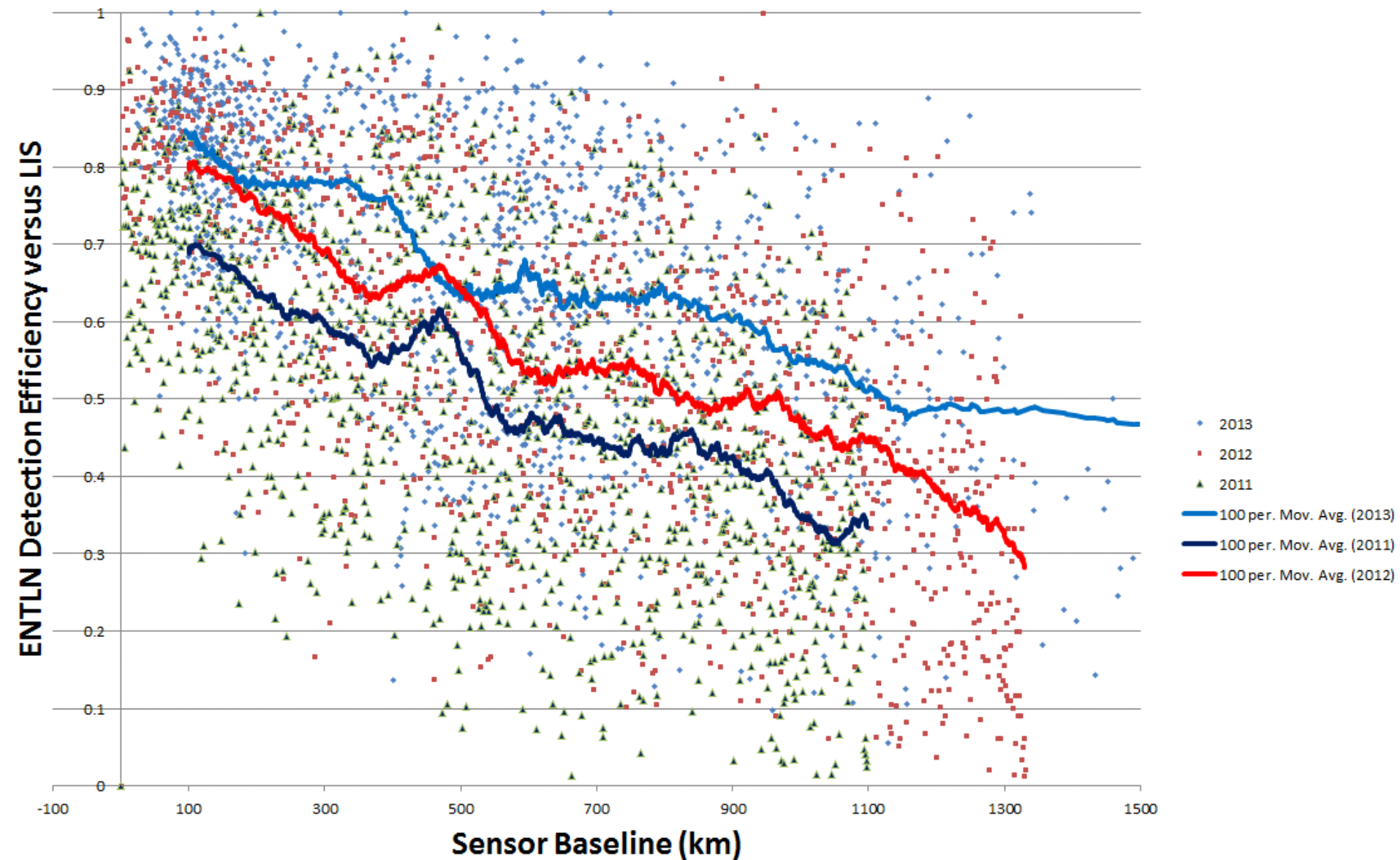

Sensor Baselines(km) 2012

Average Distance to first 5 sensors ("baseline")

Sensor Baselines(km) 2013

Detection Efficiency vs Sensor Baseline

LIS Compared to ENTLN

0.5 degrees

0.5 degrees
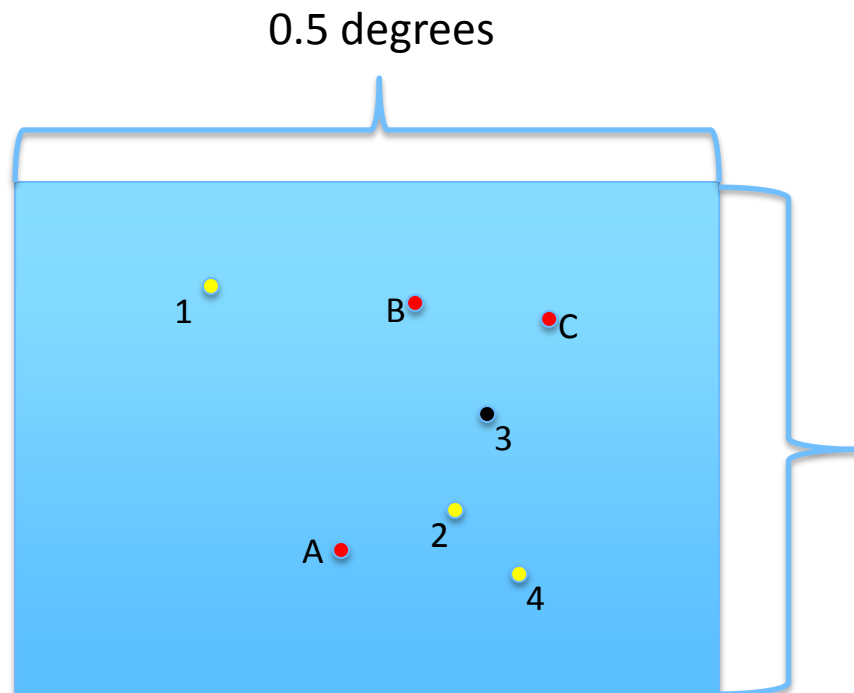
ViewTime Granule

- LIS Flashes
- ENTLN Flashes
- Coincident Flash

1   B   C   3   2   A   4

- Only include viewtime granules that are bordered on all 4 sides by other viewtime granules.
- Only ENTLN Flashes which are between the first and last LIS flash in the viewtime granule are considered.
- Coincident criteria same as ENTLN vs LIS comparison (20km and +-100ms on duration of event)
- No limitations placed on spatial extent.
- Example shows a LIS DE of 50%

1   2   B   4

A   3   C

Timeline of events
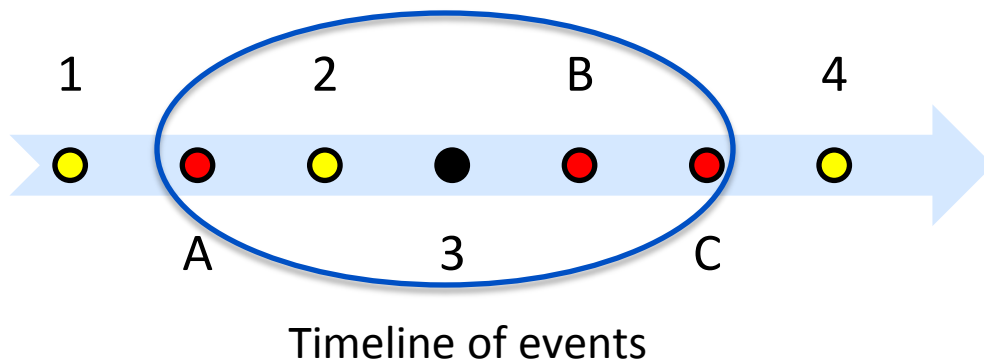
Intermediate Data Sets

LIS ViewTime Data along with "FullView" Indicator

ViewTimeID	StartTime	EndTime	Lat	Lon	TAI93Start	TAI93End	AlertFlag	EffectiveObs	ApproxThreshold	FullView
557458	2013-01-01 05:26:10.000	2013-01-01 05:26:12.000	25.25	-89.75	631171605	631171607	40	0.08	20	0
557534	2013-01-01 05:26:12.000	2013-01-01 05:28:04.000	25.25	-89.25	631171607	631171719	40	43.72	20	1
557461	2013-01-01 05:26:13.000	2013-01-01 05:26:20.000	25.25	-89.75	631171608	631171615	40	0.28	20	0
557542	2013-01-01 05:26:19.000	2013-01-01 05:28:10.000	25.25	-88.75	631171614	631171725	40	87.4	20	1
557549	2013-01-01 05:26:25.000	2013-01-01 05:28:16.000	25.25	-88.25	631171620	631171731	40	102	20	1
557464	2013-01-01 05:26:26.000	2013-01-01 05:26:37.000	25.75	-88.75	631171621	631171632	40	0.52	20	0
557551	2013-01-01 05:26:29.000	2013-01-01 05:28:20.000	25.75	-88.25	631171624	631171735	40	46.72	20	1
557555	2013-01-01 05:26:33.000	2013-01-01 05:28:22.000	25.25	-87.75	631171628	631171737	40	101.52	20	1
557561	2013-01-01 05:26:36.000	2013-01-01 05:28:27.000	25.75	-87.75	631171631	631171742	40	89.44	20	1
557565	2013-01-01 05:26:40.000	2013-01-01 05:28:29.000	25.25	-87.25	631171635	631171744	40	100.48	20	1
557466	2013-01-01 05:26:41.000	2013-01-01 05:26:42.000	25.75	-88.75	631171636	631171637	40	0.04	20	0

Intermediate Data: LIS and ENTLN Flashes in the time-space of the viewtime granule

ViewTimeID	Network	Lightning_Time	Latitude	Longitude
22117	ENTLNFLASH	2013-06-04 03:39:09.100	36.0355338	-99.6799726
22117	LIS	2013-06-04 03:39:09.103	36.079	-99.639
22117	ENTLNFLASH	2013-06-04 03:39:09.237	36.0503856	-99.6870202
22117	ENTLNFLASH	2013-06-04 03:39:10.197	36.0187855	-99.7748548
22117	LIS	2013-06-04 03:39:10.200	36.069	-99.742
22117	ENTLNFLASH	2013-06-04 03:39:10.577	36.1880169	-99.7087794
22117	LIS	2013-06-04 03:39:10.777	36.343	-99.564
22117	ENTLNFLASH	2013-06-04 03:39:10.800	36.2596386	-99.5518427
22117	ENTLNFLASH	2013-06-04 03:39:11.300	36.1994485	-99.6557122
22117	LIS	2013-06-04 03:39:12.817	36.35	-99.744
22117	ENTLNFLASH	2013-06-04 03:39:12.870	36.2294508	-99.7736786
22117	LIS	2013-06-04 03:39:12.907	36.107	-99.714

- Database LIS Flashes and ENTLN **Flashes** within the ViewTime. ENTLN flashes must be between the times of the first and last LIS flashes.

Aggregate Data into 1x1 degree bins by day

Total count of ENTLN "Hits" for June 16th 2013 in the 34, -94 lat/lon bin

| TheMonth	TheDay	TheYear	Latitude	Longitude	TheCount
6	16	2013	34	-94	337

"Hit" only if LIS FLASH is within 100 milliseconds before or after the ENTLN flash duration AND within a distance of 20km

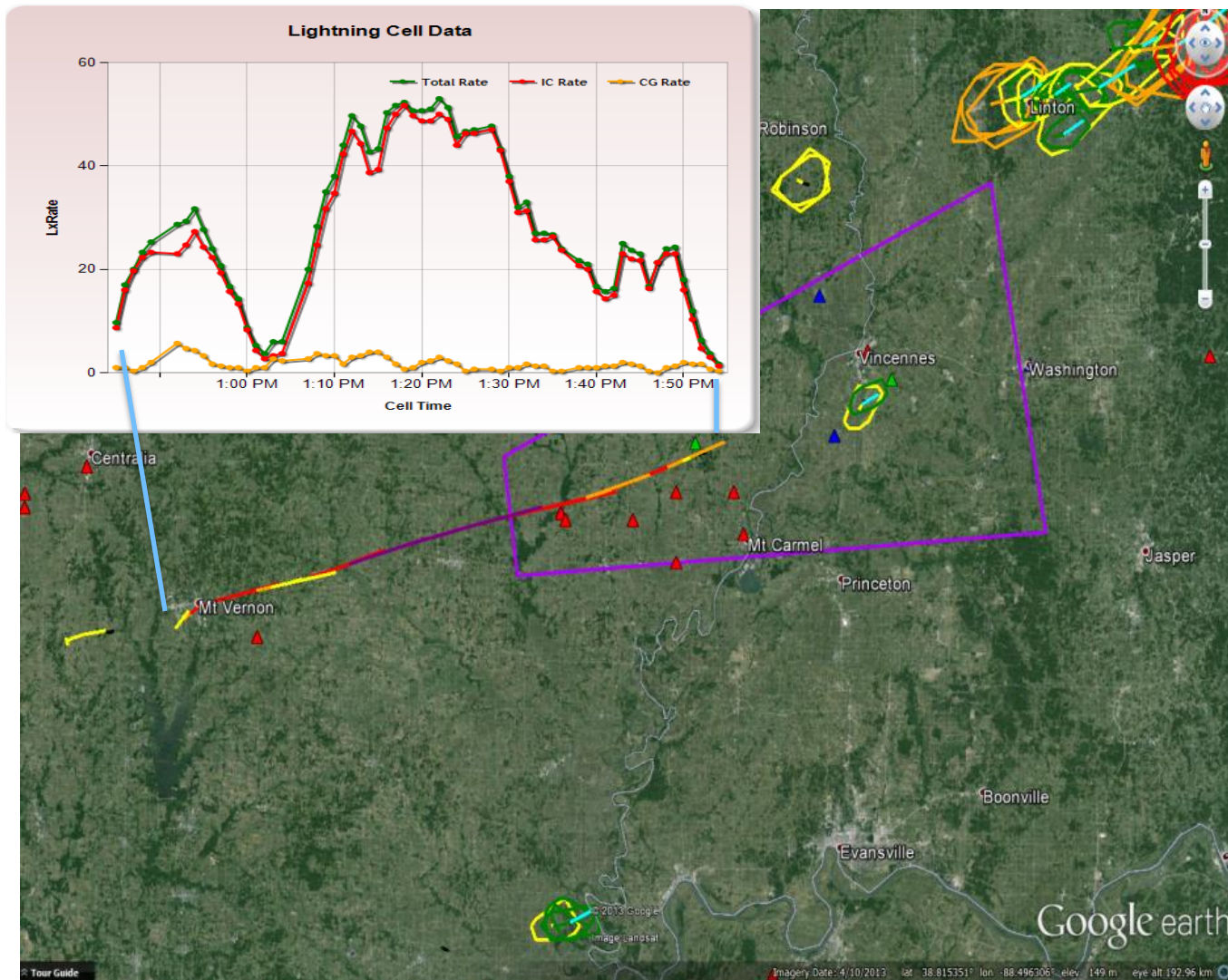Total count of ENTLN Flashes for June 16th 2013 in the 34, -94 lat/lon bin

TheMonth	TheDay	TheYear	Latitude	Longitude	TheCount
6	16	2013	34	-94	398

For this case the detection efficiency vs ENTLN is 337/398 or ~85%

LIS vs ENTLN(%) 2013

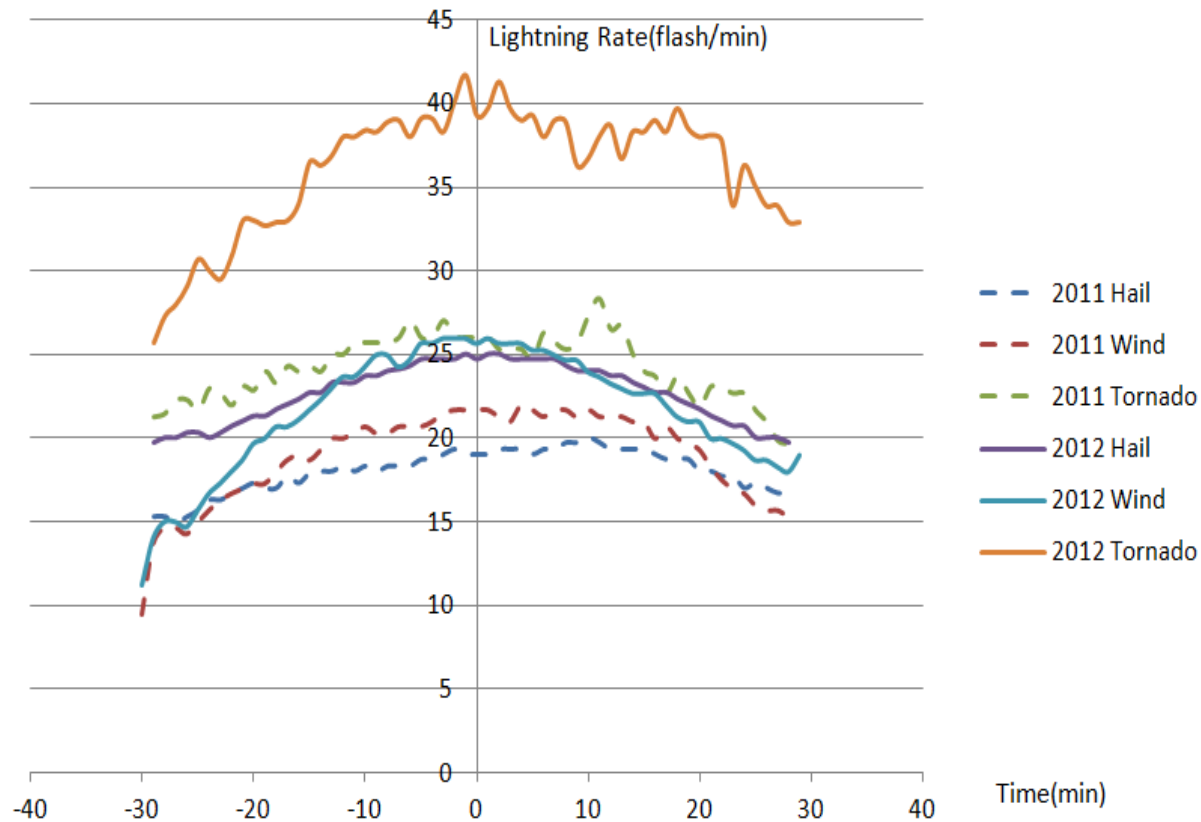Average Detection Efficiency of LIS vs ENTLN over entire area: 65%
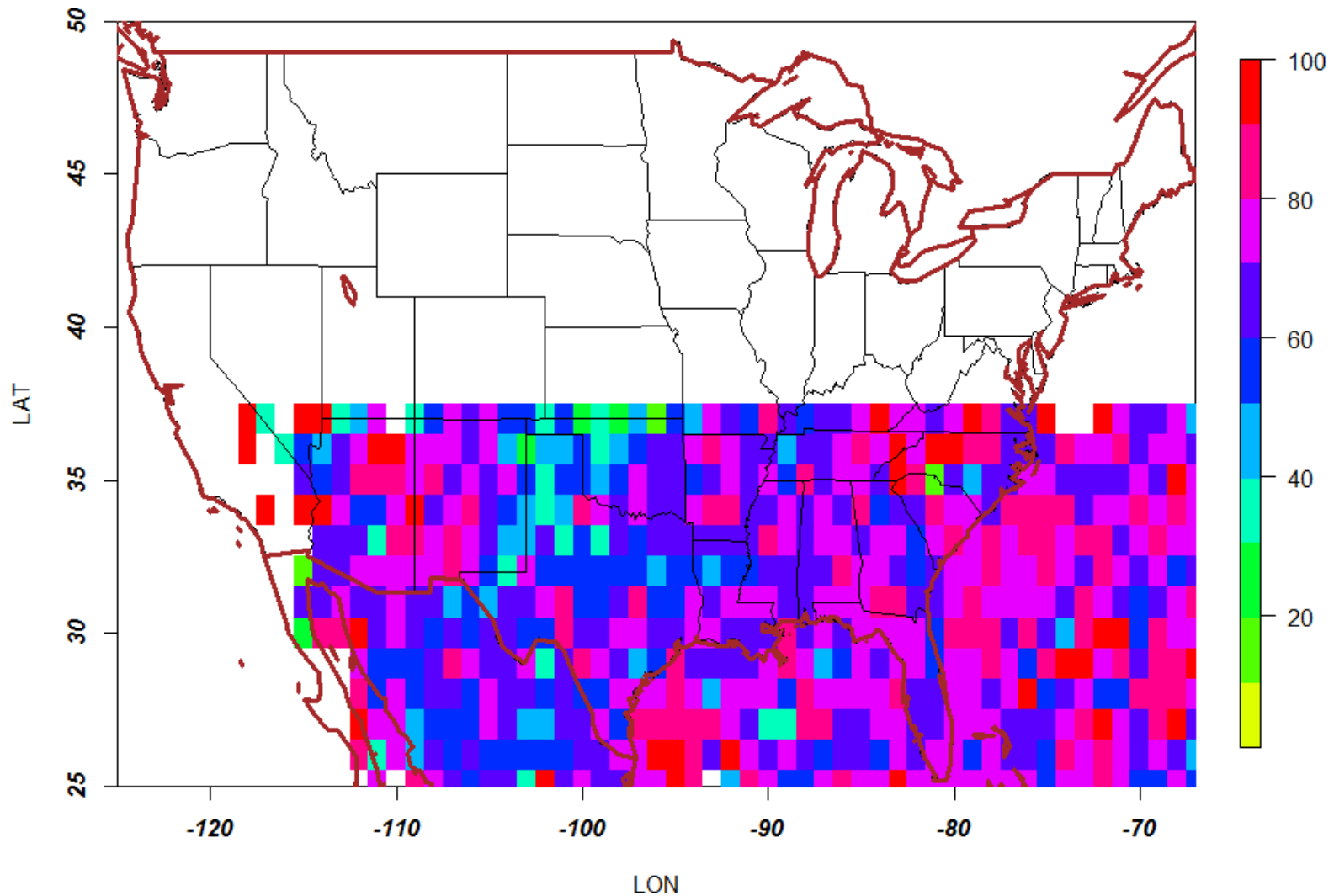
Impact of DE Increases

Lightning Rate Prior to Tornados increases 60% in 2012

Median Lightning Rate before and after severe weather in 20 Km

Related papers

- Scott Rudlosky (NOAA) – Evaluating Ground Based Lighting Detection Networks using TRMM/LIS Observations to be presented at ILDC 2014 in June

- Michael Hutchins (University of Washington) – An evaluation of ENTLN vs TRMM/LIS. Paper submitted to AMS JTECH.

Future Work

- Complete the LIS vs ENTLN comparison for previous years.

- ENTLN/LIS comparisons for other geographies such as Brazil and Australia

- Continue to produce and publish ENTLN/LIS comparisons as 2014 progresses for consumers of ENTLN data.

Thank You!

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