Geostationary Lightning Mapper Performance, Capabilities, and Applications

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With contributions from
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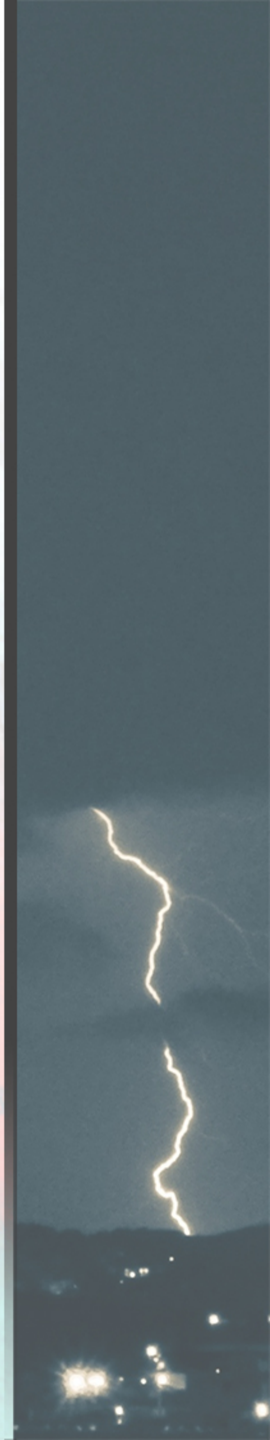
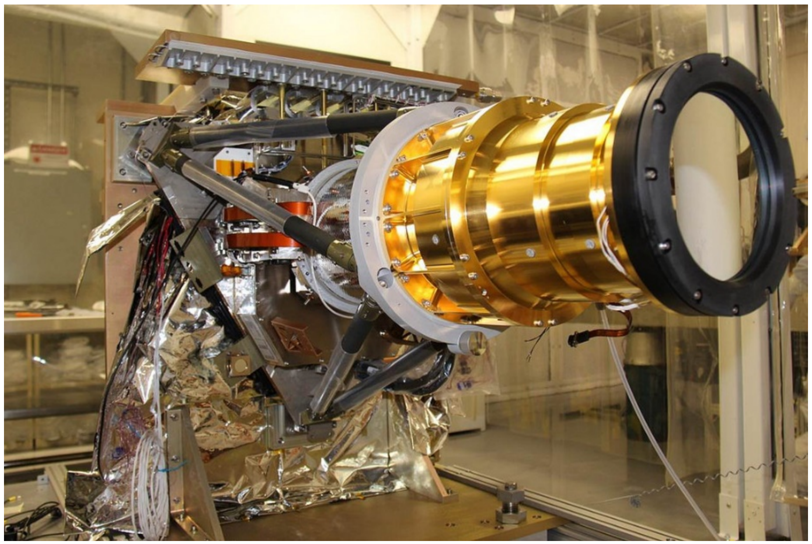
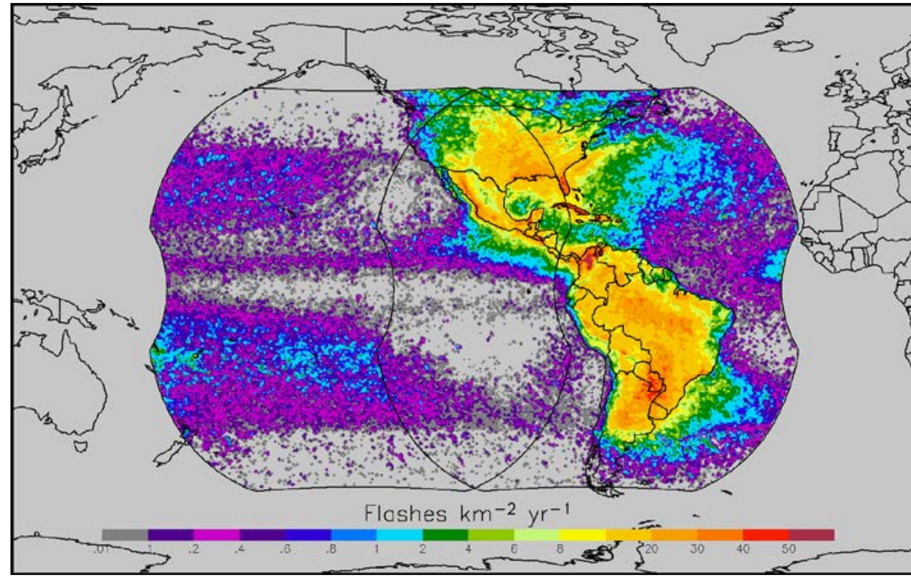
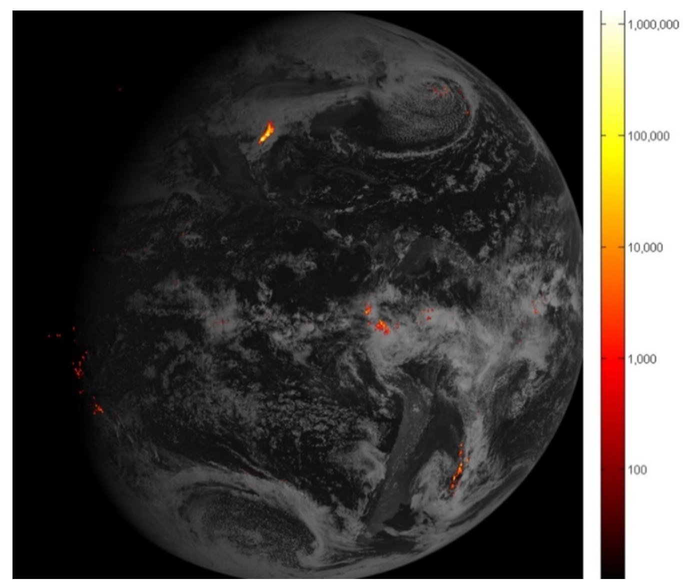
2 November 2018



The Geostationary Lightning Mapper





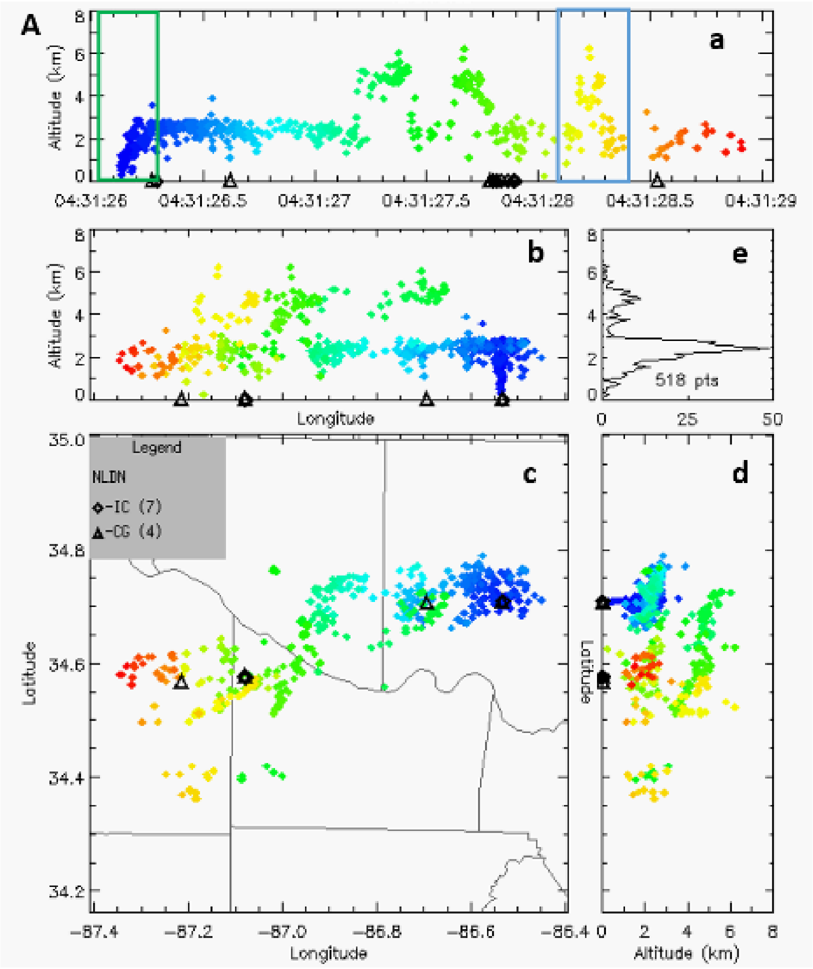


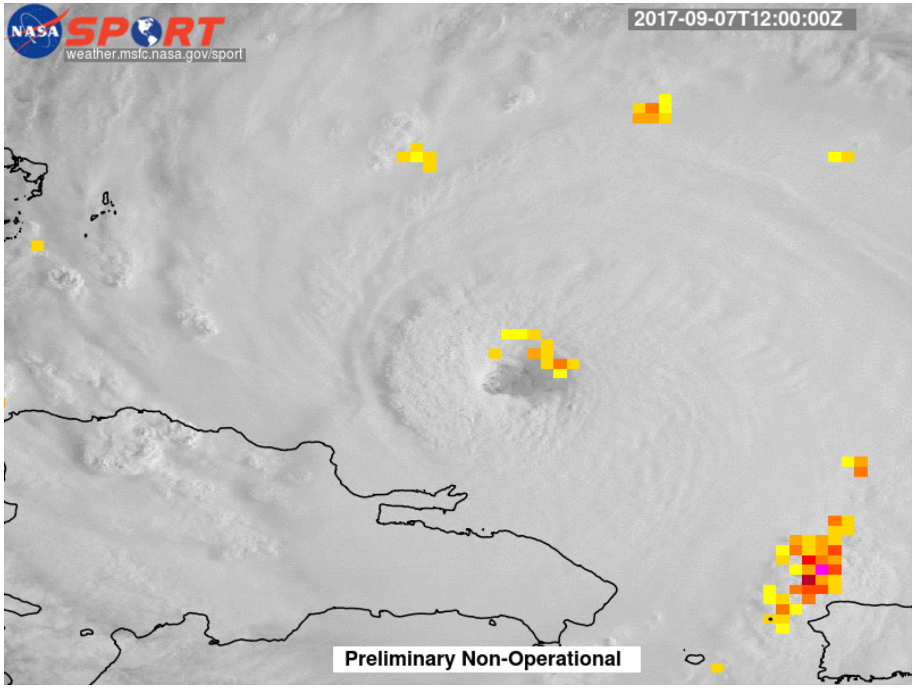
- Operates in the near IR – 777.4 nm
- Spatial resolution is 8 km x 8 km at nadir
- CCD: 1372 x 1300 pixels, sampling every 2 ms
    - CCD is not at a fixed resolution

- Detection efficiency: Day: 85% Night: ~99%

All images from www.goes-r.gov

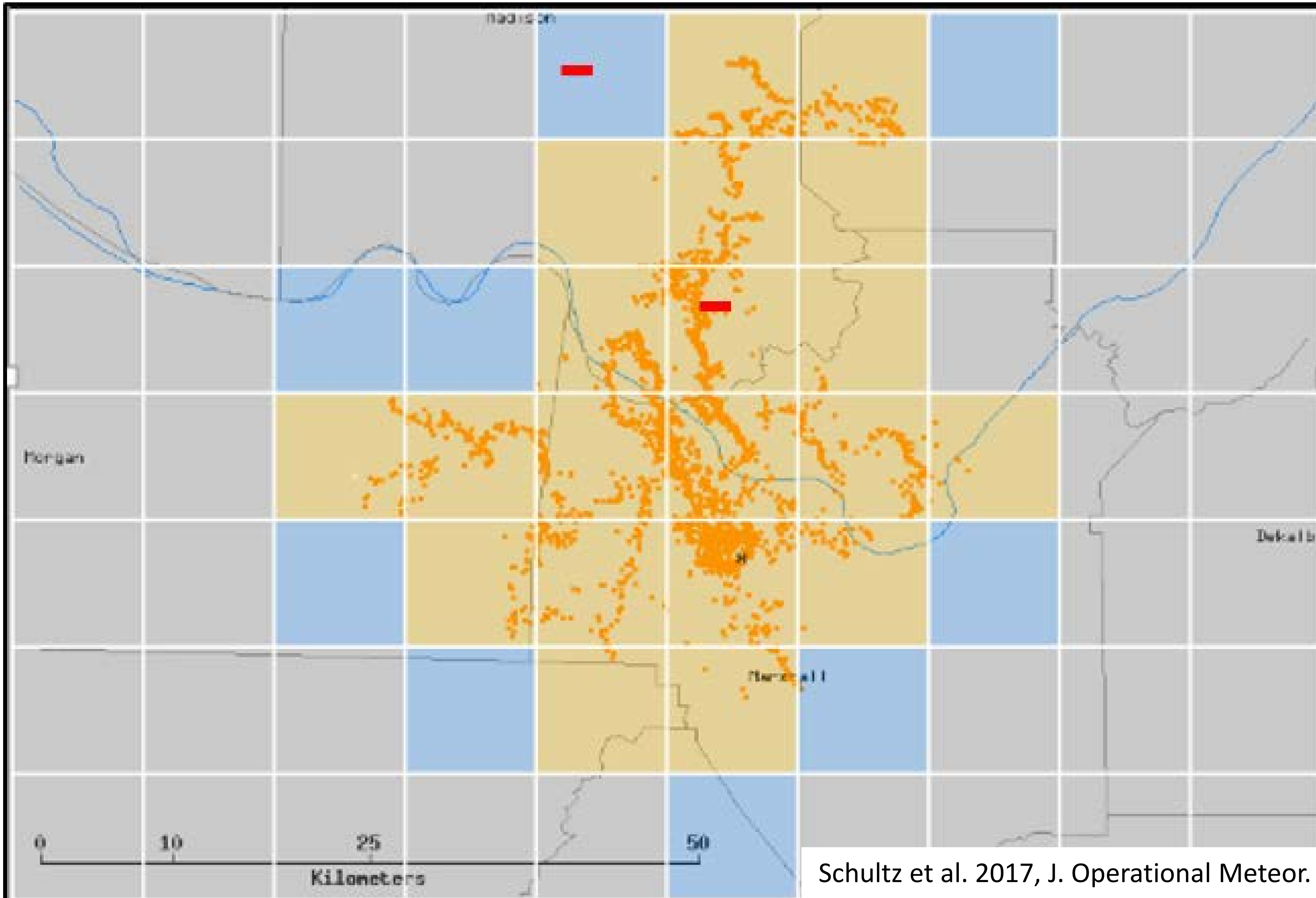
What is Total Lightning?





Schultz et al. 2018, JGR

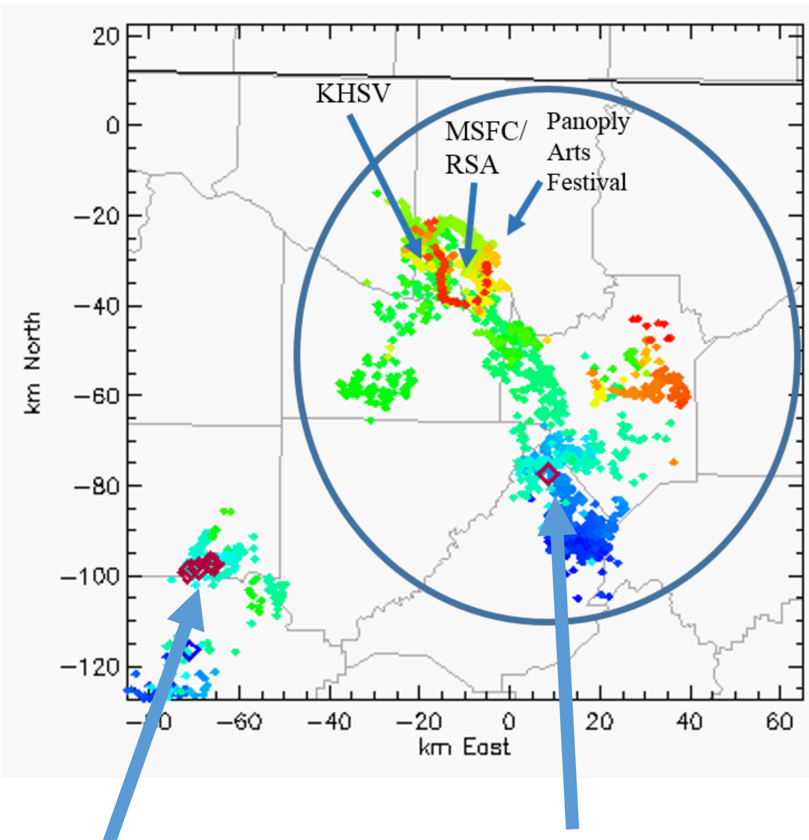
What is a flash?



Schultz et al. 2017, J. Operational Meteor.

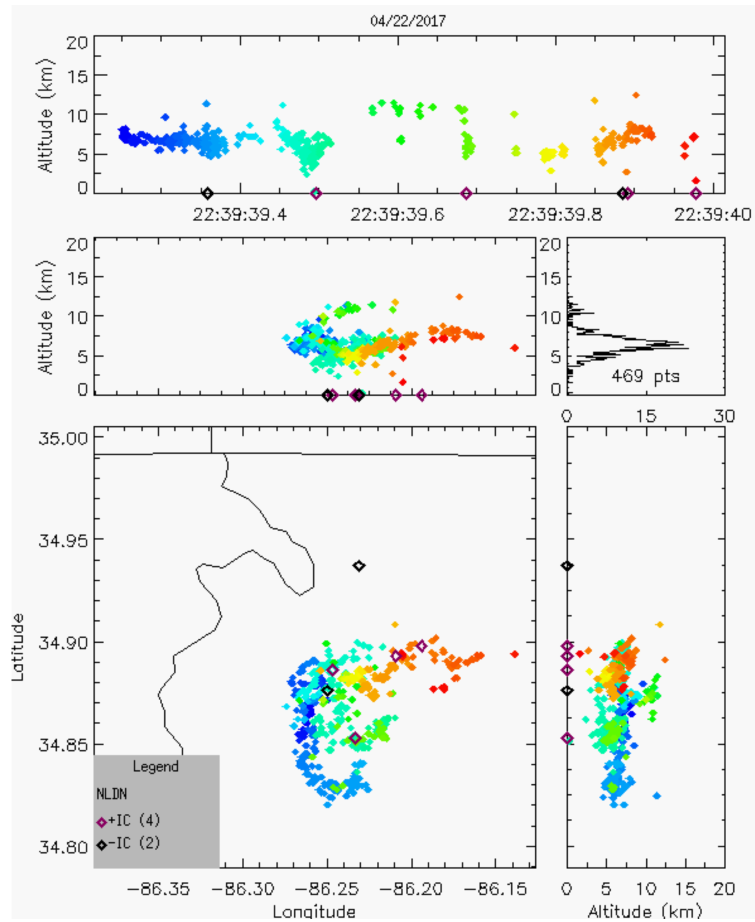
A “flash” is defined by the instrument, and the property of lightning its measuring….

Why we cant just directly compare "flash rates" from different sensors



Earth Networks 6 flashes, LMA 1 flash

Earth Networks 1 flash
LMA 1 flash



1 second of data
1 LMA flash, 1 GLM flash, 6 NLDN flashes

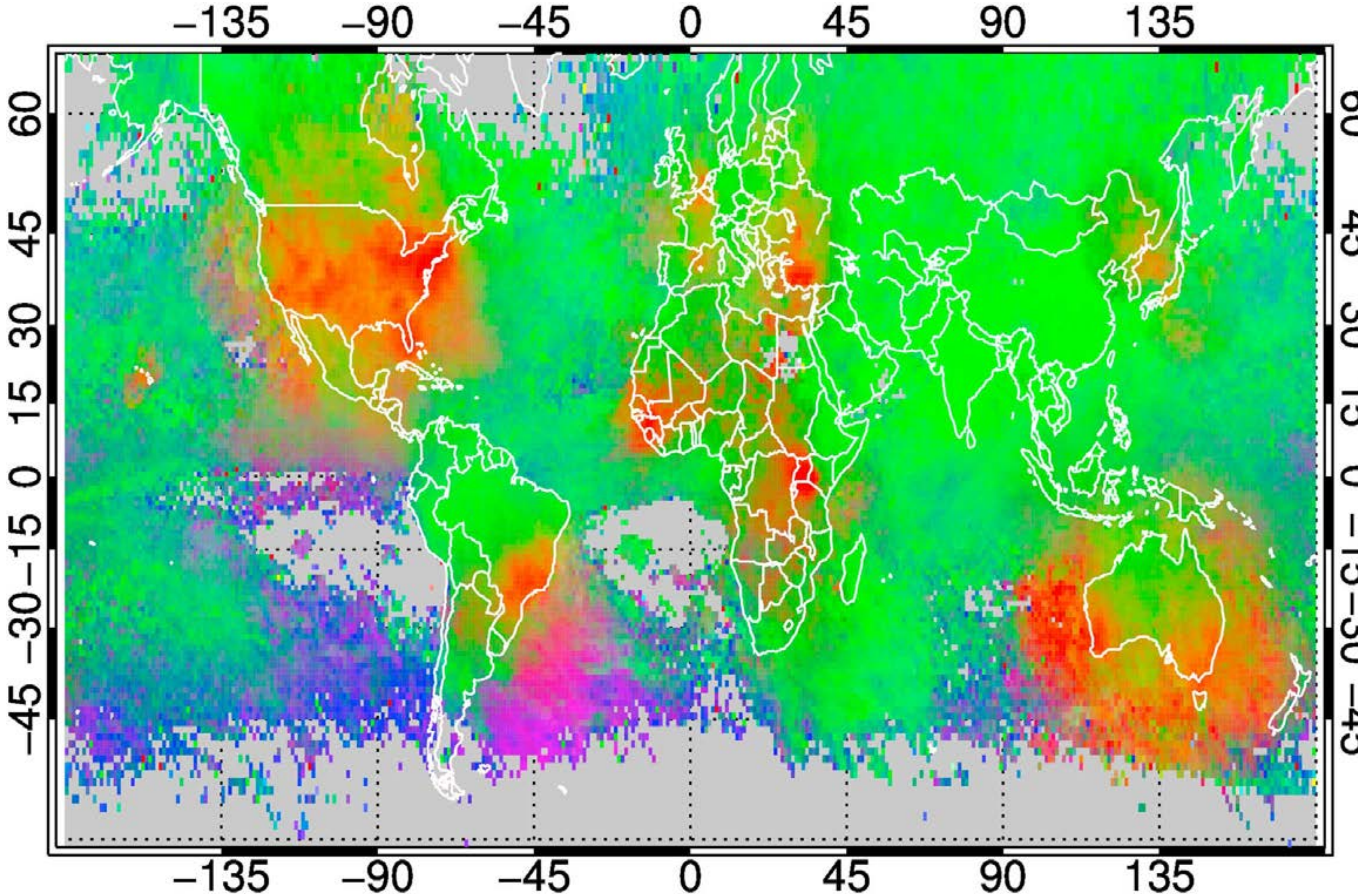
What's going on?

- Lightning location systems like NLDN, Earth Networks, etc. accurately pinpoint the location of rapid changes in the electric field
- Very good at locating cloud to ground locations and vertical propagation of flashes which are labelled as CC or IC flashes
- Lightning locating systems cannot connect two "flashes" that are separated over great distances but might be from the same lightning event.

- GLM provides excellent 2D coverage of lightning propagation through the cloud and detection efficiency is nearly uniform across the entire field of view.
- GLM has been shown to struggle in optically dense cloud when the lightning is at lower levels and light cannot escape cloud top.

Thus when it comes to all of the data available, a combined solution is the most advantageous to all parties.

How do we get around these measurement differences?



Bitzer et al. 2016 GRL

First we determine which ground based network performs best at various locations in the the GOES FOV

Red – Earth Networks Green - GLD 360 Purple - WWLLN

GLM Detection Efficiency (Timing)

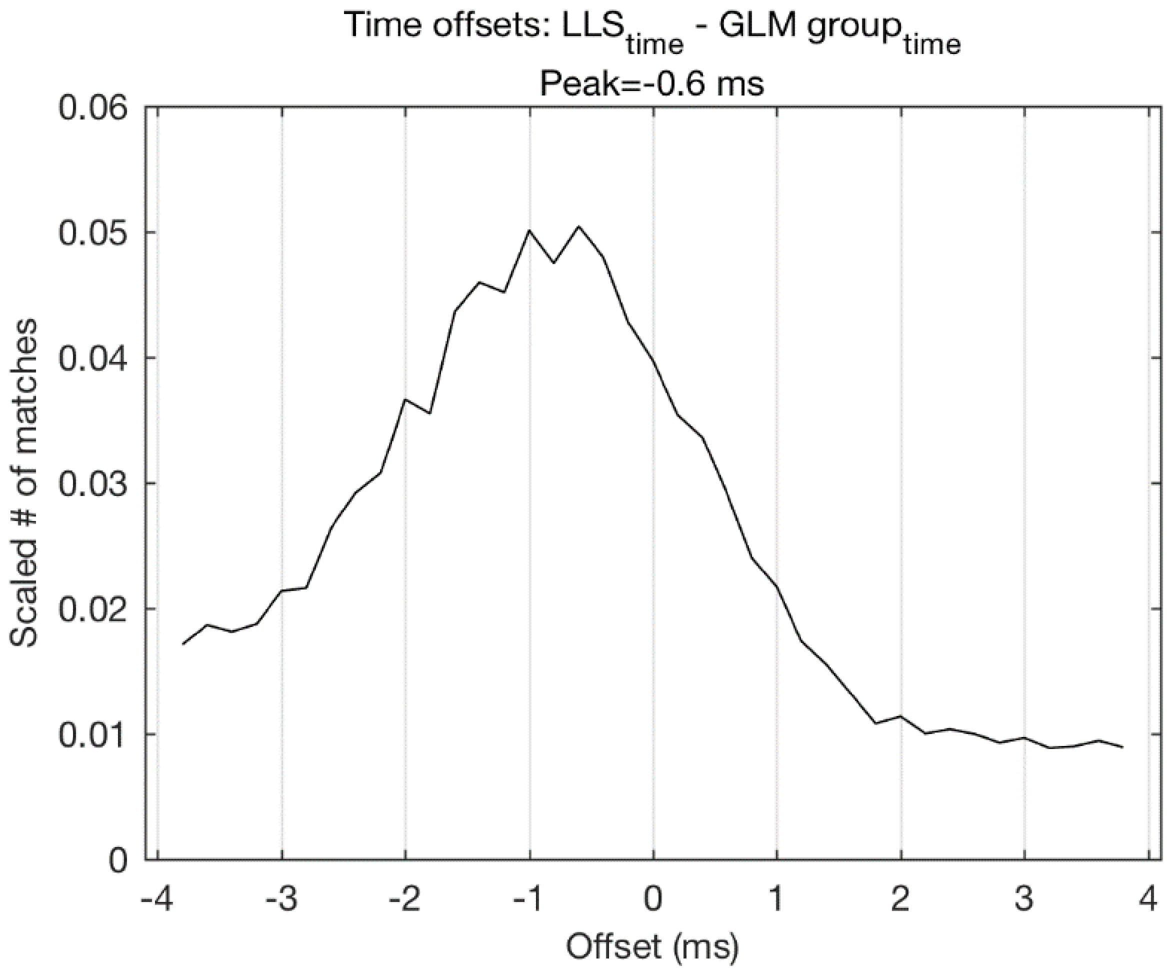


Image Courtesy of Katrina Virts, NASA Postdoctoral Program

GLM Detection Efficiency (May-June)

GLM vs GLD360

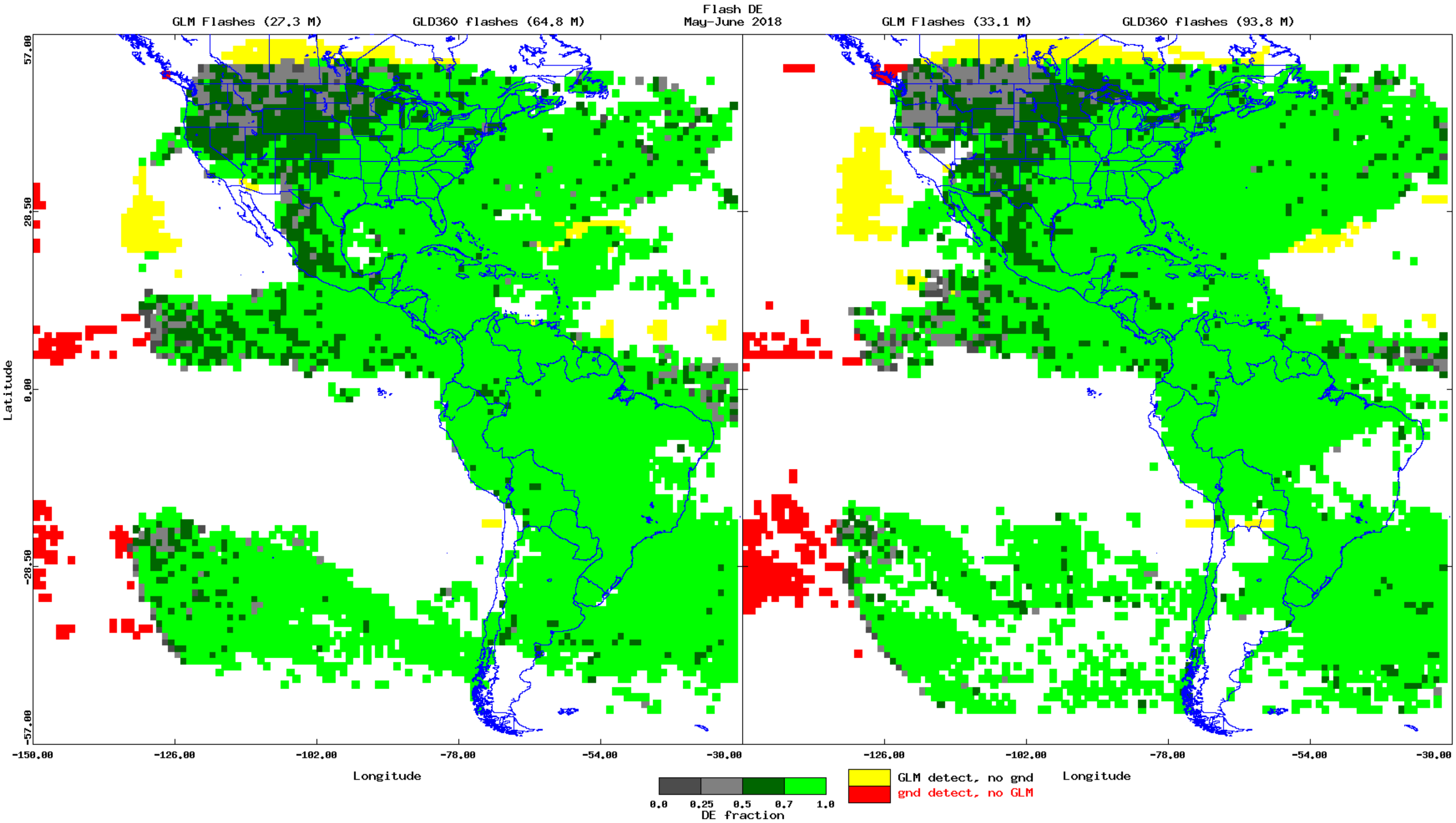
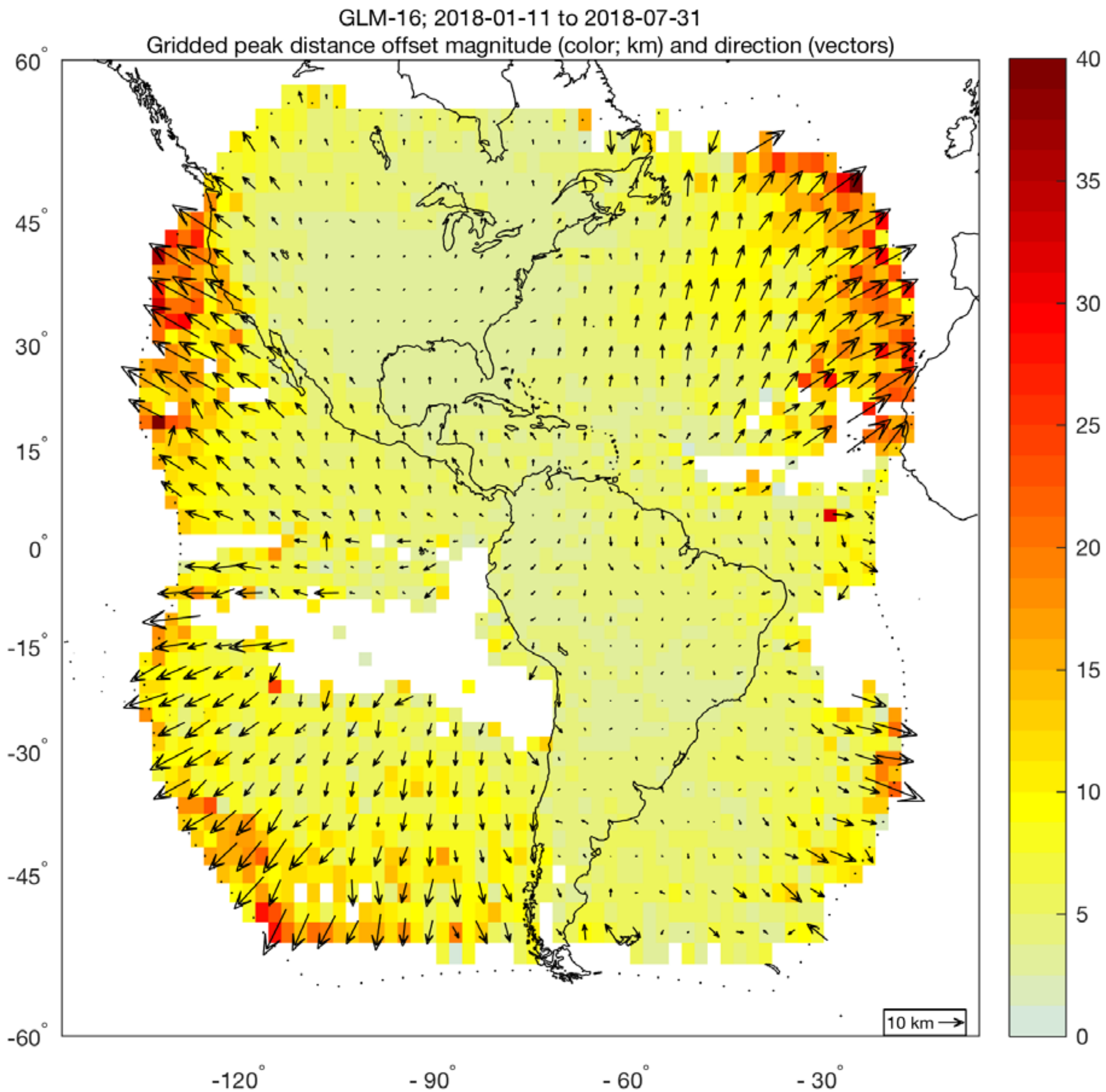


Image Courtesy of Monte Bateman MSFC/USRA

GLM Location Accuracy (Jan-July 2018)



GLM flash location vs Earth Networks flash location for collocated flashes

Image Courtesy of Katrina Virts, NASA Postdoctoral Program, MSFC

GLM is more than just flash rates

- GLM provides additional metrics like optical energy and flash area that can be useful in identifying thunderstorm intensity and flash area.

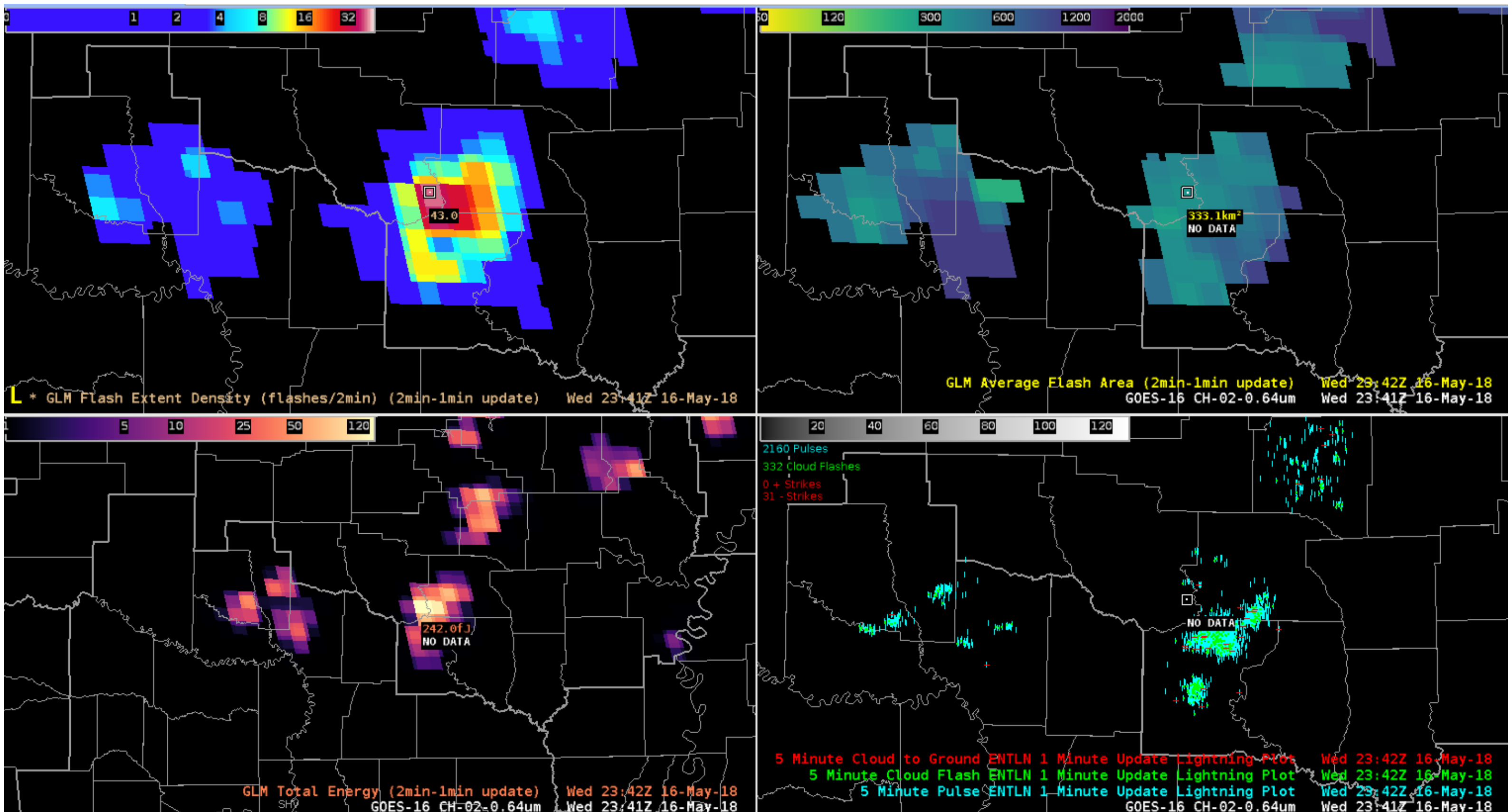


Image courtesy Dr. Kristin Calhoun NOAA/NSSL/OU Hazardous Weather Testbed Summary Document

Parallax Challenges

Differences due to assumptions about GLM cloud top heights and ground locations observed by lightning location systems.

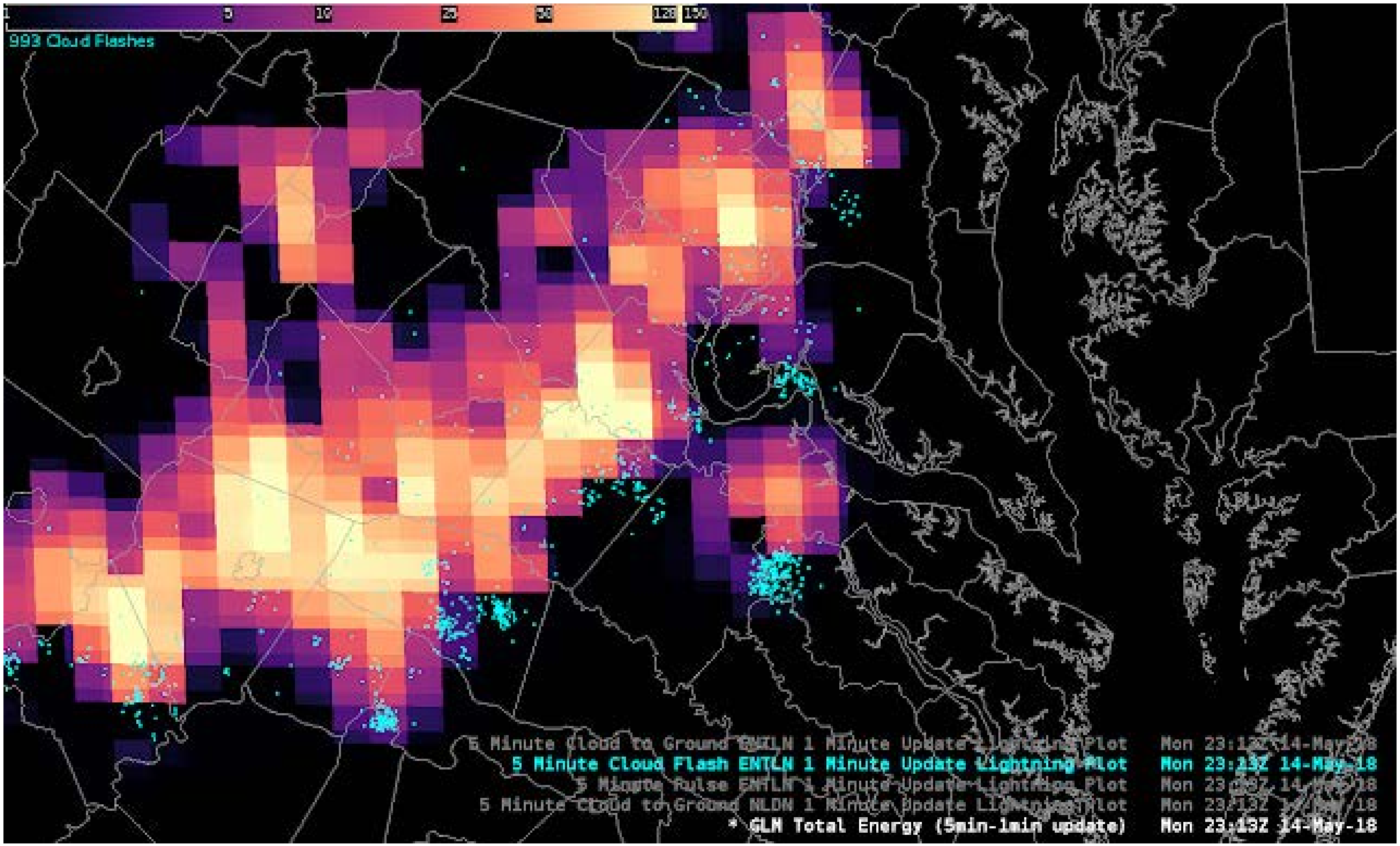
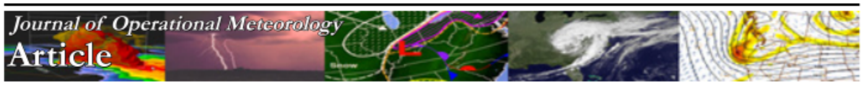


Image courtesy Dr. Kristin Calhoun NOAA/NSSL/OU Hazardous Weather Testbed Summary Document

Impact on Total Lightning to EOC Operations

Schultz, C. J., G. T. Stano, P. J. Meyer, B. C. Carcione, T. Barron, 2017: Lightning decision support using VHF total lightning mapping and NLDN cloud-to-ground data in North Alabama. *J. Operational Meteor.*, **5** (11), 134-145, doi: https://doi.org/10.15191/nwajom.2017.0511



Lightning Decision Support Using VHF Total Lightning Mapping and NLDN Cloud-to-Ground Data in North Alabama

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ABSTRACT

This study focuses on lightning safety applications at NASA's Marshall Space Flight Center in preparation for the use of new Geostationary Lightning Mapper data once operational in 2017 from GOES-16. A total of 13 years of North Alabama Lightning Mapping Array and National Lightning Detection data are analyzed for lightning safety applications. Data are analyzed using three range ring criteria used by the Marshall Space Flight Center Emergency Operations Center for monitoring and warning on lightning hazards (32-km, 16-km and 9-km). Approximately 75% of the time, the total lightning observations from the North Alabama Lightning Mapping Array provide additional lead time on the first cloud-to-ground flash, with the 25th to 75th percentile of these lead times between 0 and 23 minutes. The use of NALMA also incurs additional downtime of up to 36 minutes versus the use of cloud-to-ground data alone. Seventy-nine percent of the time that lightning is detected by the lightning mapping array in the 16-km range ring, lightning also is observed to impact Marshall Space Flight Center directly. Thirty percent (309/1043) of these events inside the 16-km range ring do not contain a cloud-to-ground flash, but continue to pose a threat to personnel and property. Thus, the threat of lightning is likely under-realized to the public because safety criteria are often based on cloud-to-ground data alone. Minor seasonal differences in lead time are observed, with the most notable difference between autumn and winter,

http://nwafiles.nwas.org/jom/articles/2017/2017-JOM11/2017-JOM11.pdf

Provides an median of 8 additional minutes on the first cloud-to-ground lightning flash to MSFC EOC to warn MSFC personnel of the threat of lightning.

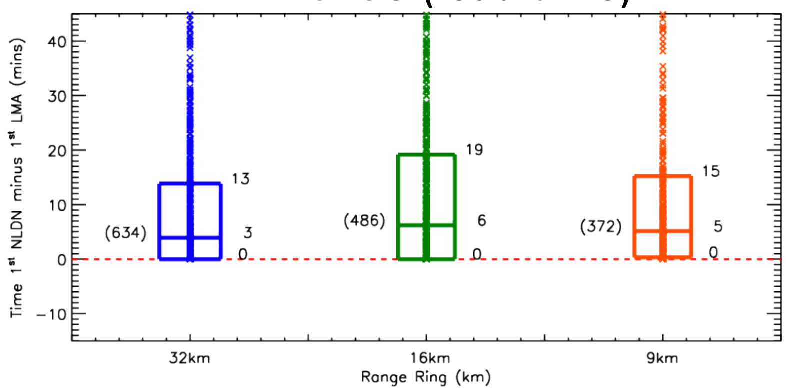
Maximum lead time of 36 minutes

20% of the days, the first flash was a cloud-to-ground flash (i.e., zero lead time).

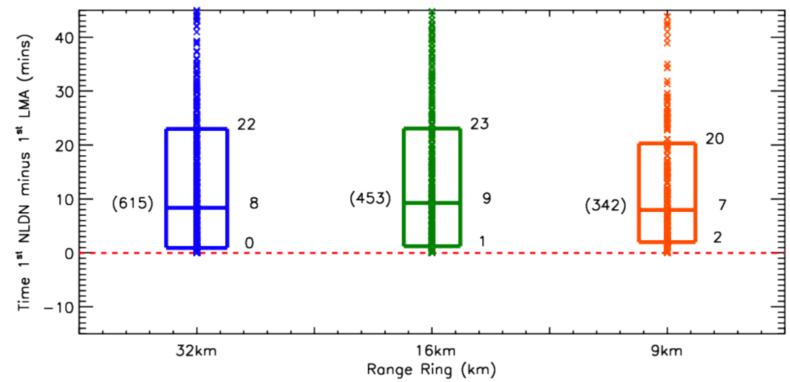
Ability for MSFC personnel to visualize data for themselves to understand threat.

How Spatial Information on Lightning Influences Lead Time

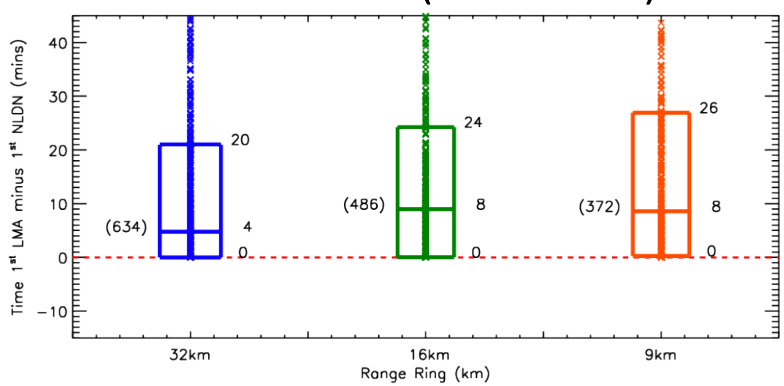
IC+CG (lead time)



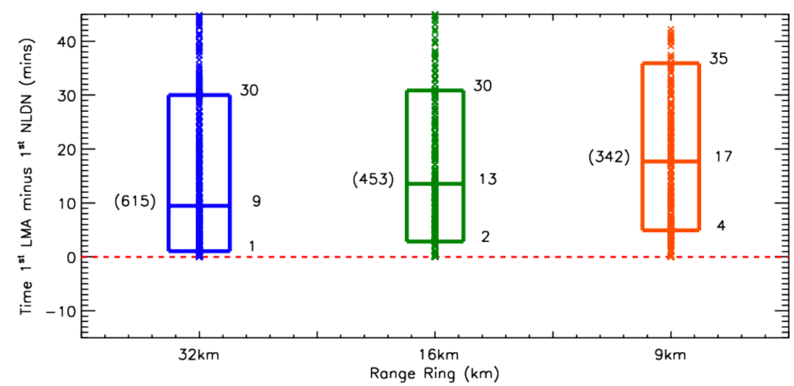
CG only (lead time)



IC+CG (down time)



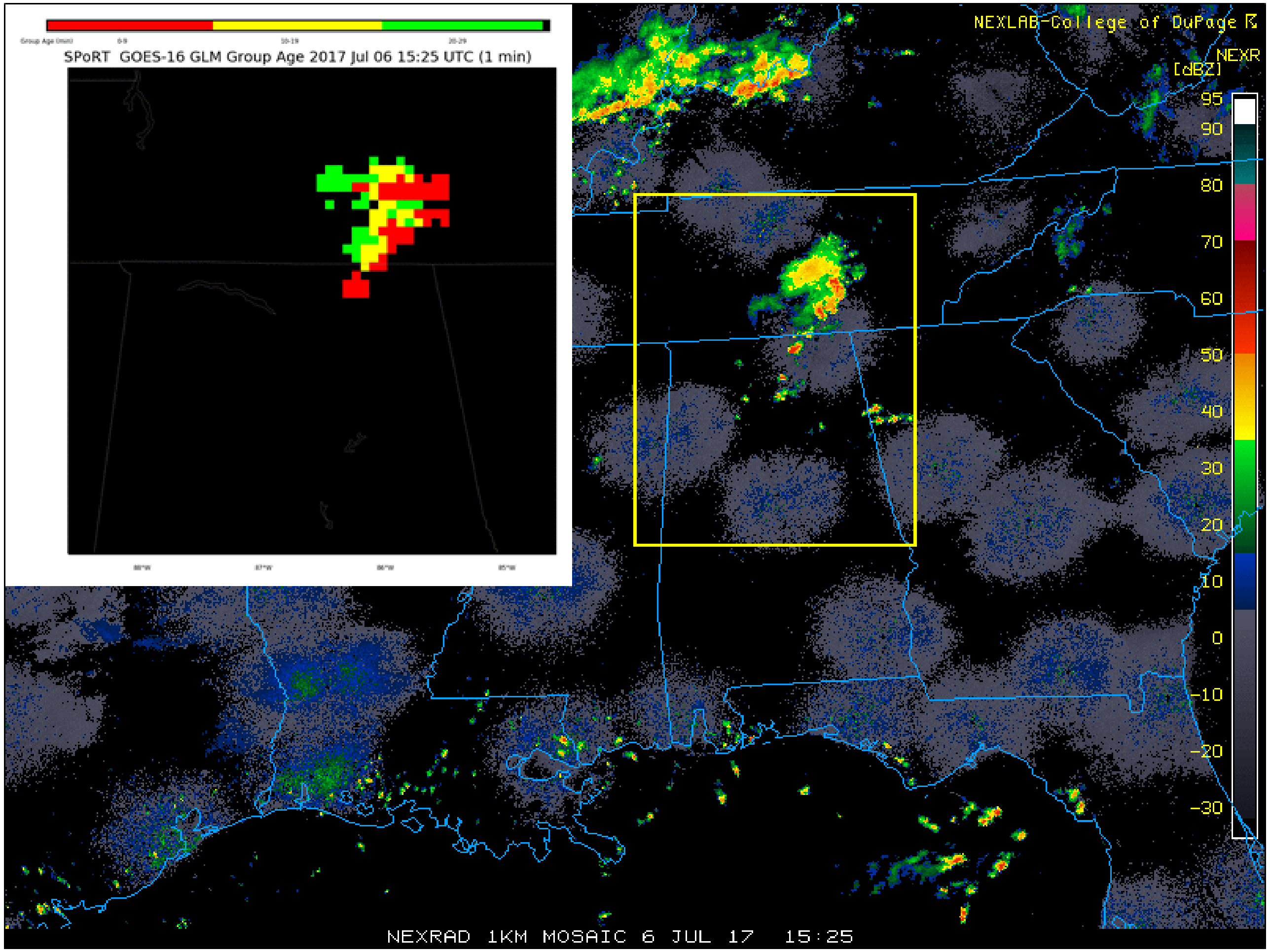
CG only (down time)



Inclusion of the IC data reduces the extra lead time by 3-5 minute. Areal information from LMA provides approximately 5-6 minutes of extra lead time.

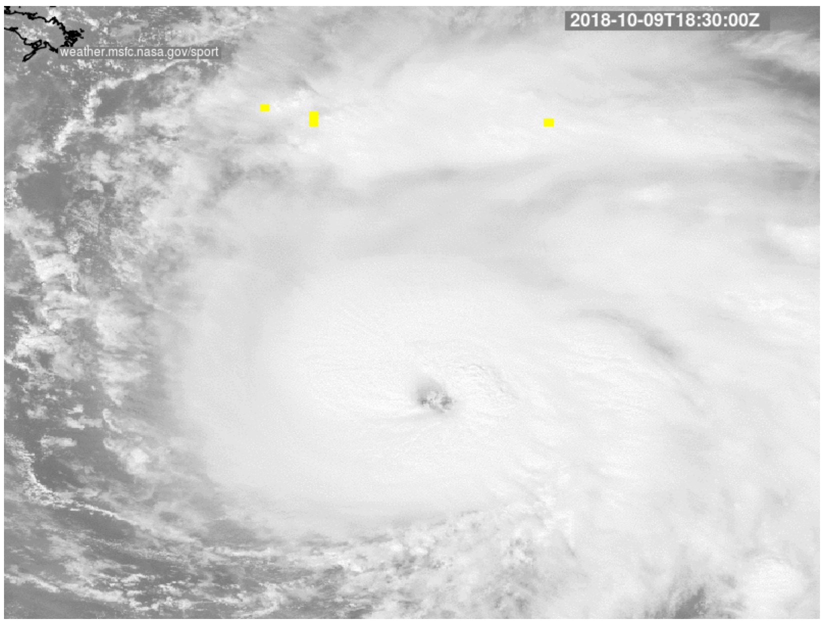
- We took 80 hours of GLM Validation Campaign data to determine the number of instances when the inter flash interval over a GLM pixel was between 30 and 45 minutes.
  - Each GLM pixel was considered an individual location similar to that of a decision maker like an emergency manager.
- Approximately 218 million GLM pixels that contained lightning were examined resulting in 7.4 million lightning pairs that spanned 1-45 minutes . Of those 7.4 million pairs, only 120,500 exceeded an interstroke interval of 30-45 minutes (1.6%).

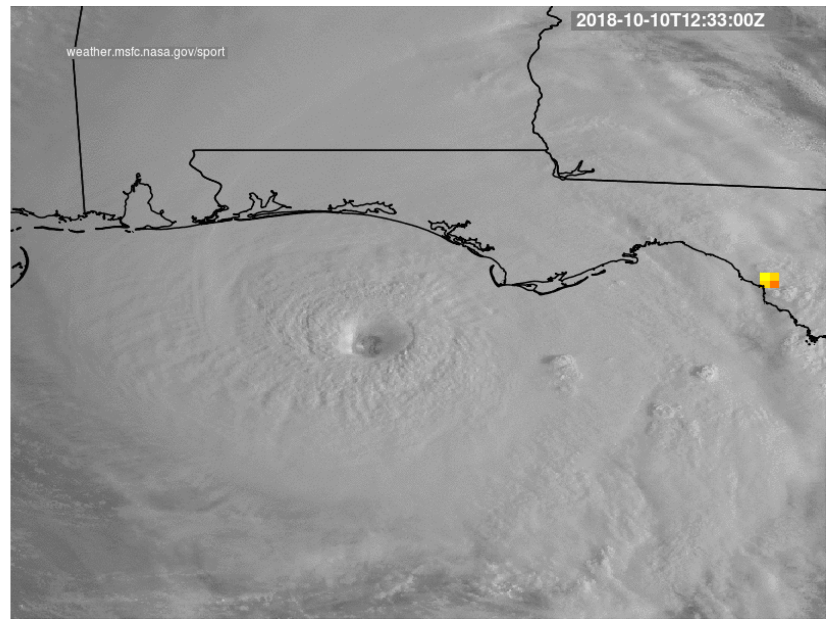
Placing those pairs in the context of current lightning safety metrics for commercial airlines, US Air Force, and EMA/NWS, this study observed that the temporal criteria were violated 9.5%, 3.5%, and 1.6% of the time in this 80 hour sample of GLM data.



Hurricane Intensification and Maintenance

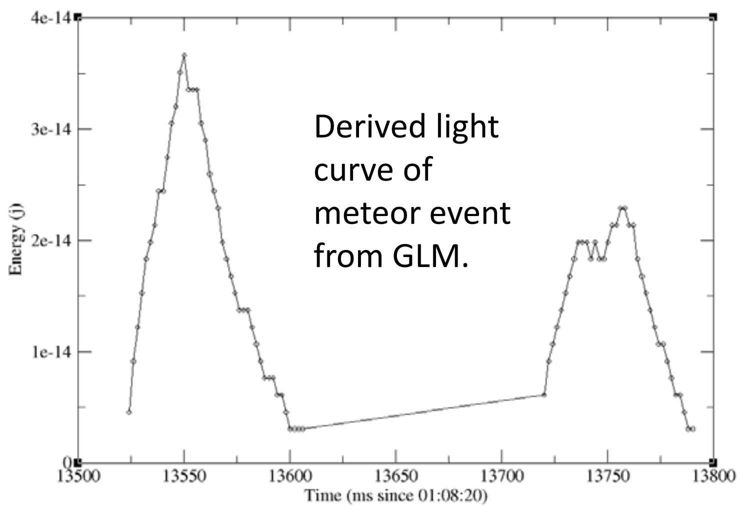
The presence of lightning ***and*** the location of the lightning relative to the maximum winds is a telling feature on if a storm will maintain its strength, intensify, or weaken.





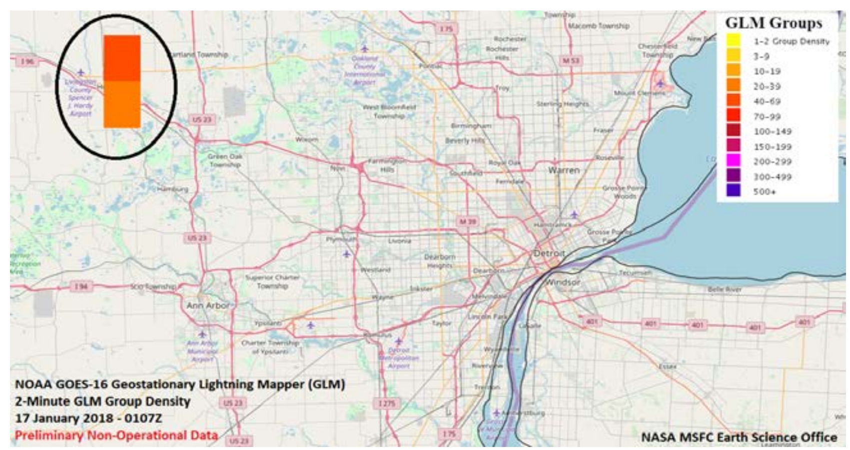
If the lightning is near the eye or in the radius of maximum winds, there is a 92% probability that the storm will continue to strengthen or maintain its strength. (Stevenson et al. 2018, *Weather and Forecasting*)

GLM also detects bolides!

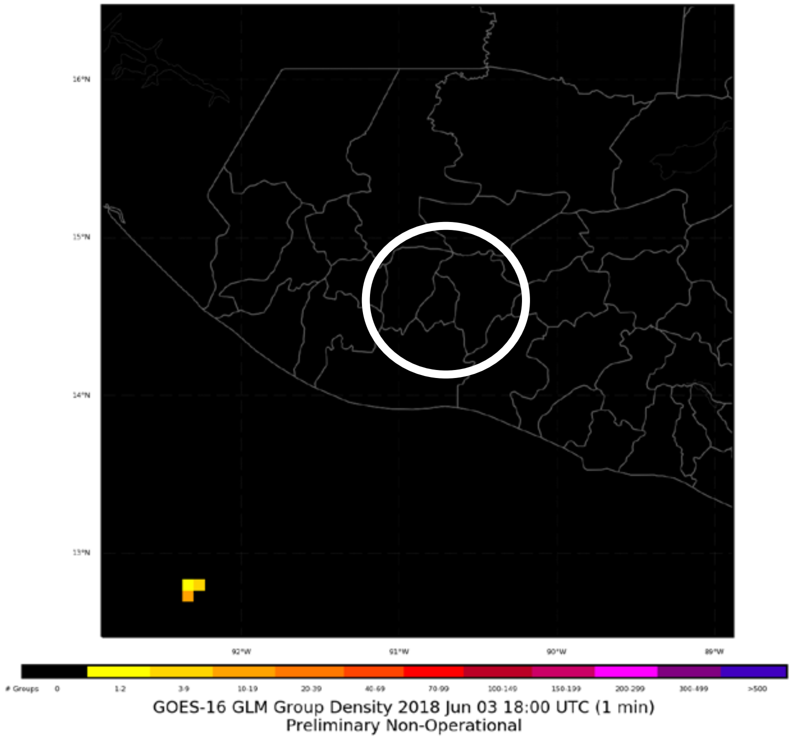


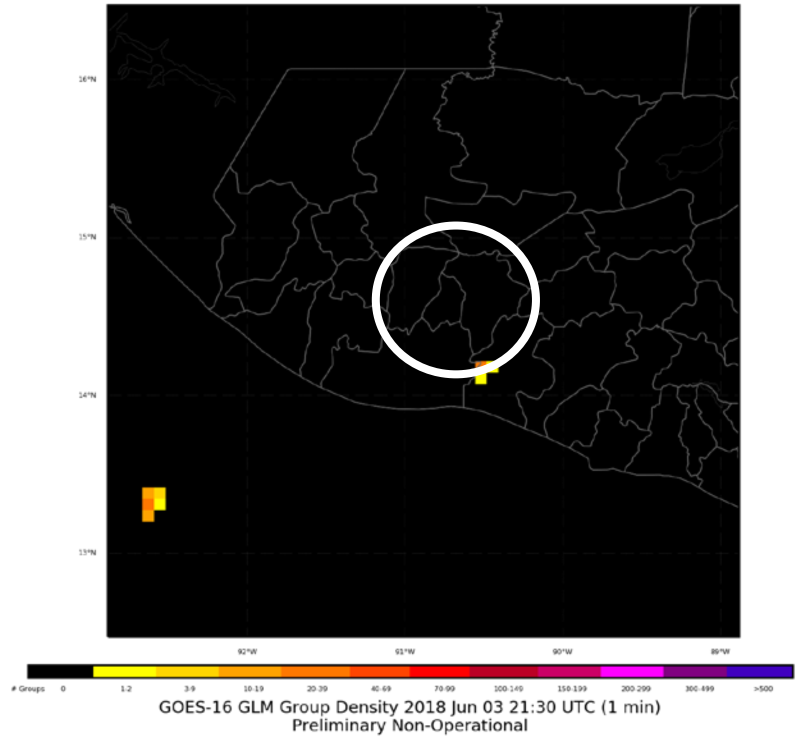
Derived light curve of meteor event from GLM.

Courtesy of Danielle Mosier of NASA MSFC EV-44.



Volcanic Lightning - Fuego Volcano 3 June 2018





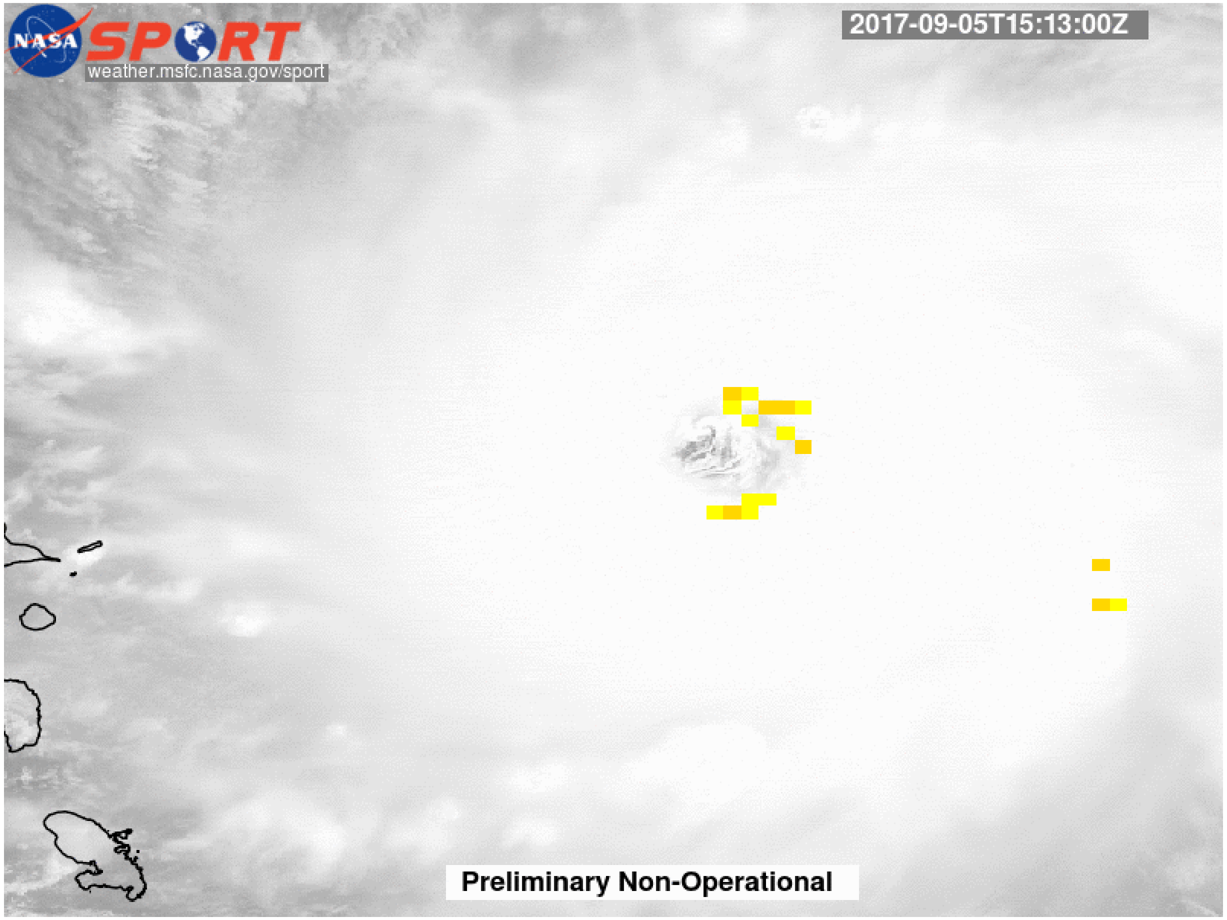
1800-1850 UTC

GLM detections follow the initial volcanic plume development

2130-2210 UTC

GLM detections align in space and time with the pyroclastic flow

QUESTIONS?



GLM Data,
Hurricane Irma, 1513-1700 UTC, 5 September 2017