

# Evaluating Ground-Based Lightning Detection Networks using TRMM/LIS Observations

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GOES-R GLM Science Team Workshop*

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DEPARTMENT OF  
ATMOSPHERIC & OCEANIC  
SCIENCE



# Outline

- Motivation and Objectives
- Domain and Data
- Methods
- WWLLN Results
- ENTLN Results
- GLD360 Results
- Summary

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## *Disclaimer:*

- *Each of the ground-based networks has strengths and weaknesses in terms of detection efficiency and location accuracy, types of lightning detected, and areal coverage, this paper does not attempt to quantify or explain any differences between these networks.*
- *The networks are continuously evolving, and our analysis describes performance during fixed periods of time, so caution must be taken when interpreting results.*

# Motivation and Objectives

## ▪ Motivation

- Although the expansion and improvement of long-range lightning datasets have increased their applicability, these applications require knowledge of network detection capabilities.
- Improved knowledge of relationships between satellite and ground-based lightning datasets will allow researchers, algorithm developers, and operational users to better prepare for the spatial and temporal coverage of the upcoming GOES-R GLM.

## ▪ Objective

- Document the present ground-based network (GBN) performance and illustrate how it varies in space and time. Improved understanding of GBN detection capabilities will enhance their use in weather research and operations.

# Domain and Data

## ■ Domain

- $\sim 38^\circ \text{N}$  to  $\sim 38^\circ \text{S}$
- Prime Meridian to  $-180^\circ \text{W}$

## ■ Datasets

- TRMM/LIS Flashes
  - Group times and locations
- ENTLN Strokes
  - Originally examined flashes
- GLD360 Strokes
  - Reduced domain (only to  $25^\circ \text{S}$ )
- WWLLN Strokes



# Methods

## ▪ Flash-to-stroke comparison

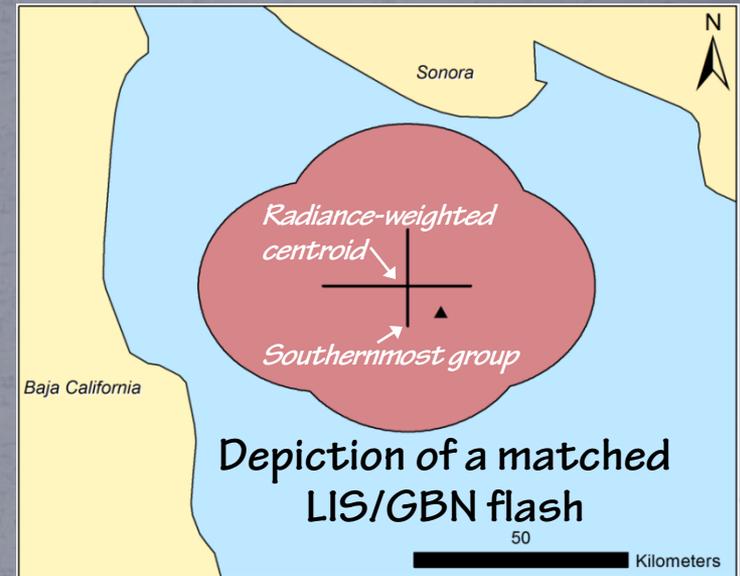
- Match individual LIS flashes with GBN reported strokes
- Relative detection efficiency (DE) is the number of LIS flashes seen by the GBNs

## ▪ Spatial criteria

- Within 25 km of any LIS group (i.e., the furthest north, south, east, and west)

## ▪ Temporal criteria

- Within 330 ms before, during, and 330 ms after a LIS flash

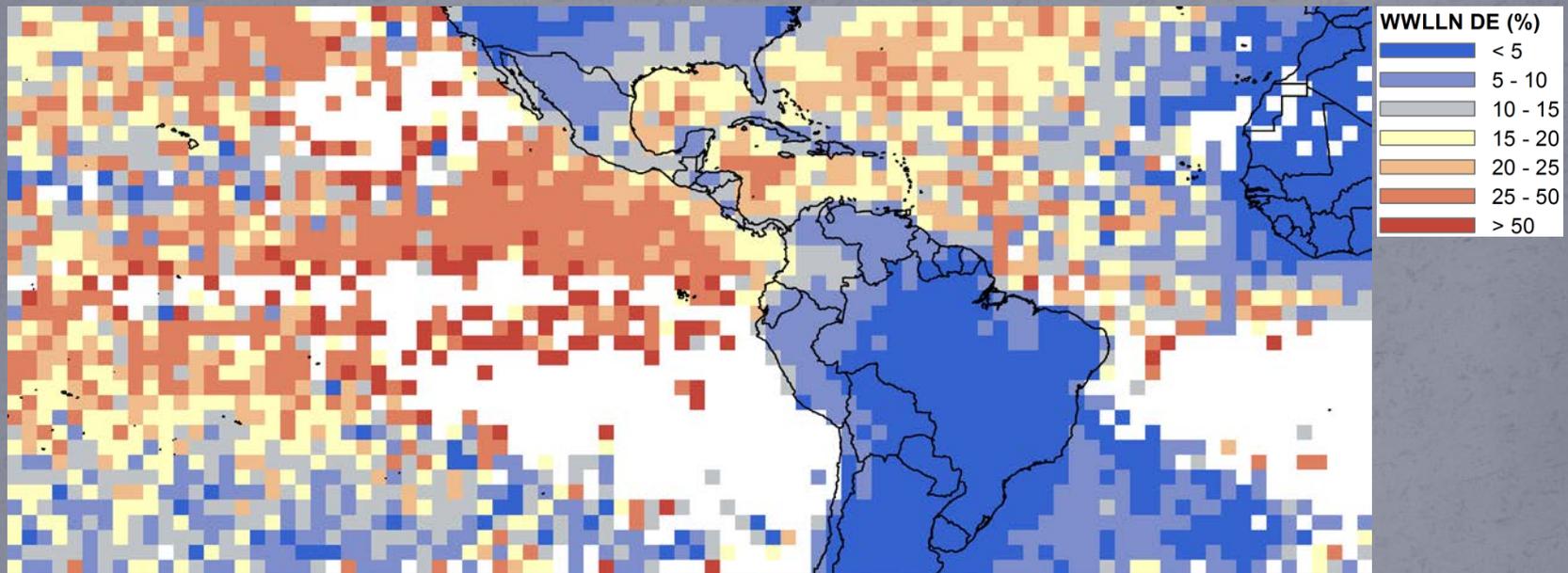


## Temporal Criteria



# WWLLN Results (2009-2012)

“Evaluating WWLLN Performance Relative to TRMM/LIS”



Time Period	Overall	Land	Ocean	N. America	S. America
2009	6.0	4.0	12.3	8.0	2.3
2010	6.8	4.8	13.9	7.6	4.1
2011	8.1	5.8	15.2	8.7	4.8
2012	9.2	6.4	17.3	10.7	4.9
4YRS	7.5	5.2	14.7	8.7	4.0

Rudlosky and Shea 2013  
*Geophys. Res. Letters*

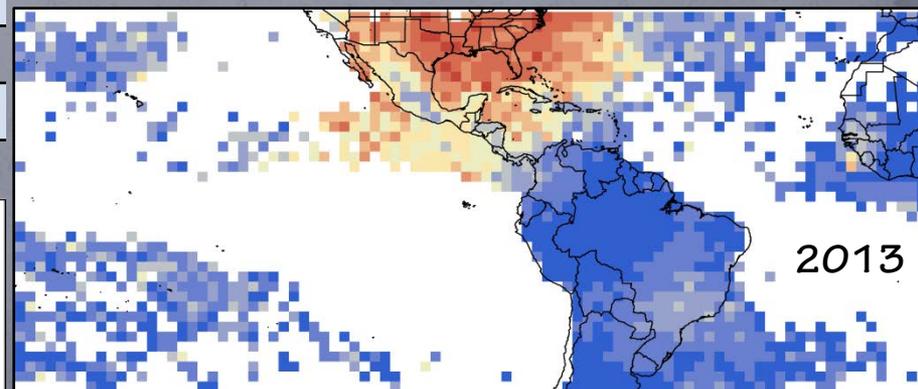
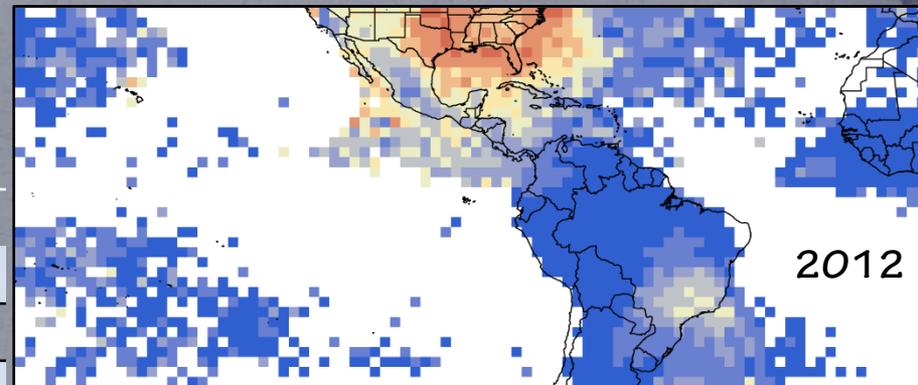
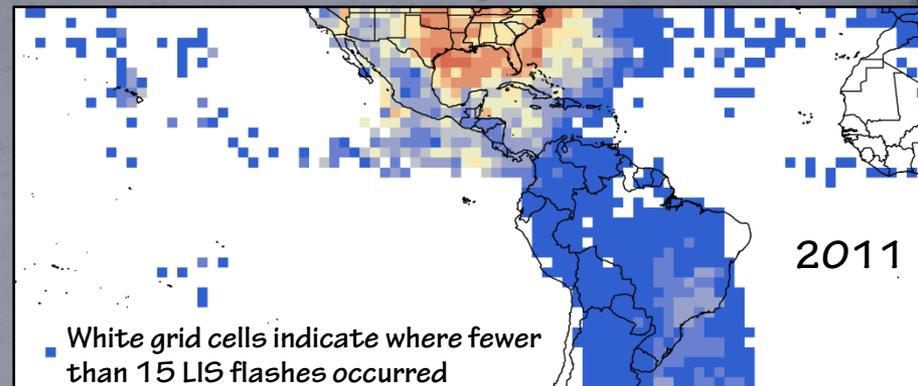
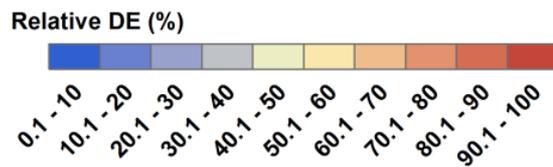
Metric (2012)	WWLLN
DE (%)	9.2
LD (km)	10.8
Multiplicity	1.60
Single Stroke %	67.5

# ENTLN Results (2011-2013)

- Most notable spatial feature is the expansion of the region surrounding CONUS with relative DE >50%
- Performance improves in each geographical subdomain, with the best regional performance (71.9%) over CONUS

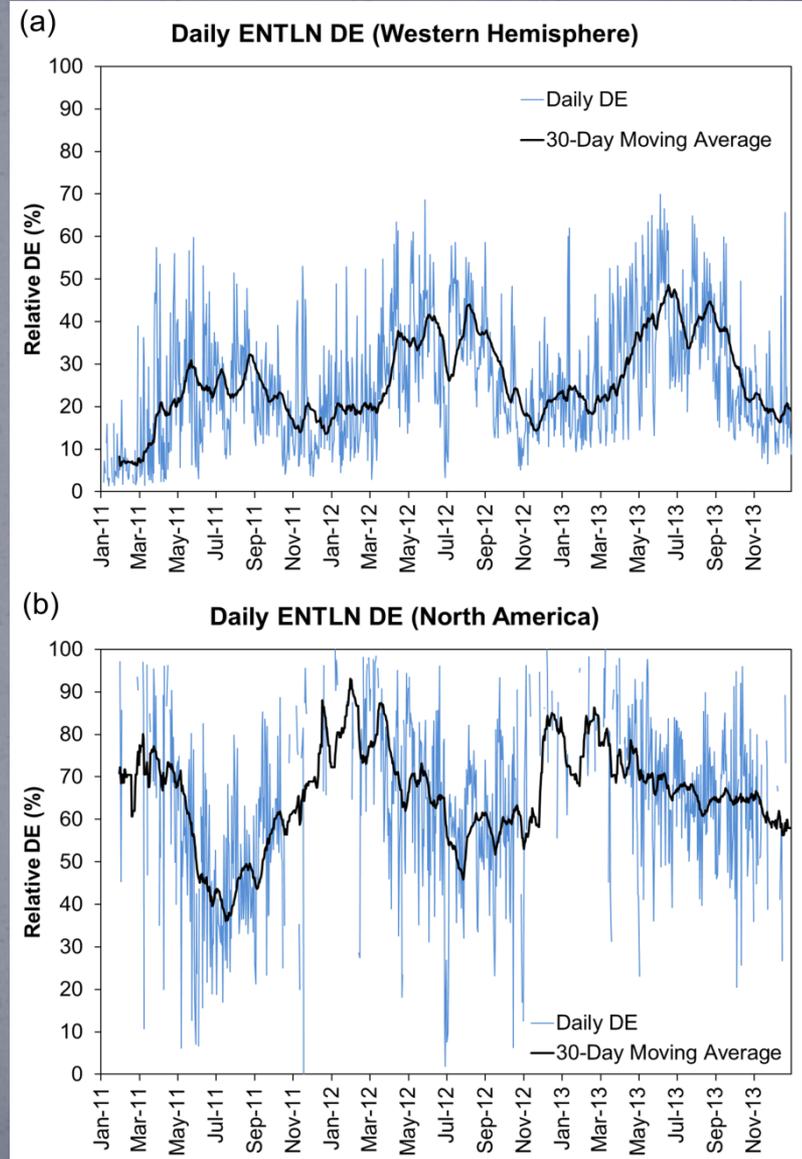
Relative DE (%)	2011	2012	2013	2011-13
W. Hemisphere	21.6	28.0	31.4	27.0
CONUS	62.4	74.4	79.7	71.9
N. America	50.3	60.0	67.4	59.0
S. America	5.4	11.3	11.5	9.6
Oceans	25.4	35.7	41.2	34.2

Rudlosky (2015)  
J. Operational Meteor.



# ENTLN Results (2011-2013)

- The daily relative flash DE generally exceeds 15% (50%) in the Western Hemisphere (North America), but large day-to-day variability is evident
- Average distance and timing offsets between matched LIS/ENTLN events are 10.8 km and 25.0 ms (not shown)
- The average timing offset is positive, but the ENTLN reports its first event before 48.6% of LIS flashes begin



Rudlosky (2015) *J. Operational Meteor.*

# Matched LIS/ENTLN Flash Distributions

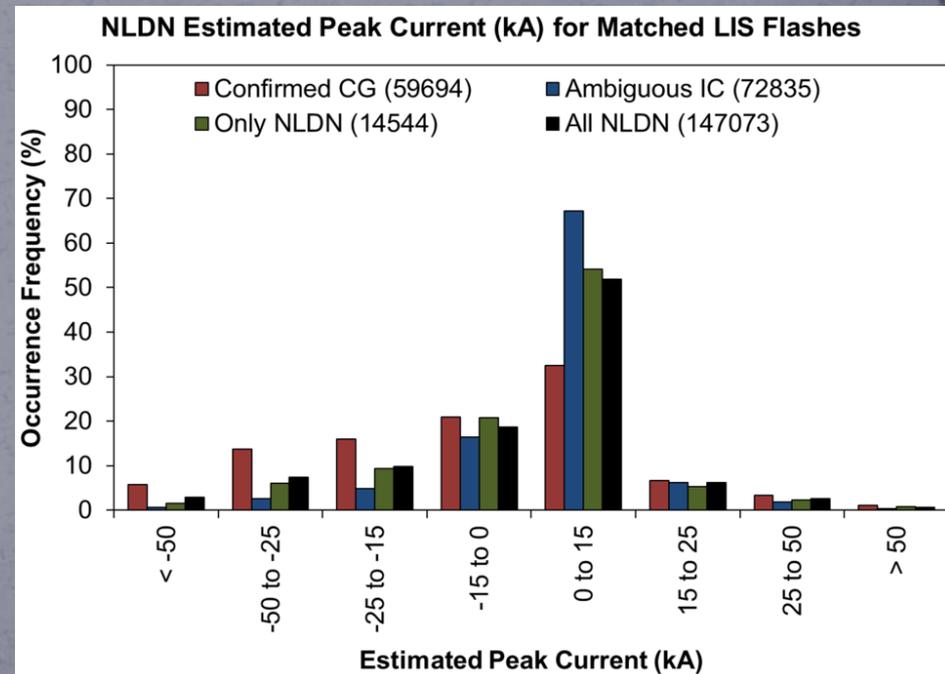
	Confirmed CG	Ambiguous IC	Ambiguous CG	Confirmed IC	Unmatched	Only NLDN
Year (Stroke Count)	ENTLN CG NLDN CG	ENTLN IC NLDN CG	ENTLN CG No NLDN	ENTLN IC No NLDN	No ENTLN No NLDN	No ENTLN NLDN CG
3YRS (351542)	17.0%	20.7%	8.1%	26.1%	24.0%	4.1%
LIS Characteristics						
Duration (ms)	24.0	21.8	18.3	11.8	5.1	12.2
Area (km <sup>2</sup> )	428.4	293.2	288.8	230.2	197.3	316.0
MNEG (count)	14.9	9.8	9.6	7.7	6.8	11.0
MGA (km <sup>2</sup> )	378.4	251.9	249.3	200.4	176.1	282.9

- NLDN data helps characterize flash type (CG vs. IC), allowing investigation of the LIS characteristics of IC and CG flashes
- The ENTLN detects the strongest LIS flashes, and the LIS characteristics also indicate that CG flashes transfer more charge than IC flashes
  - MNEG = Maximum Number of Events per Group
  - MGA = Maximum Group Area

# Matched LIS/ENTLN Flash Distributions

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	ENTLN CG NLDN CG	ENTLN IC NLDN CG	ENTLN CG No NLDN	ENTLN IC No NLDN	No ENTLN No NLDN	No ENTLN NLDN CG
2011 (122707)	13.3%	15.9%	6.6%	26.7%	30.8%	6.8%
2012 (118958)	19.3%	17.4%	10.4%	27.4%	22.9%	2.6%
2013 (109877)	18.6%	29.7%	7.3%	24.0%	17.5%	2.9%
3YRS (351542)	17.0%	20.7%	8.1%	26.1%	24.0%	4.1%

- This comparison provides important insights into the ambiguity of flash classification in both datasets
- 67.2% of the Ambiguous IC flashes have NLDN estimated peak currents in the ambiguous weak +CG range (0–15 kA)
- Ambiguous IC flashes appear to be mostly IC, with some true CG flashes
- Findings illustrate the challenge of classifying IC and CG flashes



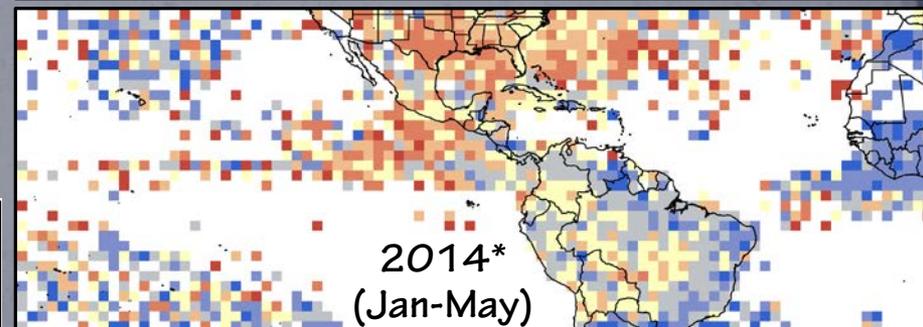
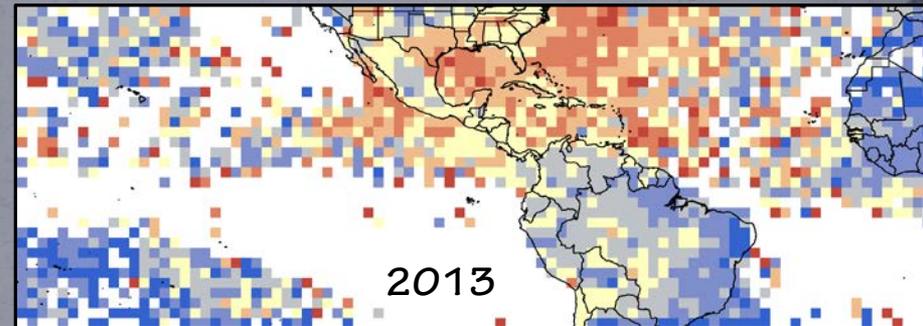
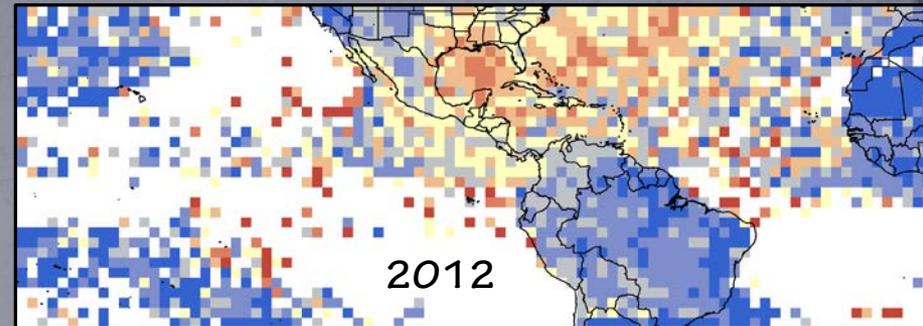
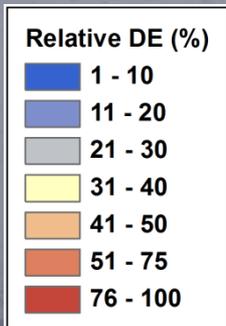
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# GLD360 Results

- The GLD360 has a large region with relative DE greater than 30%, with no clear land/ocean contrast
- Performance appears to be improving, although the partial 2014 disguises this trend

Relative DE (%)	2012	2013	2014*
W. Hemisphere	20.4	24.4	22.1
CONUS	35.8	38.6	48.5
N. America	33.5	35.5	47.4
S. America	11.7	16.8	16.4
Oceans	26.8	30.6	23.2

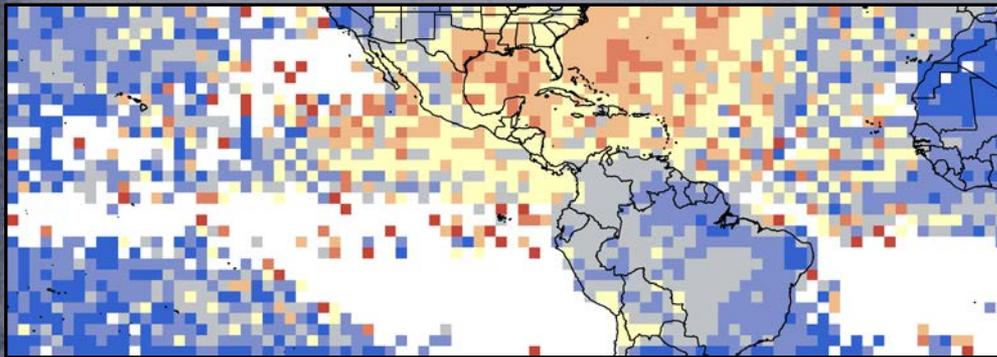
\* 2014 only includes January – May



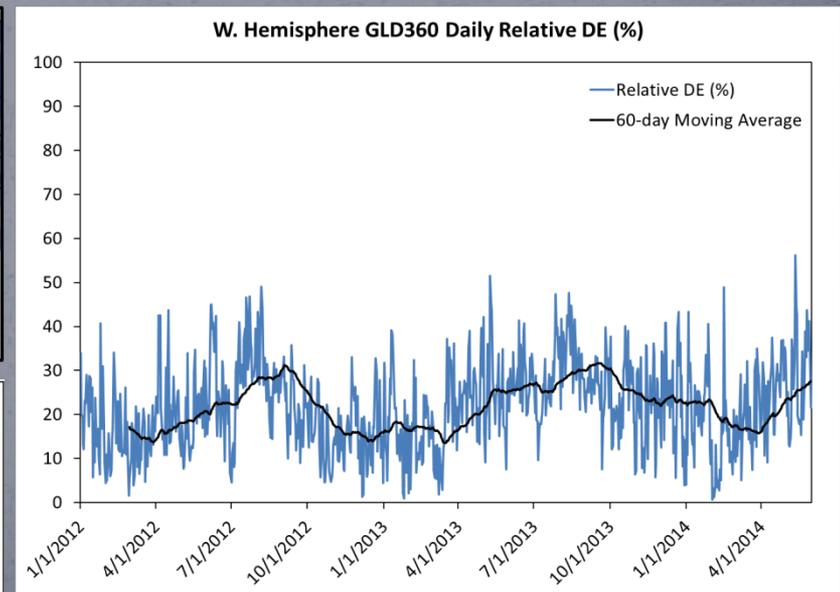
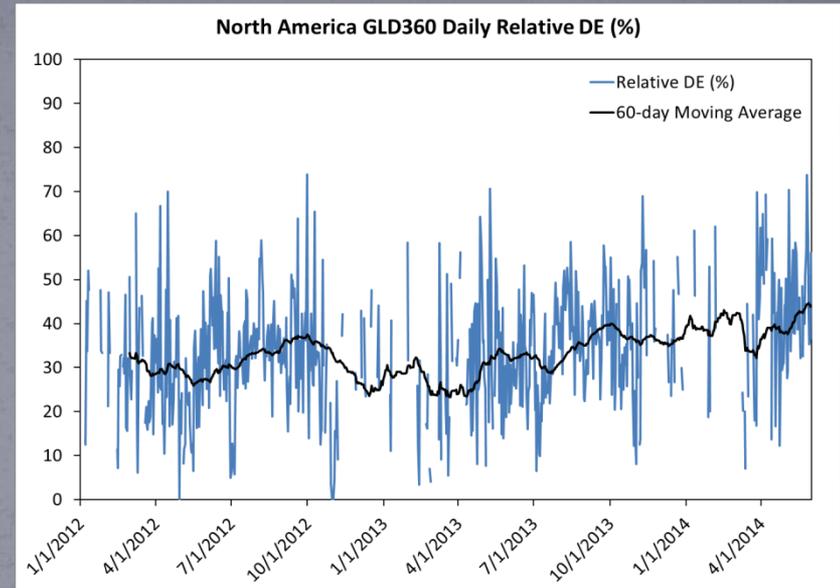
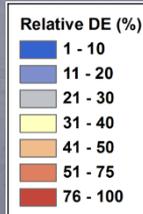
Shaded grid cells indicate where fewer than 15 LIS flashes occurred (i.e., less confident relative DE estimates)

# GLD360 Results

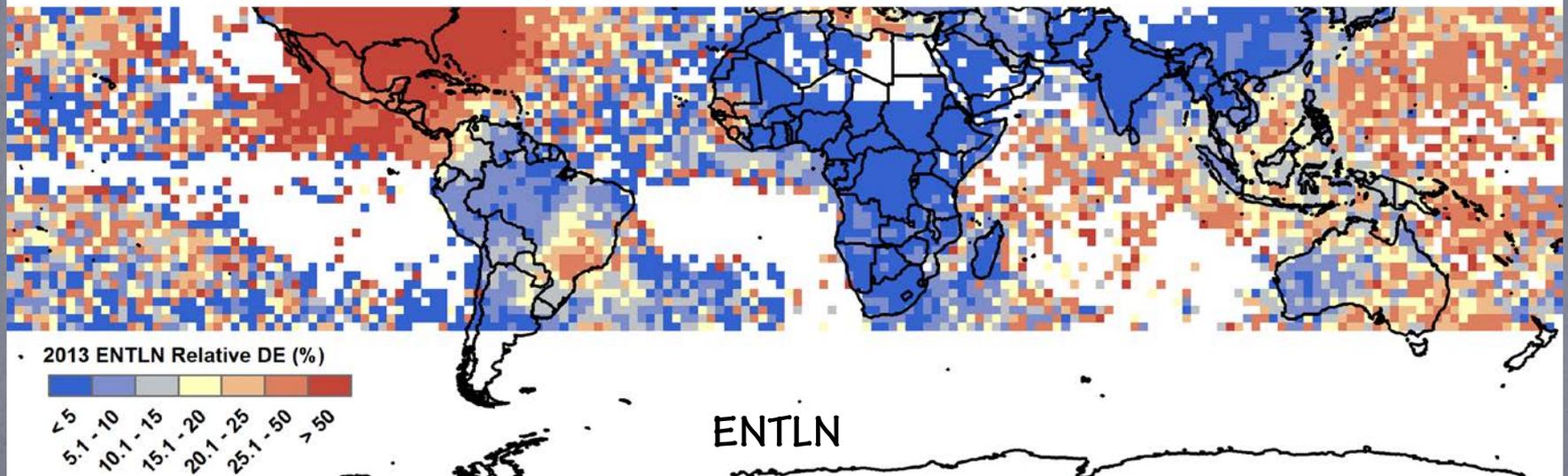
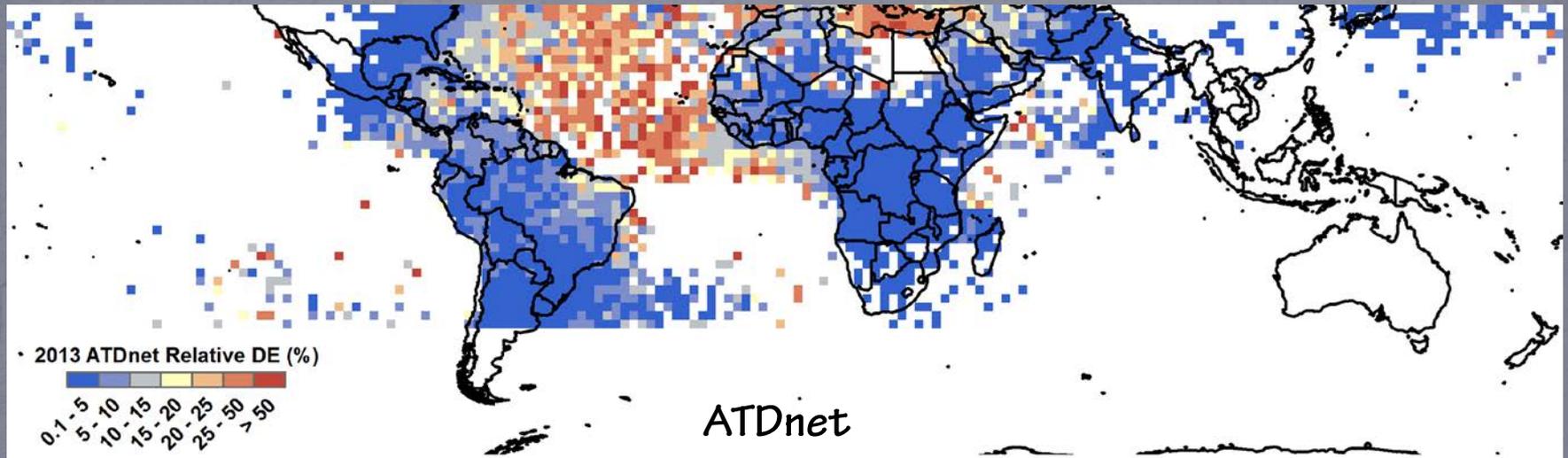
- Daily relative DEs further illustrate the improving GLD360 performance
- The daily relative flash DE generally exceeds 25% in North America (10% in the Western Hemisphere), but large day-to-day variability is evident



Relative DE (%) Jan. 2012 – May 2014



# “Global” Relative Detection Efficiencies



Note the relaxed color scale relative to previous imagery

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