Vaisala's NLDN and GLD360 performance improvements and aviation applications

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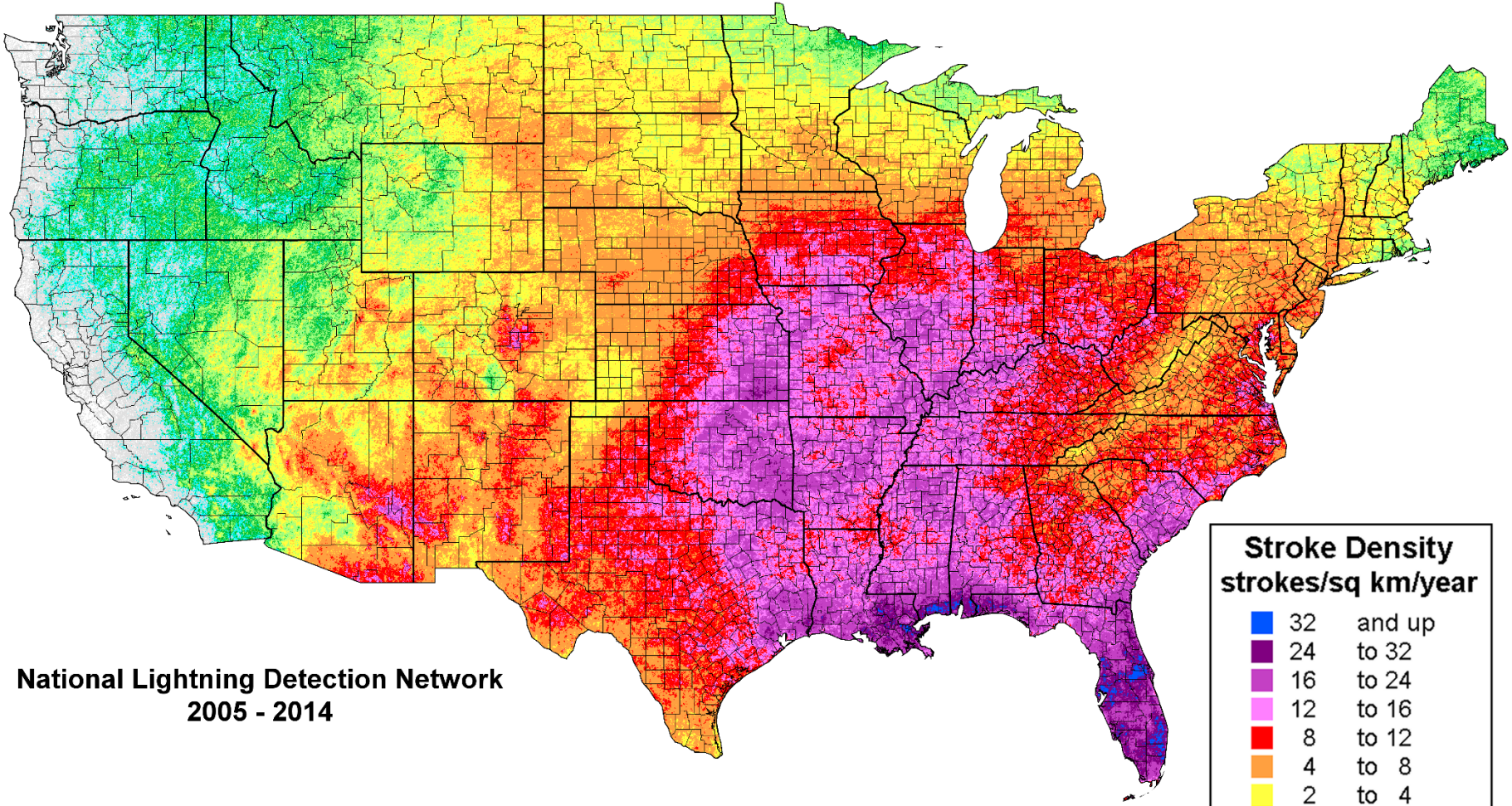
Introduction

- **Continuous CONUS Data Since 1989**
  - The U.S. National Lightning Detection Network (NLDN) has been providing real-time, continental-scale lightning data since 1989.
  - The NLDN has undergone continuous and quantified improvement through upgrades in 1995, 2003-4, 2010-12, and now 2015. Each were coupled with detailed performance analyses.

- **Continuous Global Data Since 2009**
  - The Global Lightning Dataset (GLD360) has been providing real-time, global lightning data since 2009.
  - The GLD360 has undergone continuous and quantified improvement through upgrades in 2011 and now 2015. Each were coupled with detailed performance analyses.

- **Today, NLDN and GLD360 data are used for many aviation applications, including ground operations safety, en-route, and METAR/SPECI thunderstorm reporting**

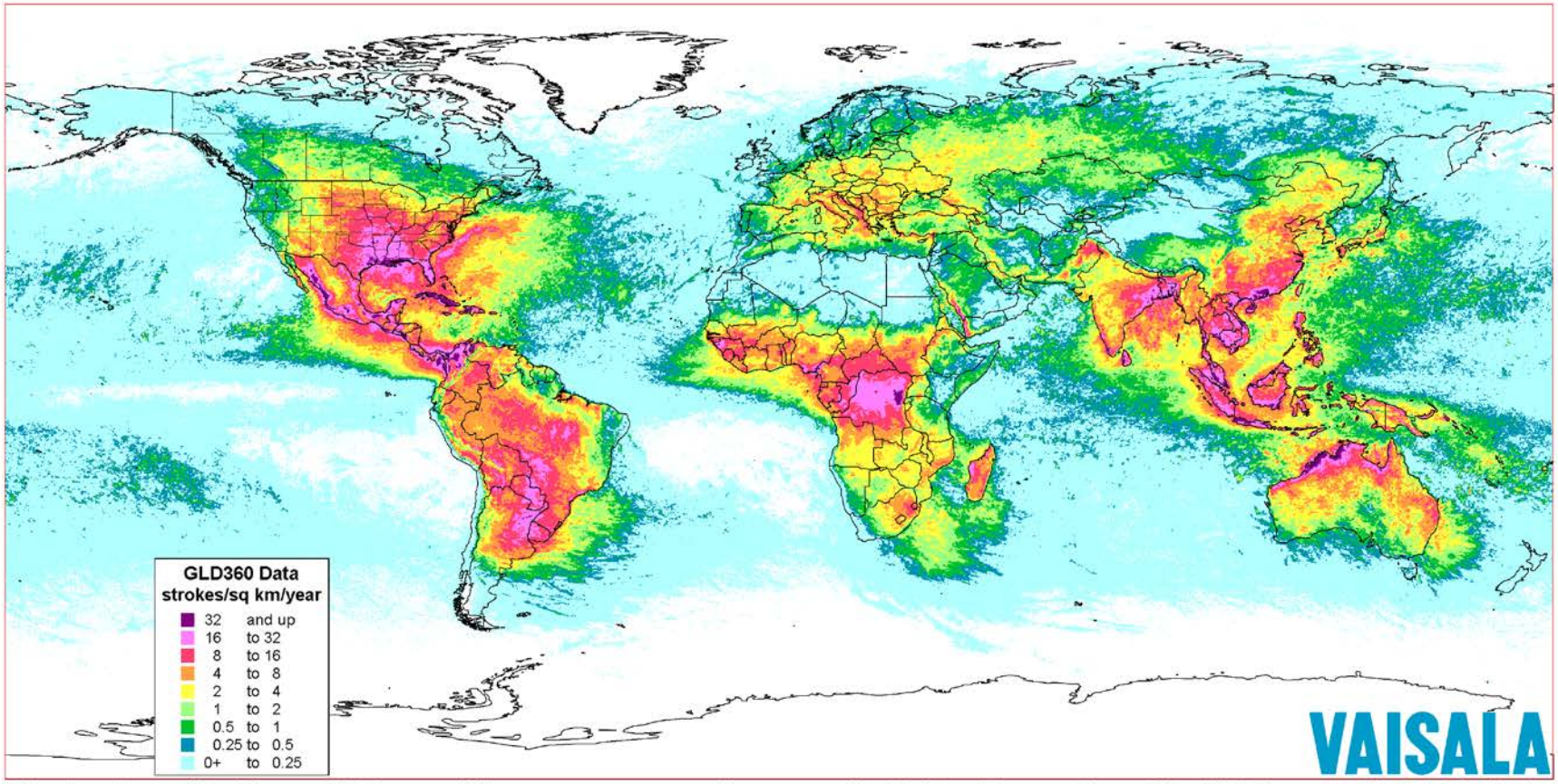
Long Term Climatological Dataset



National Lightning Detection Network
2005 - 2014

Annual Global Lightning Density Map

GLD360 data – 2012 - 2014



Stroke Density Map - 20 km grid **January 1, 2012 - December 31, 2014** **GLD360 data**

2015 Upgrade Summary

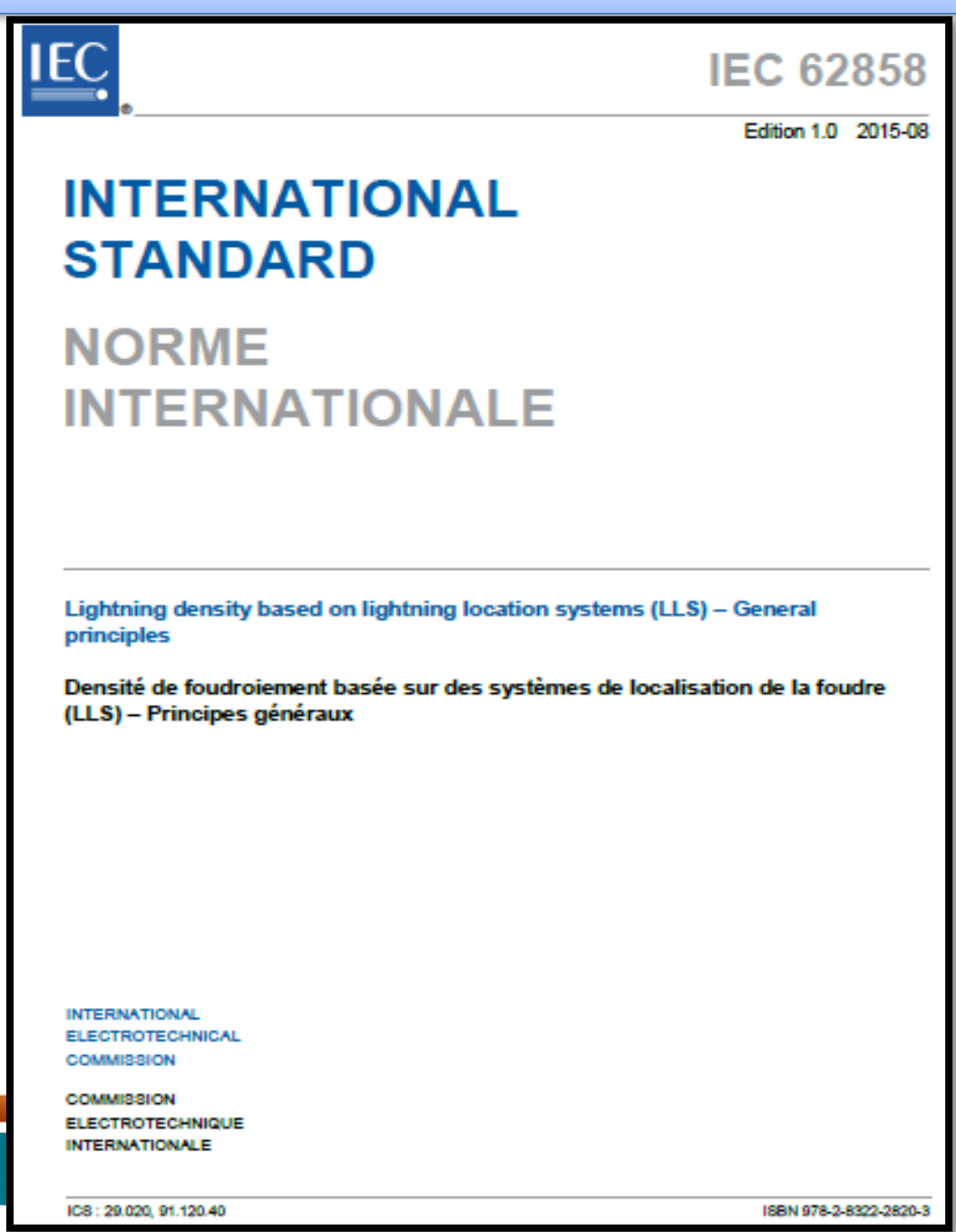
- **NLDN**
  - Includes new burst processing algorithm for increased detection of cloud pulses
  - The new location algorithm reports on average 10% more cloud lightning pulses
  - Through a prior upgrade, the NLDN already had achieved a cloud flash detection efficiency of ~50% with a median location accuracy of ~150 m

- **GLD360**
  - Includes an improved propagation model
  - Includes more refined sensor correlation heuristics
  - Includes significant expansion of network optimization tools
  - The new location algorithm reports on average 80% more cloud-to-ground strokes plus cloud pulses with a median location accuracy of ~2 km

LLS Validation Techniques

- LLS Self-Reference
- Rocket-Triggered Lightning and Lightning Strikes to Tall Objects
- Video Camera Measurements
- Inter-Comparison among LLSs

These techniques were published in **IEC standard** document 62858 entitled: “Lightning Density Based on Lightning Location Systems”.


IEC

IEC 62858

Edition 1.0 2015-08

INTERNATIONAL STANDARD

NORME INTERNATIONALE

Lightning density based on lightning location systems (LLS) – General principles

Densité de foudroiement basée sur des systèmes de localisation de la foudre (LLS) – Principes généraux

INTERNATIONAL ELECTROTECHNICAL COMMISSION

COMMISSION ELECTROTECHNIQUE INTERNATIONALE

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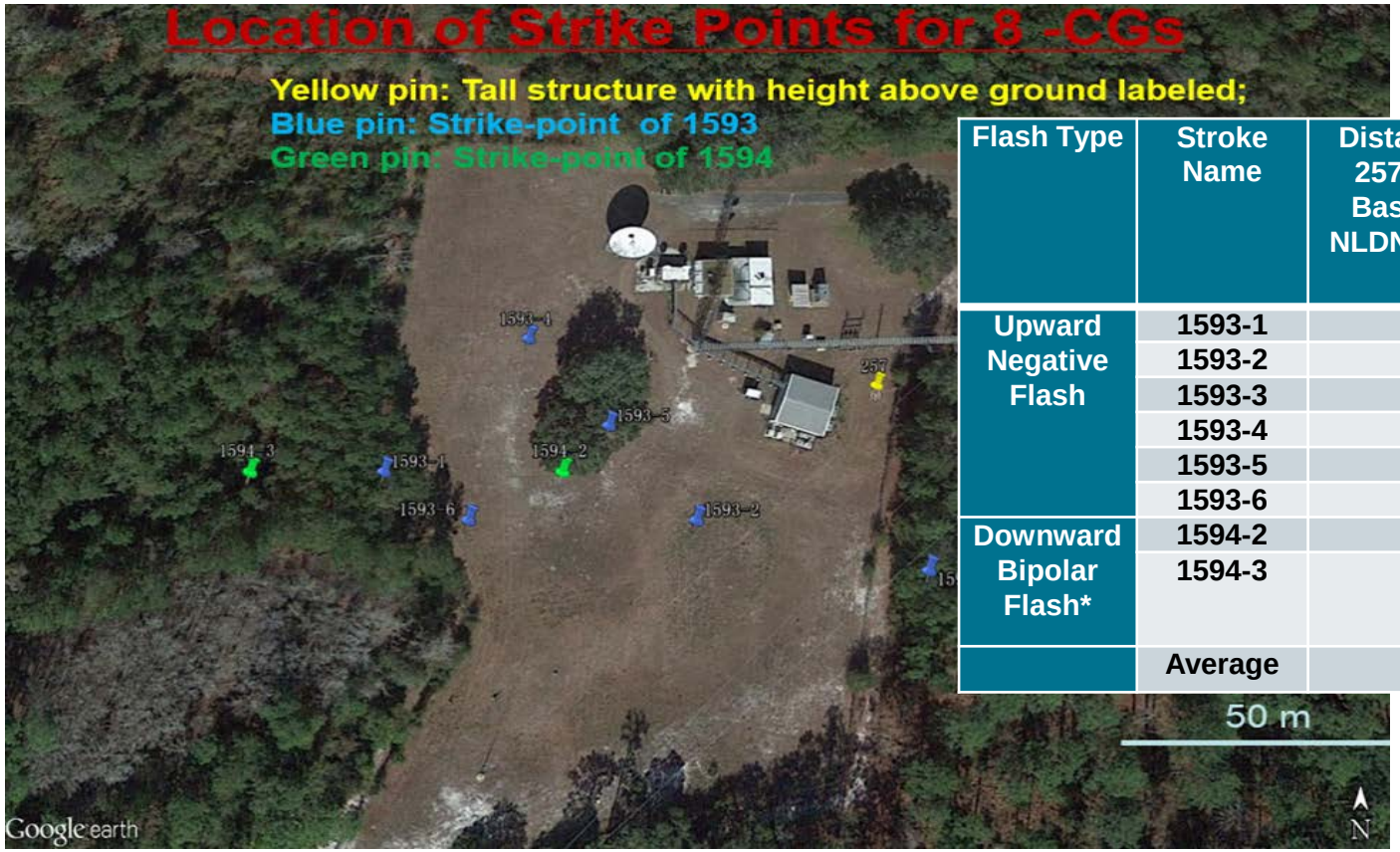
Performance Characteristics Validation

Rocket-Triggered Lightning

Lightning Strike to a Tower

NLDN Data and Location of Strike Point

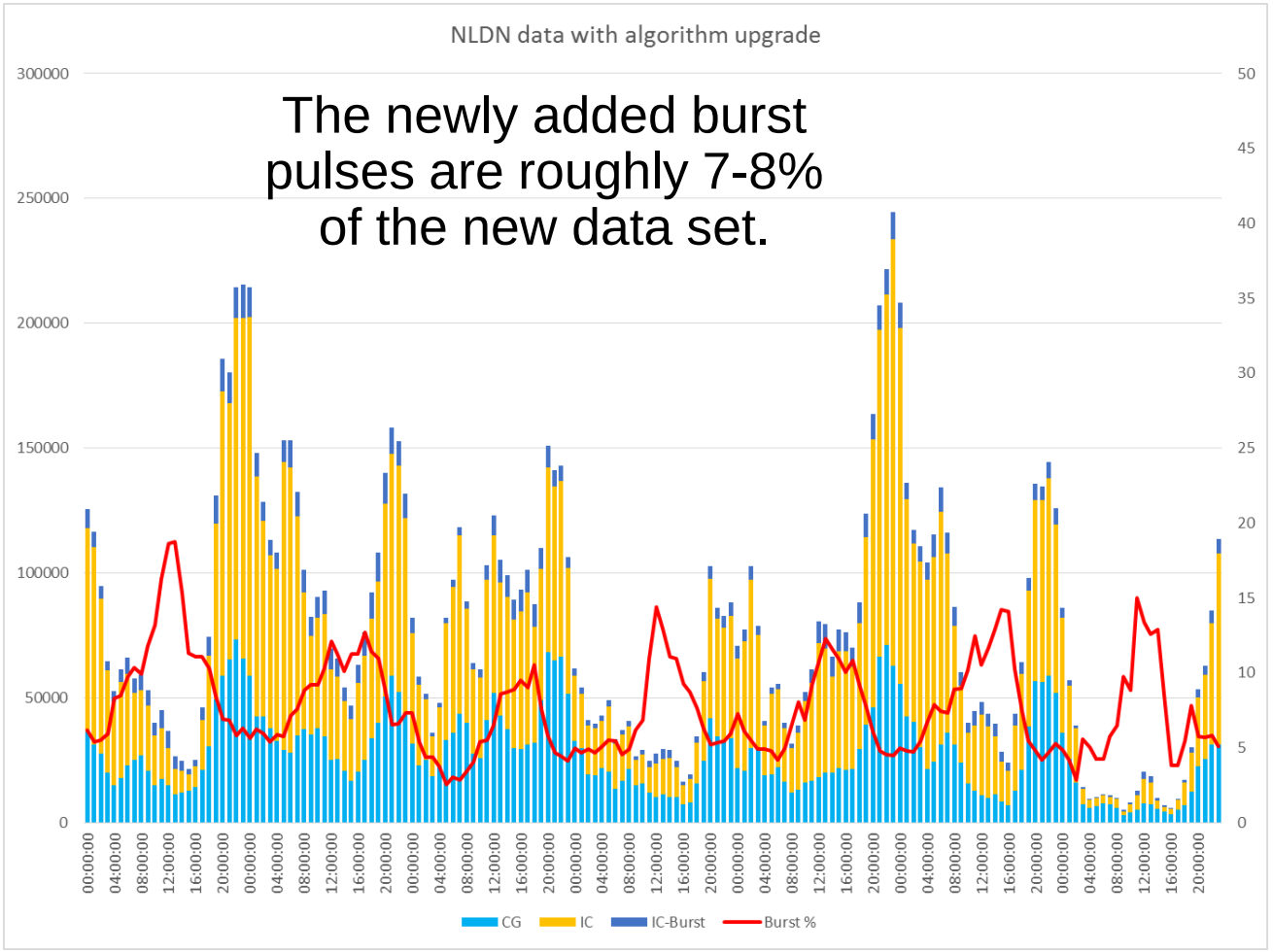


Flash Type	Stroke Name	Distance to the 257 m Tower Based on the NLDN Locations (m)
Upward Negative Flash	1593-1	110
	1593-2	50
	1593-3	40
	1593-4	80
	1593-5	60
	1593-6	90
Downward Bipolar Flash*	1594-2	70
	1594-3	140
	Average	80

Locations of strike points given by the NLDN for 8 negative strokes. Blue pins are strike-points of CG flash 1593 and green pins are strike points of CG flash 1594. Yellow pin is the location of the tower.

NLDN cloud lightning improvements

Comparison of old vs new algorithm for one week



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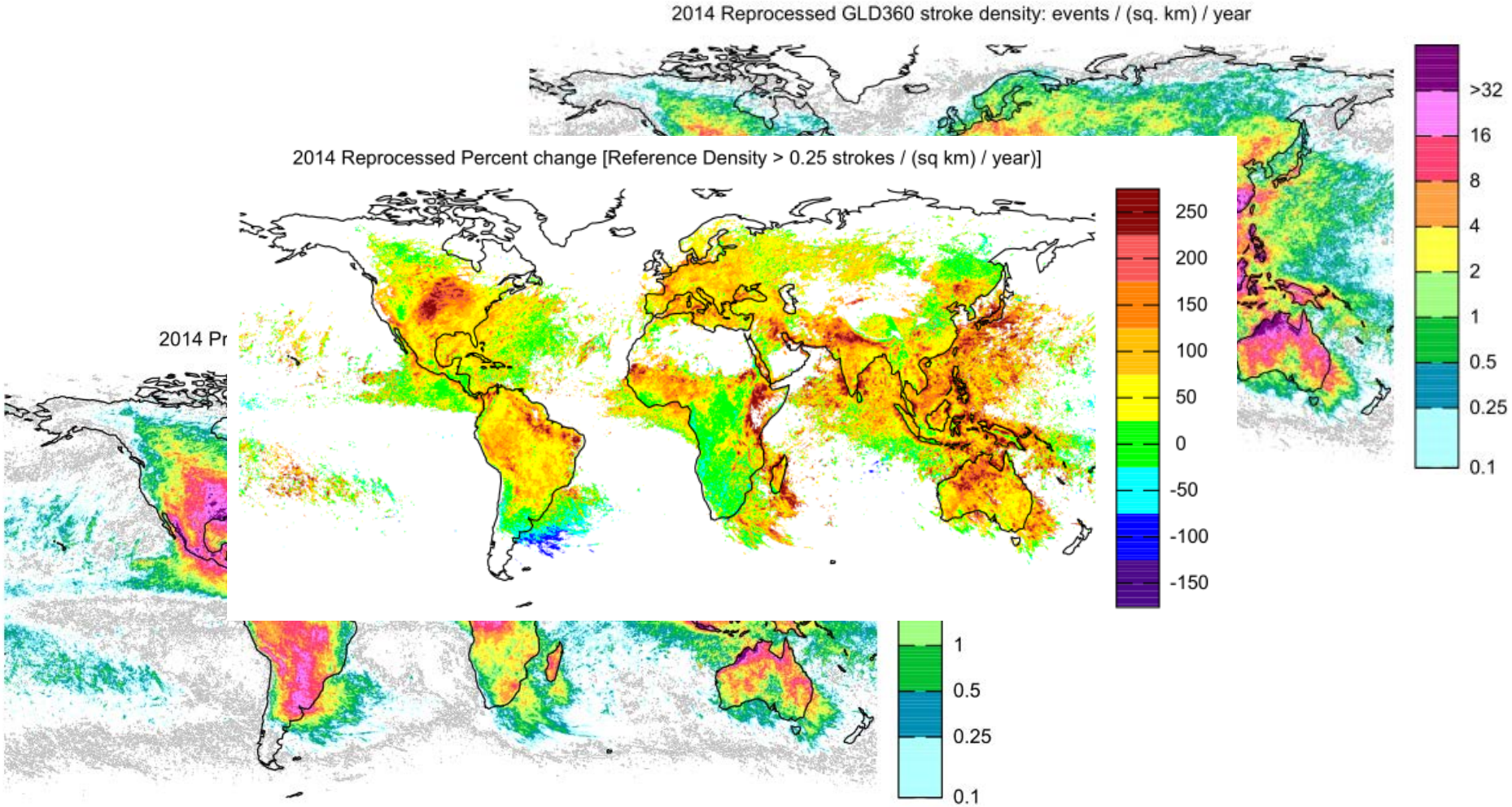
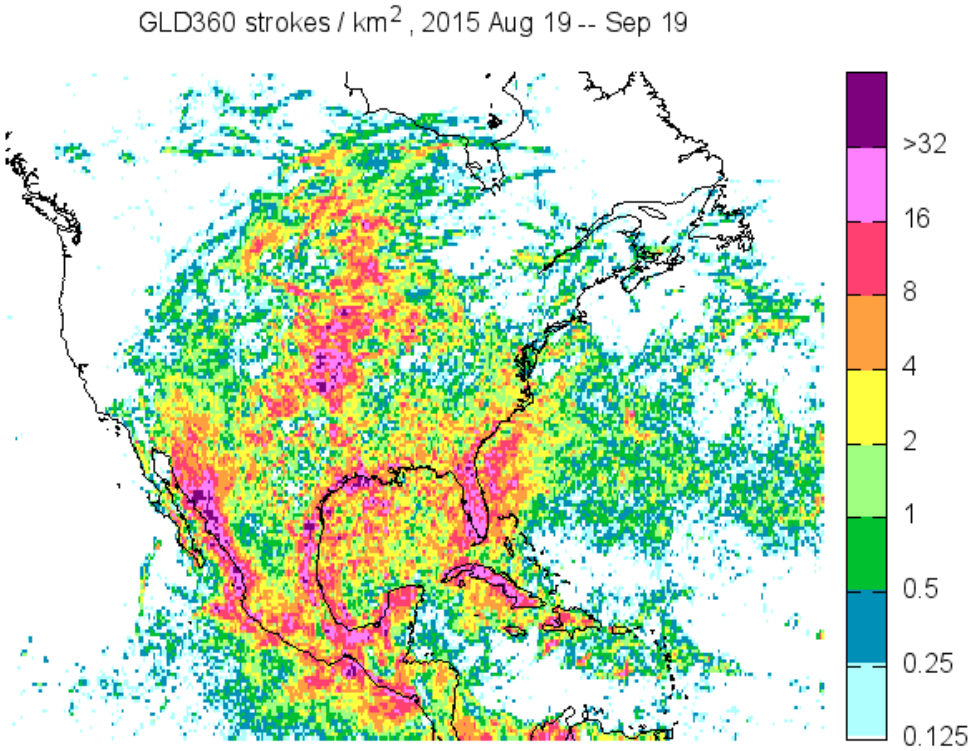
GLD360 lightning density map comparisons

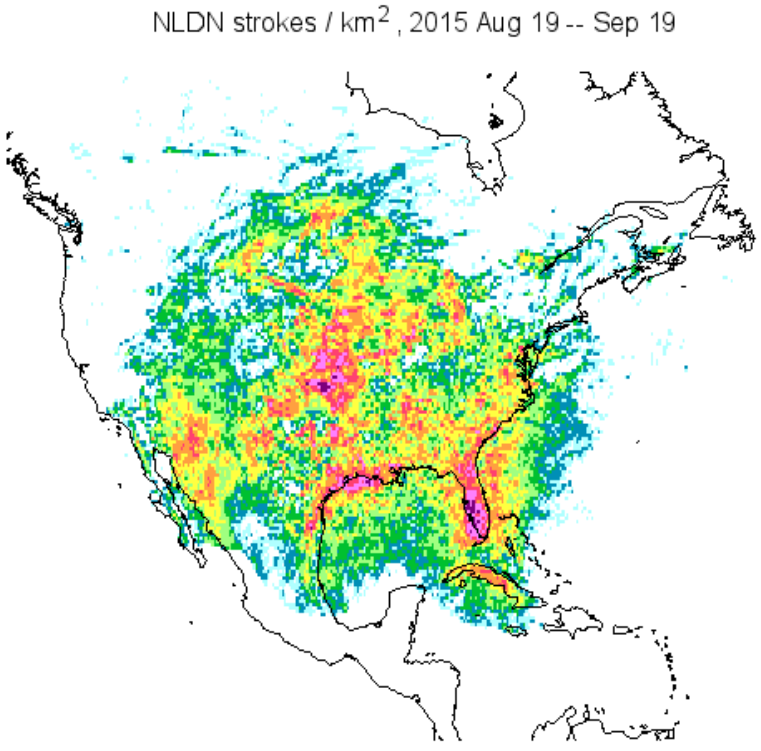
New vs Old location algorithm for 2014



GLD360 vs NLDN lightning density map comparisons

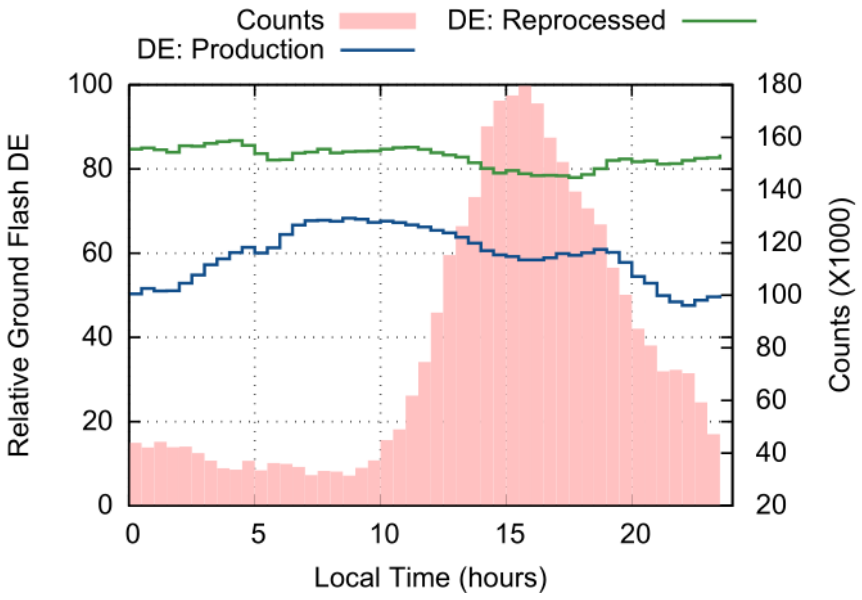
19 August to 18 September 2015

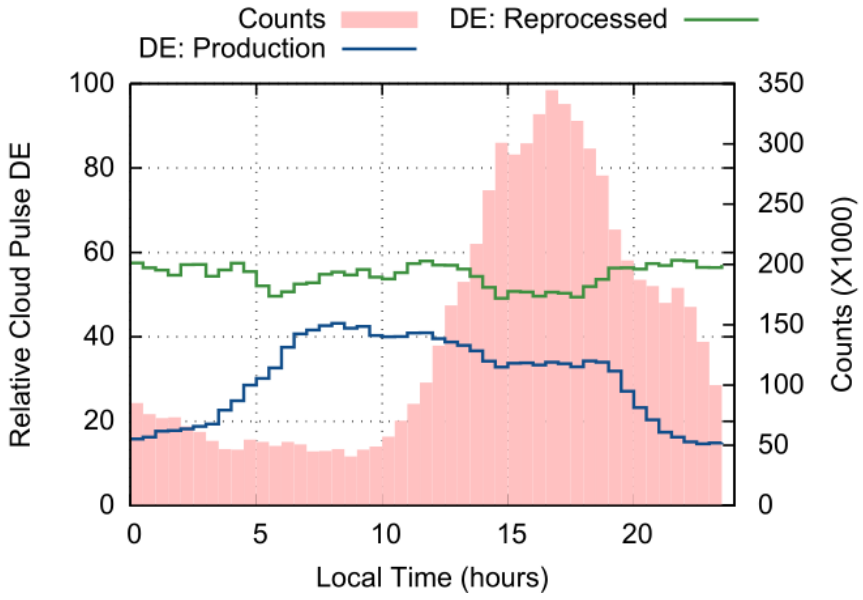




GLD360 performance validation using NLDN as ground truth

New vs Old location algorithm for 2014





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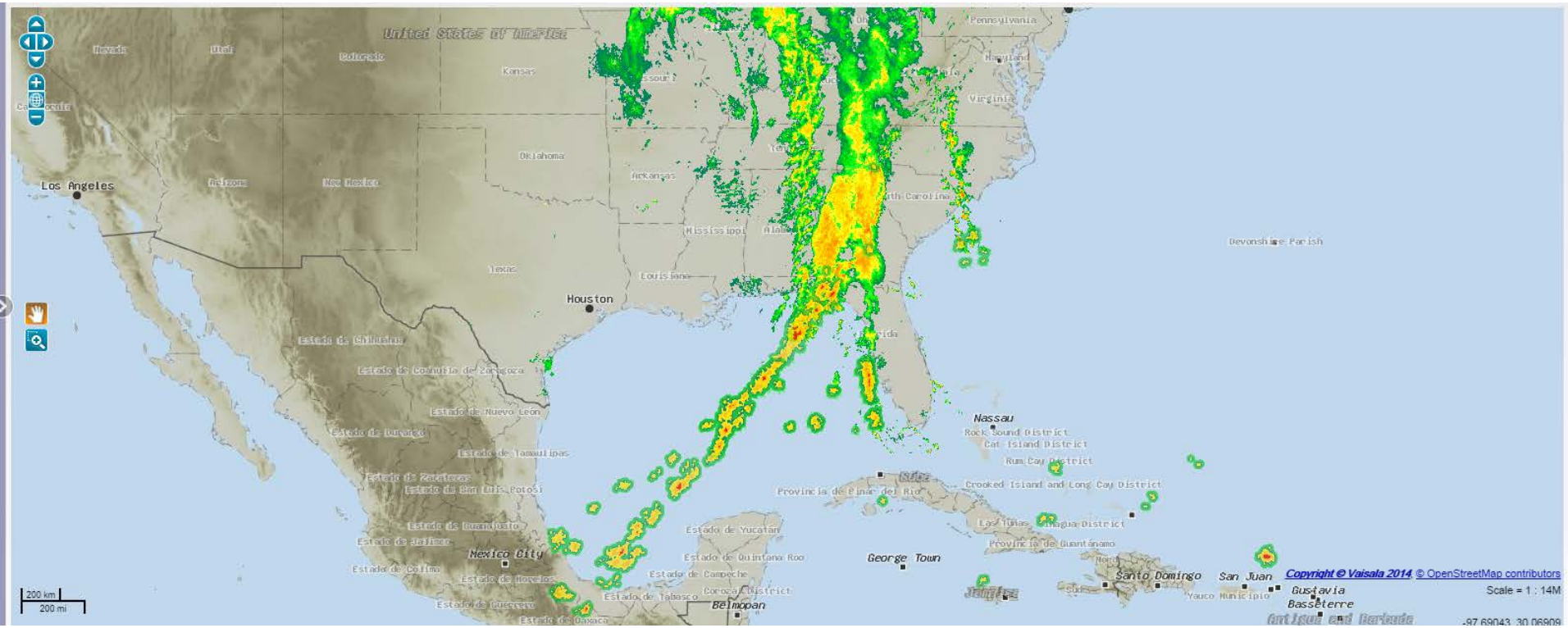
Current NLDN and GLD360 Real-Time Performance Characteristics

Characteristic	NLDN	GLD360
Cloud-to-Ground Flash detection efficiency	>95%	~80%
Median stroke location accuracy	~150 m	~2 km
Cloud Flash detection efficiency	~60%*	~35%*

* **Requires further validation. There is some evidence to suggest each network is detecting a higher percentage of cloud lightning flashes, pending further investigation.**

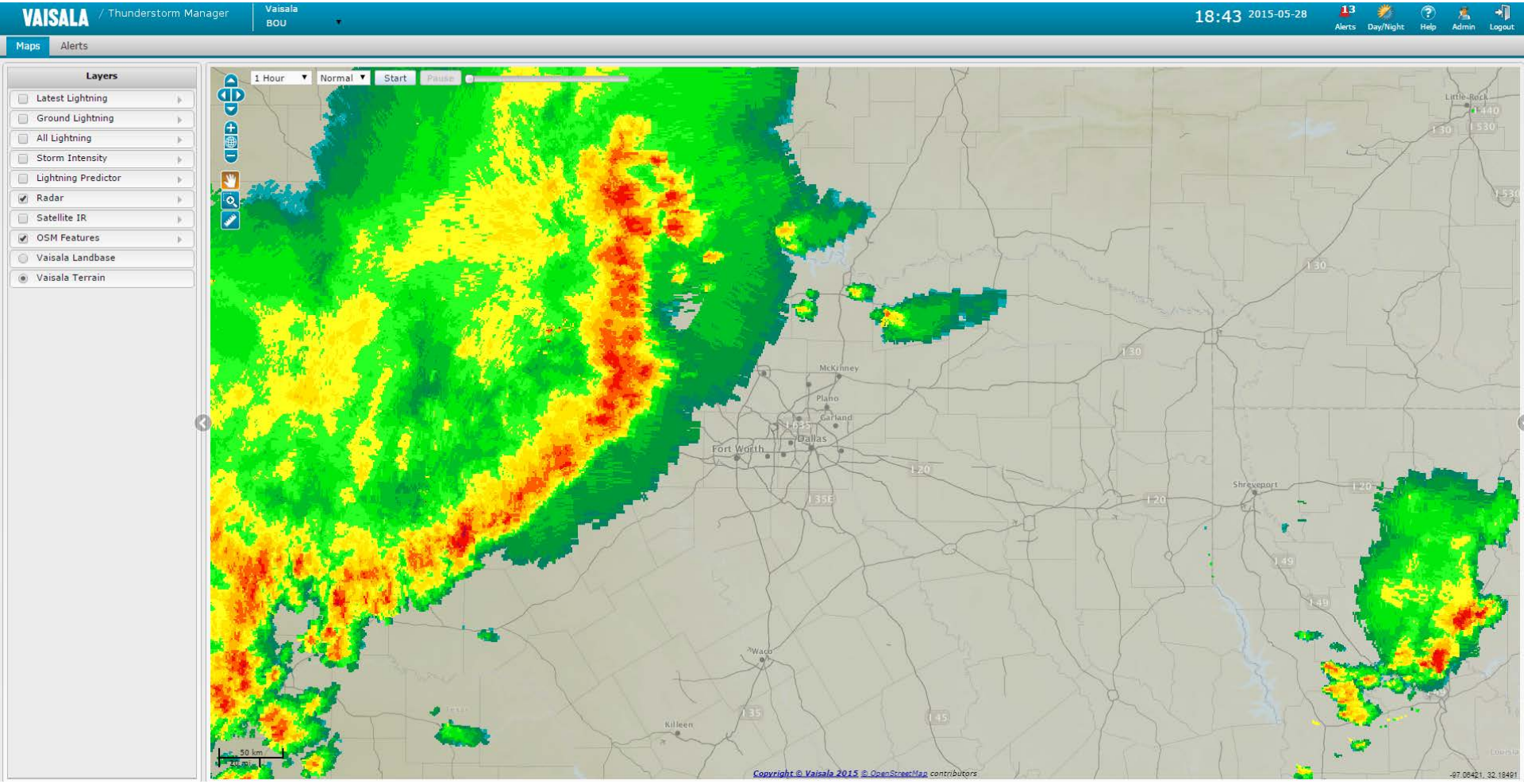
Weather radar reflectivity

Weather radar reflectivity with lightning-derived weather radar reflectivity proxy



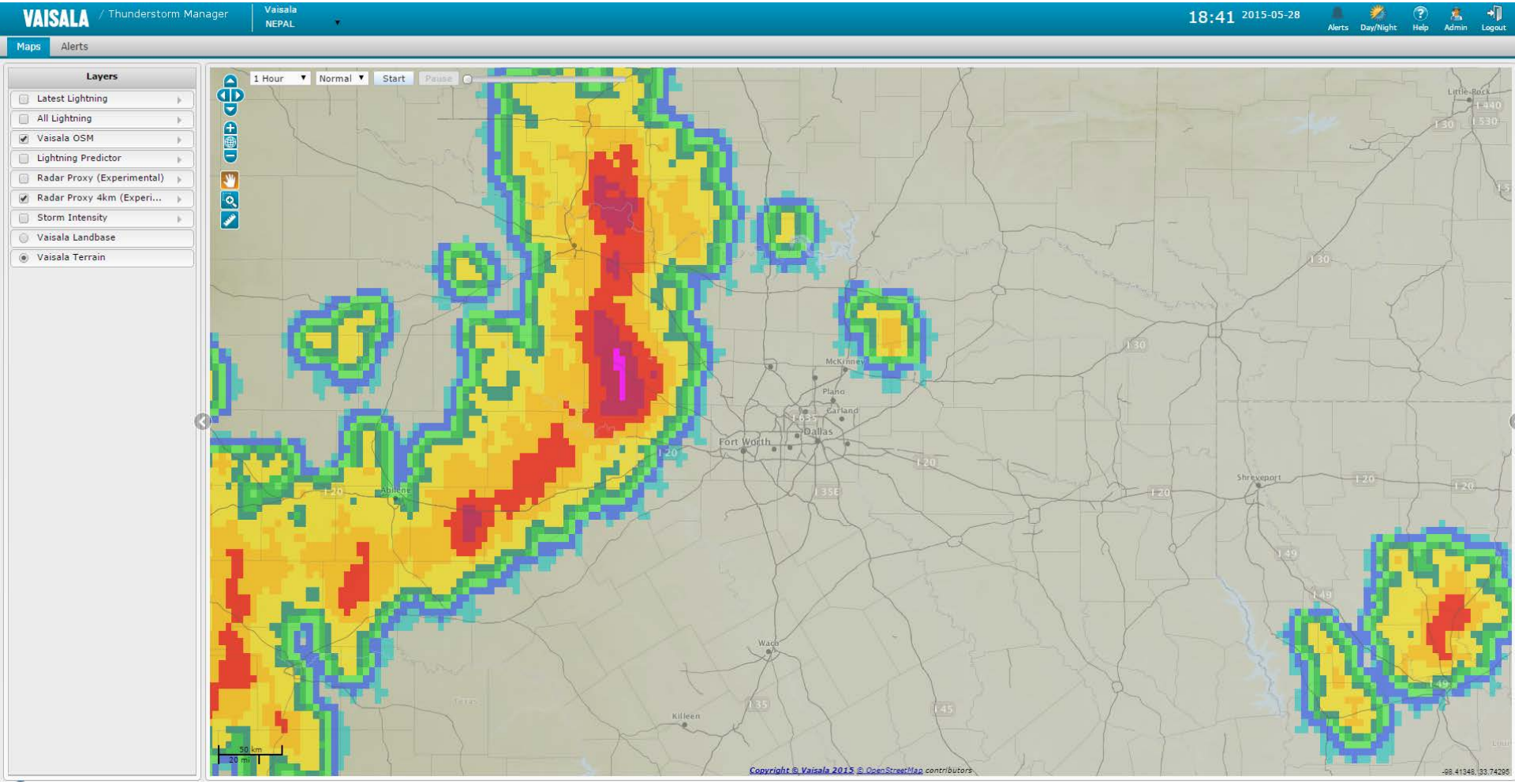
Vaisala AviCast features

Weather radar reflectivity

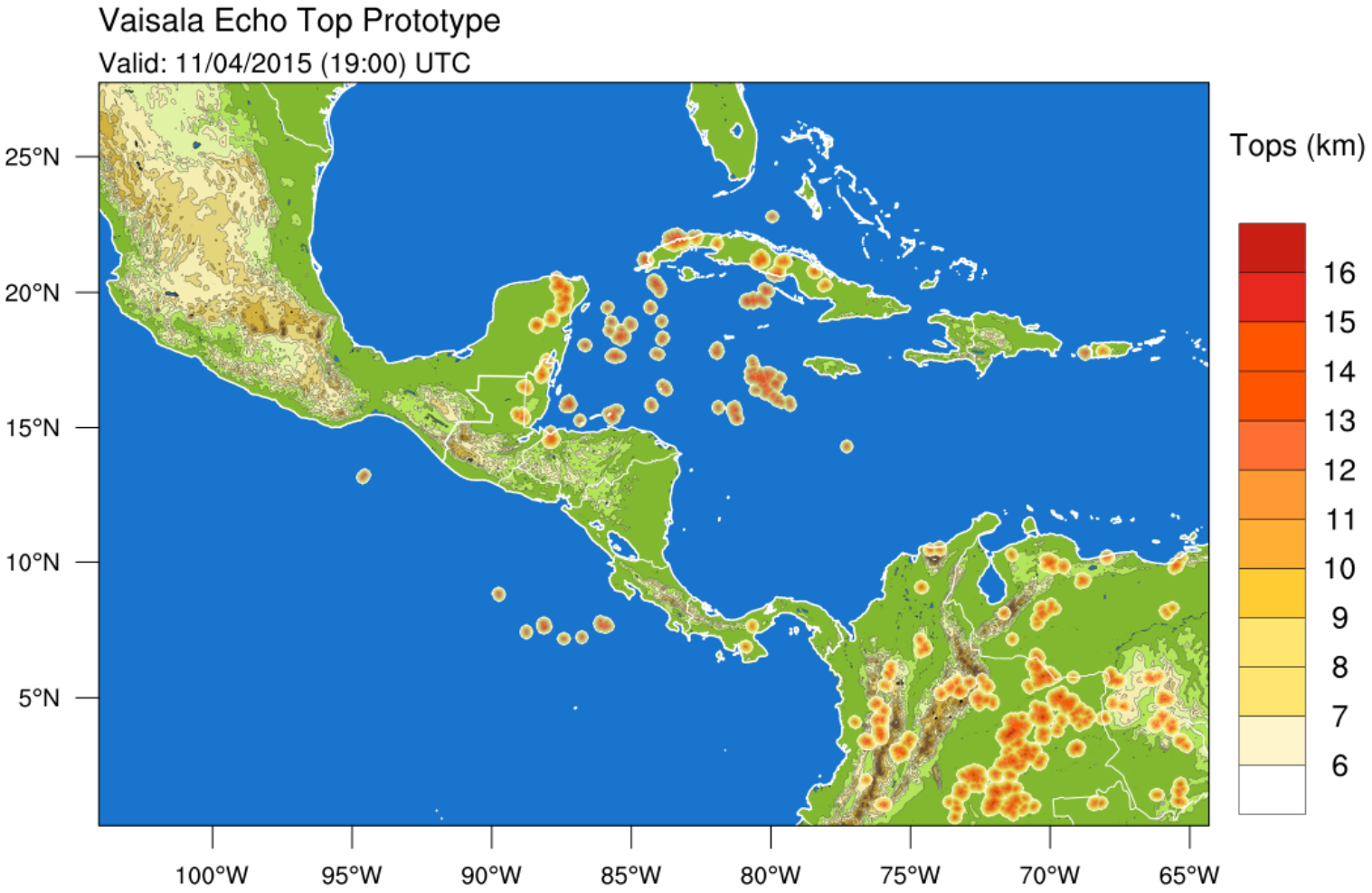


Vaisala AviCast features

Lighting-derived weather radar reflectivity proxy

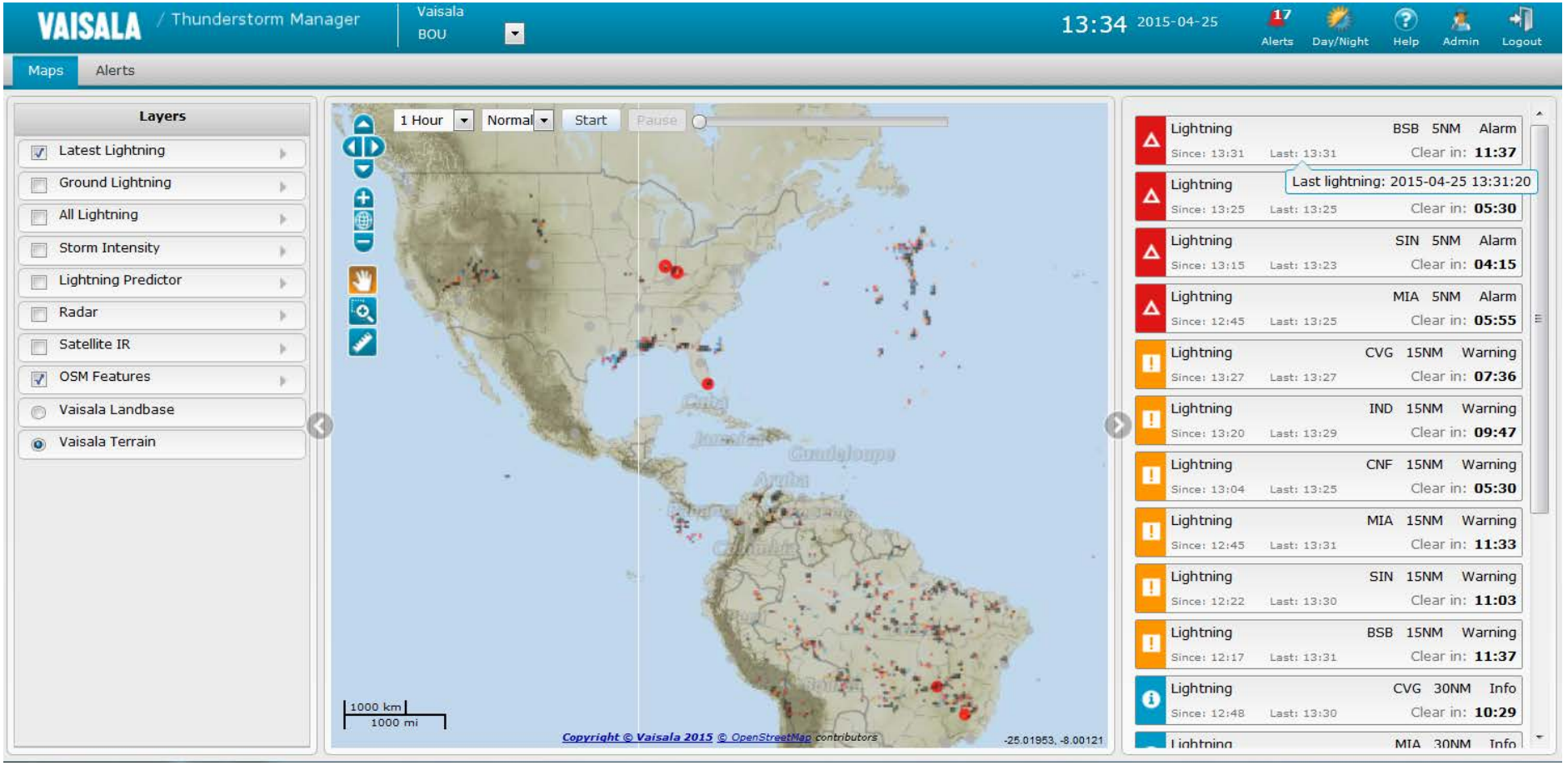


Vaisala lightning-derived echo top proxy prototype

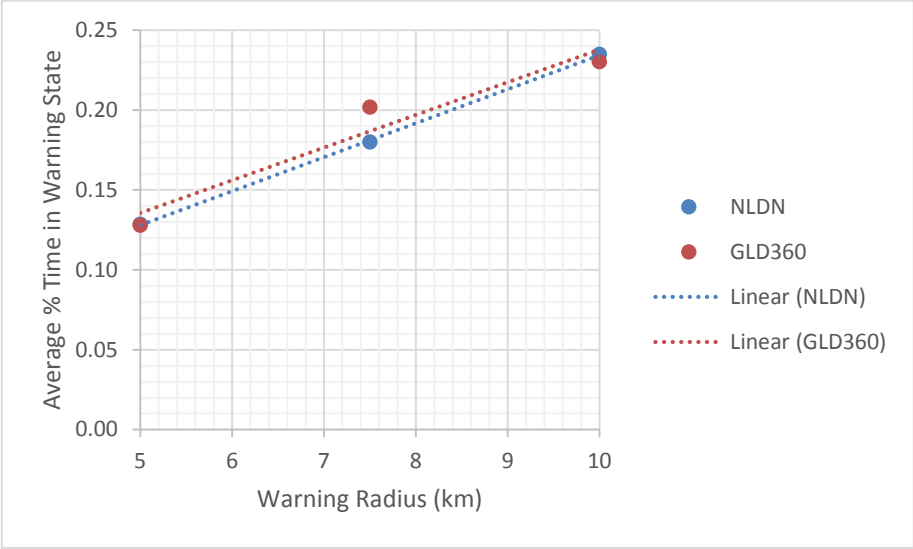


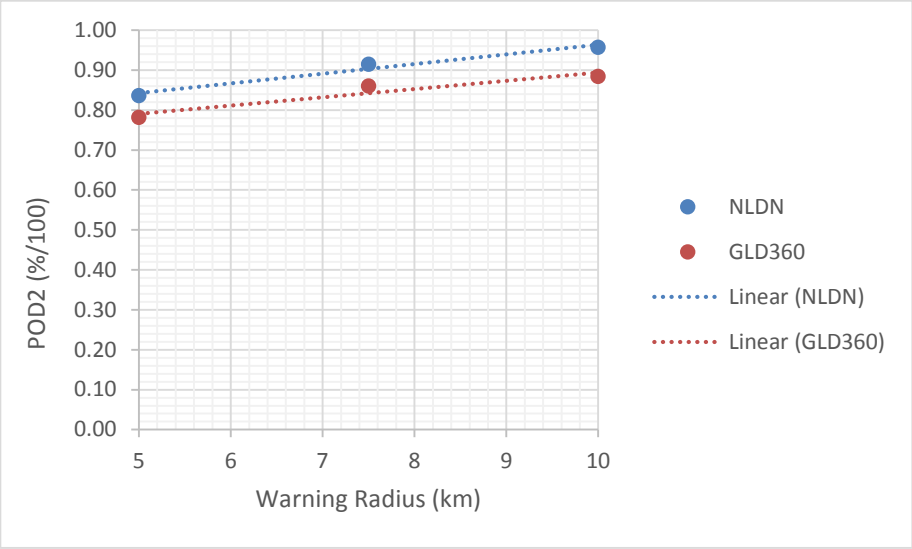
Vaisala AviCast Lightning Display

Multi-Airport display with alarms – USA, Brazil



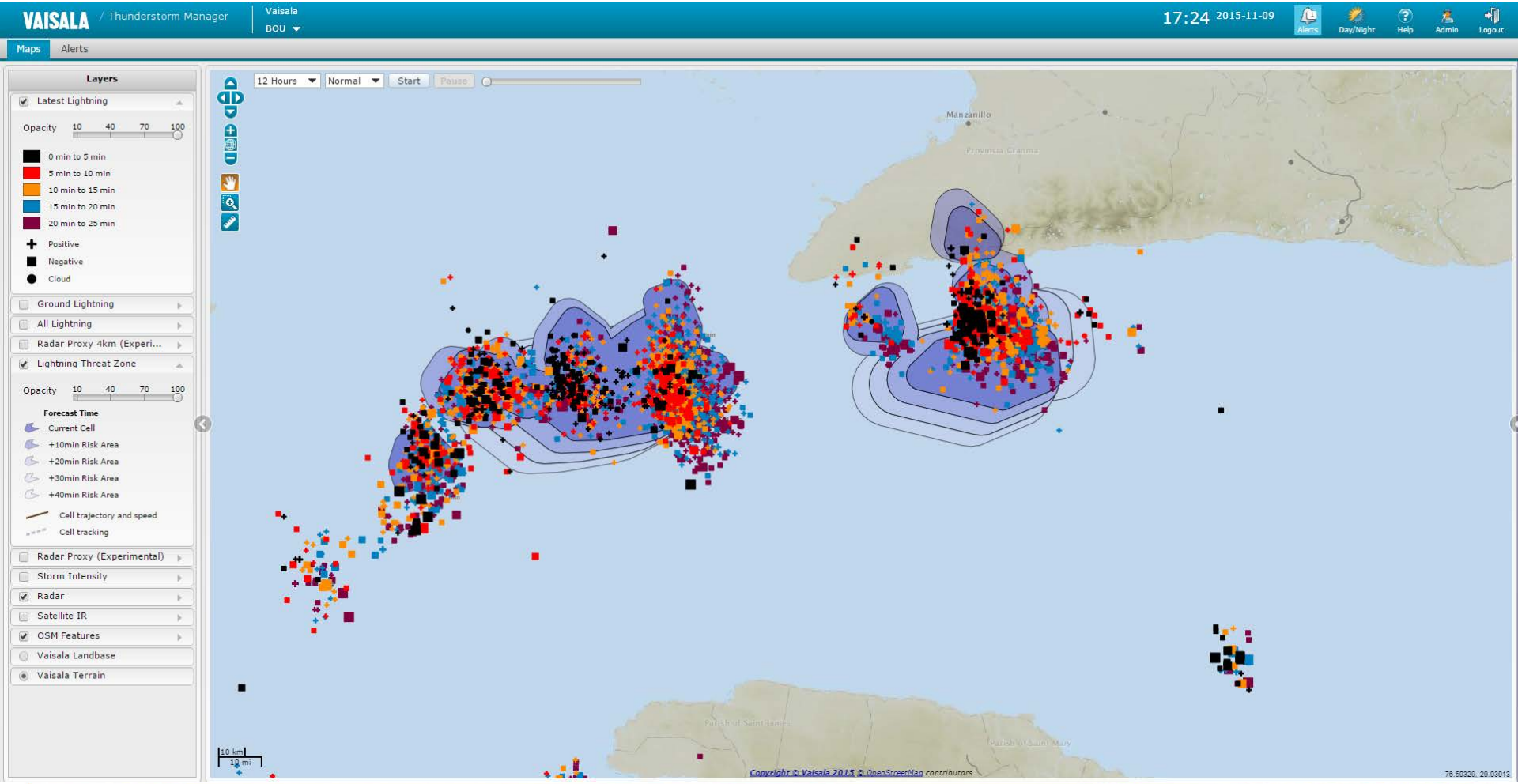
NLDN and GLD360 ground operations lightning warning comparisons for 3 months





Vaisala AviCast lightning features

Lightning cell identification, tracking, intensity, and 1-hour forecast



Summary

- **On 18 August 2015, Vaisala implemented new location algorithms for the NLDN and GLD360**

- **Performance significantly improved for the following characteristics:**
  - NLDN cloud flash/pulse detection efficiency
  - GLD360 total (cloud + cloud-to-ground) flash/pulse detection efficiency
  - GLD360 cloud-to-ground stroke location accuracy

- **GLD360 can now truly be called a total lightning network**

- **NLDN and GLD360 data are both being used today for the following applications**
  - Lightning warnings for airport ground operations, including lightning threat nowcasts
  - Weather Radar reflectivity and echo top proxies
  - METAR/SPECI integration for present weather thunderstorm reporting