The RELAMPAGO Lightning Mapping Array: Preliminary scientific results and application to GLM calibration and validation

Timothy J. Lang, Eldo Avila, Rich Blakeslee, Jeffrey Burchfield, Matthew Wingo, Philip Bitzer, Lawrence D. Carey, Wiebke Deierling, Steve Goodman, Bruno Lisboa Medina, Gregory Melo, and Rodolfo Pereyra

* RELAMPAGO LMA Deployment Successful, and Network Demonstrates how GLM Detection Efficiency Depends on Lightning Evolution/Type *

Introduction

RELAMPAGO (Remote sensing of Electrification, Lightning, And Mesoscale/microscale Processes with Adaptive Ground Observations) was a National Science Foundation (NSF) field campaign to understand intense and severe convection in central Argentina, near the Sierras de Cordoba mountain range.

Network Map

OPEN

Deployment and Data

Deployment Info

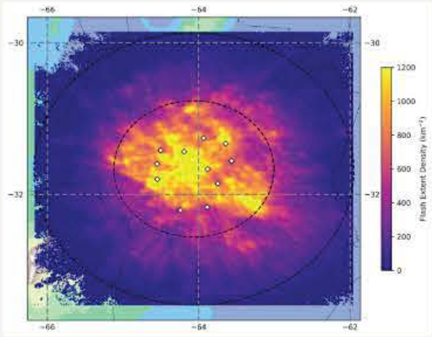
- 11 stations in center of Cordoba province, Argentina
- Installation began 10/24/18
- Valid ops 11/8/18 thru 4/19/19 (163 days, including RELAMPAGO IOP/EOP)
- Teardown began 4/30/19

Station Availability vs. Time

OPEN

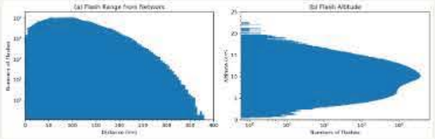
Overall Science Results

Flash Extent Density (11/8/2018-4/19/2019)



- 1,681,211 flashes within 100 km
- Lightning w/in 100 km on 76 of 163 days (46.6%)

Flashes vs. Range and Altitude



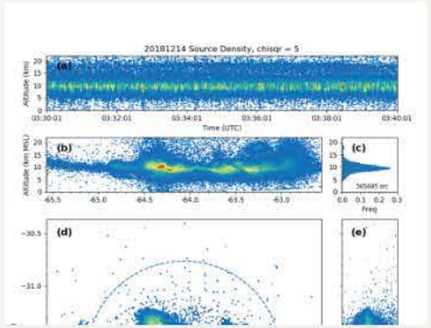
- 1.28M flashes beyond 100 km
- Most distant flash = 379 km
- Flash altitude mode ~10 km, but secondary maximum near 6 km due to anomalous/stratiform lightning

Diurnal Cycle

OPEN

12/14/2018 MCS

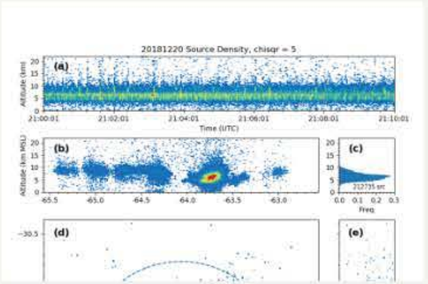
Source Density Example



OPEN

12/20/2018 Anomalous Storm

Source Density Example



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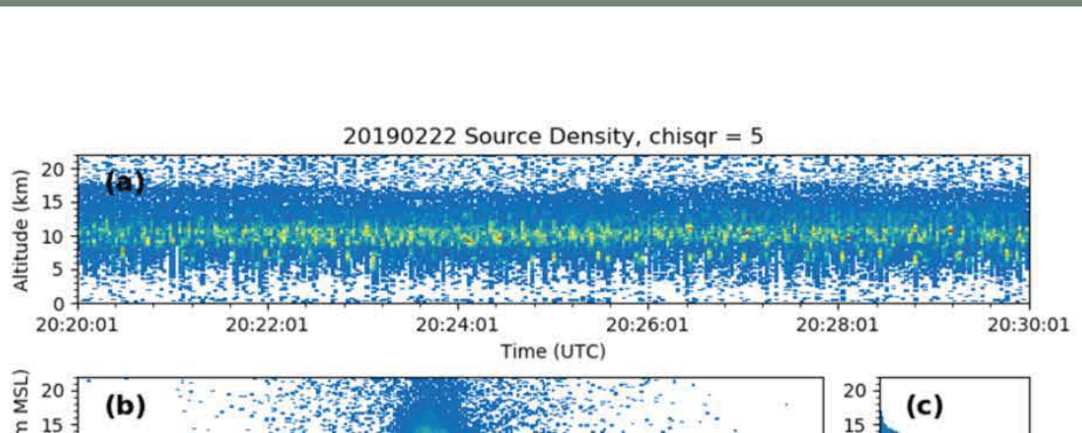

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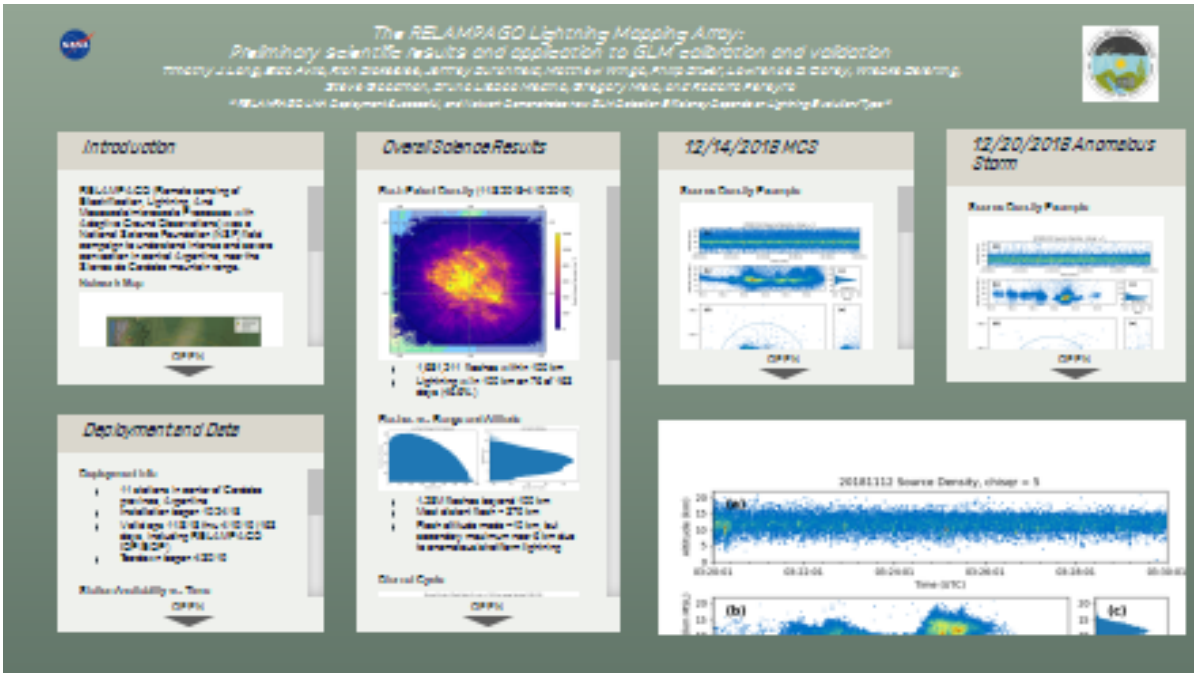

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PRESENTED AT:

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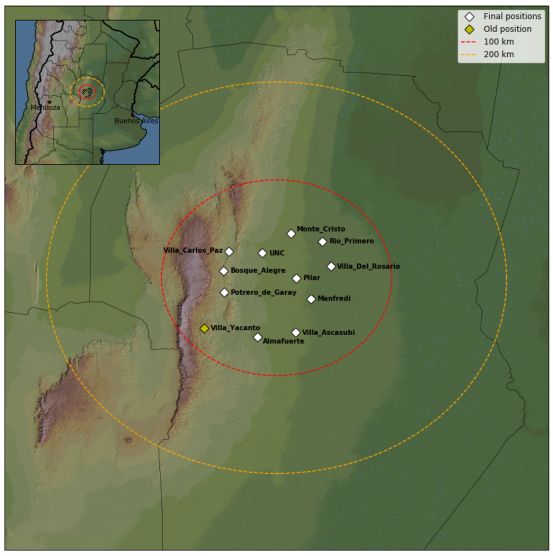

In order to address RELAMPAGO science goals, as well as to assist with ground validation of the Geostationary Lightning Mapper (GLM) instrument on the GOES-16/17 satellites, NASA Marshall Space Flight Center (MSFC) installed an 11-station Lightning Mapping Array (LMA) in this region.

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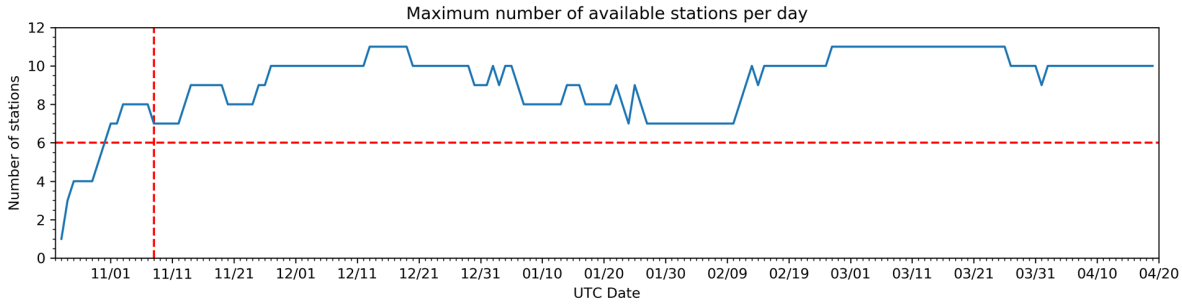
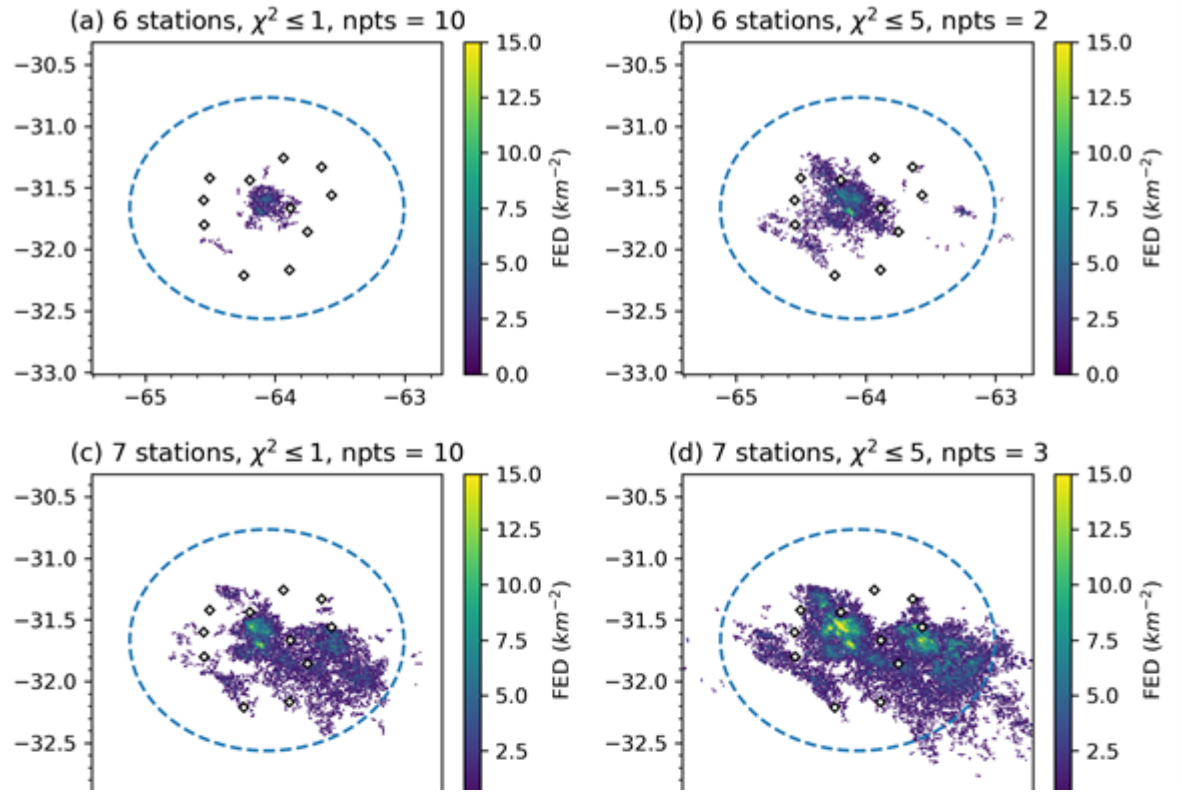
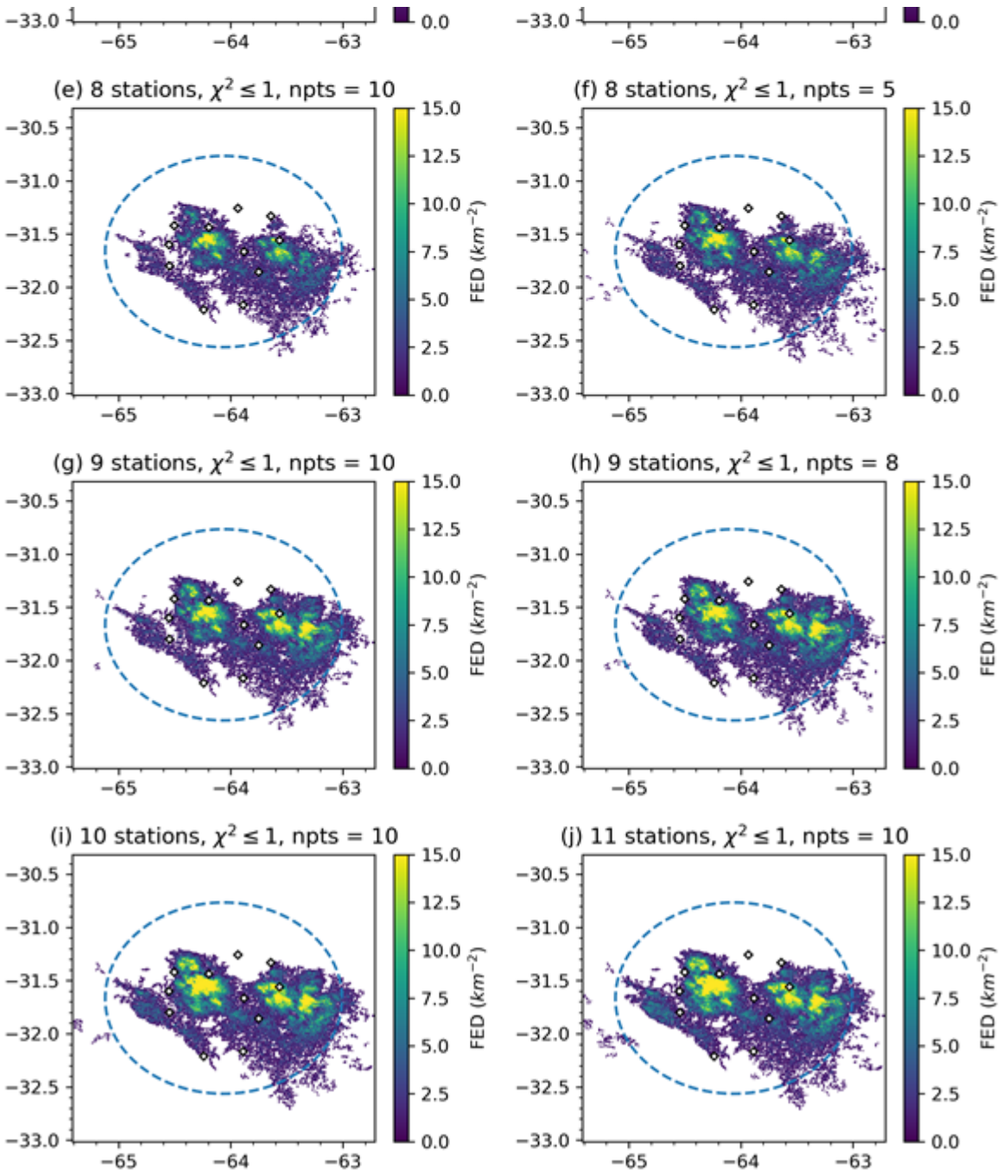


Station readiness was lowest early in the ops period and then again during late January into early February

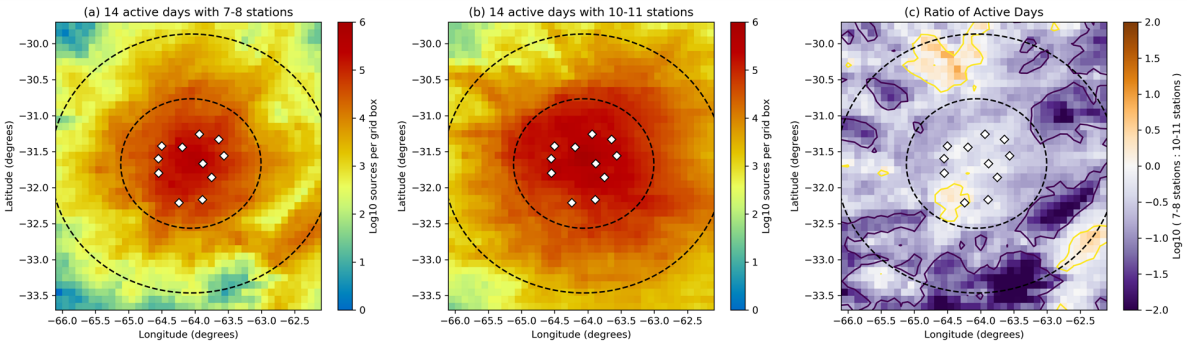
Flash Extent Density vs. Station Availability





Using more generous criteria for chi^2 and points per flash, even with 7 stations we can recover the rough FED envelope of a full network within 100-km range

Source Density vs. Station Availability



With 7-8 stations, on active days we can have the same order of magnitude of source densities as active 10-11 station cases

Conclusion: *Use caution when comparing days with different station availability, but data within 100-km range are good.*

RELAMPAGO LMA Data Products

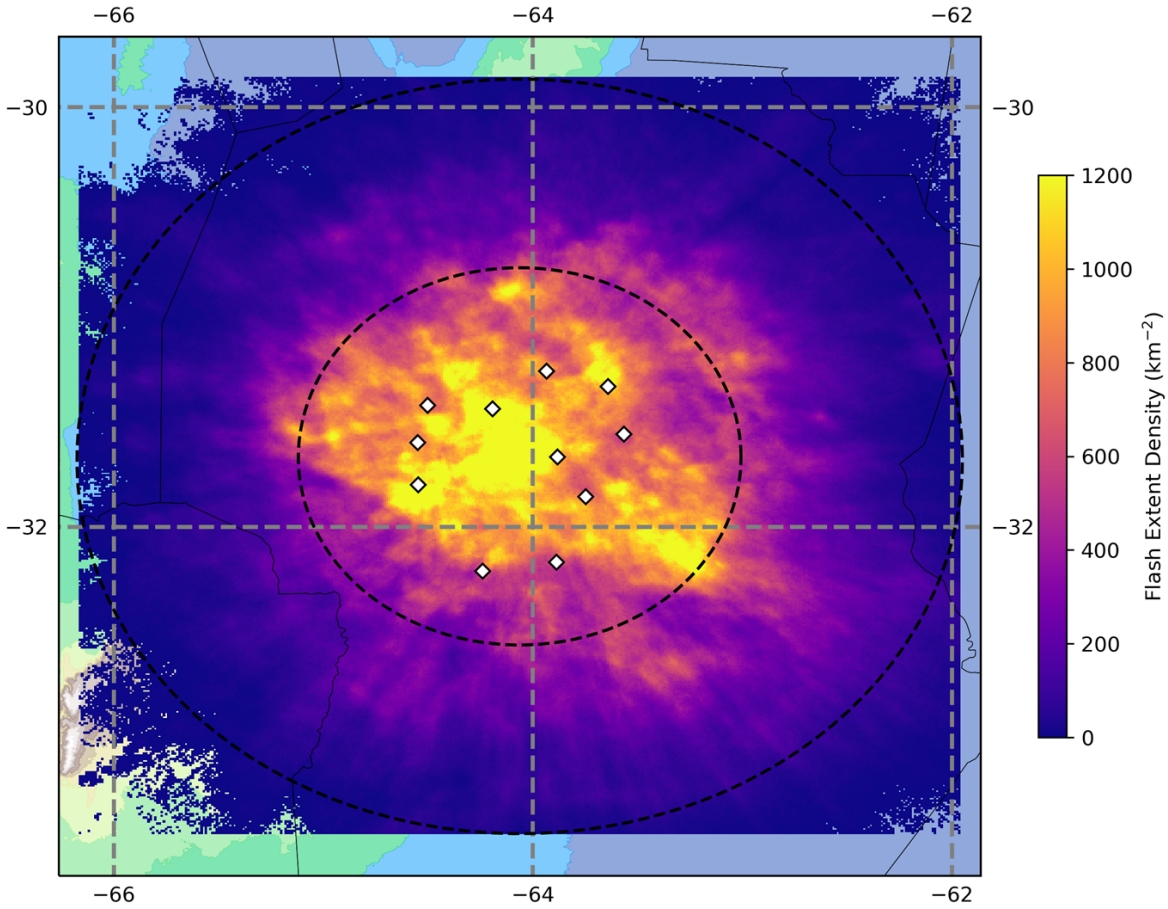
- Level 1 – Source locations, standard ASCII LMA format, 10-minute files
- Level 2 – Flashes identified (minimum 5 pts), HDF5, 10 minutes
- Level 3 – Gridded flash products (1 min x 1 x 1 x 1 km3), netCDF4, one file per variable, 10 minutes

Data available at: RELAMPAGO LMA Dataset (https://goes-r.nsstc.nasa.gov/home/dataset/relampago-lma)

Password controlled, contact Timothy Lang (timothy.j.lang@nasa.gov) and Geoffrey Stano (gts0007@uah.edu) for access

OVERALL SCIENCE RESULTS

Flash Extent Density (11/8/2018-4/19/2019)



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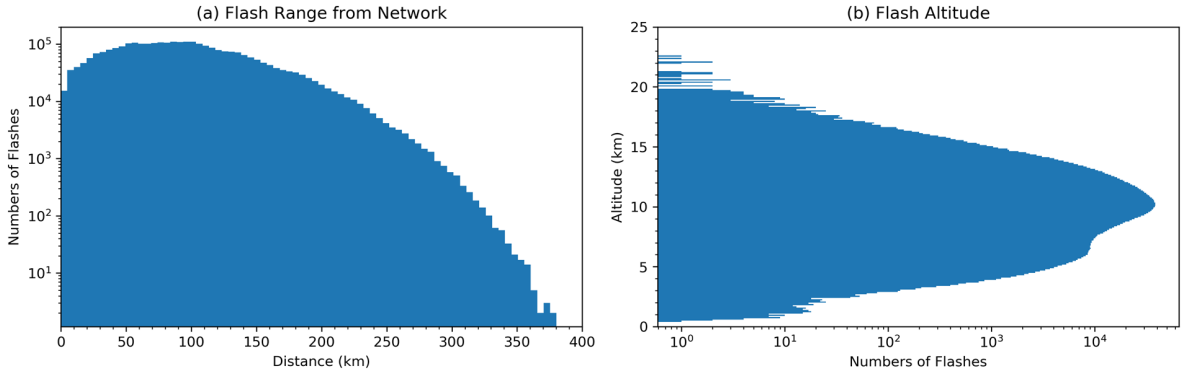

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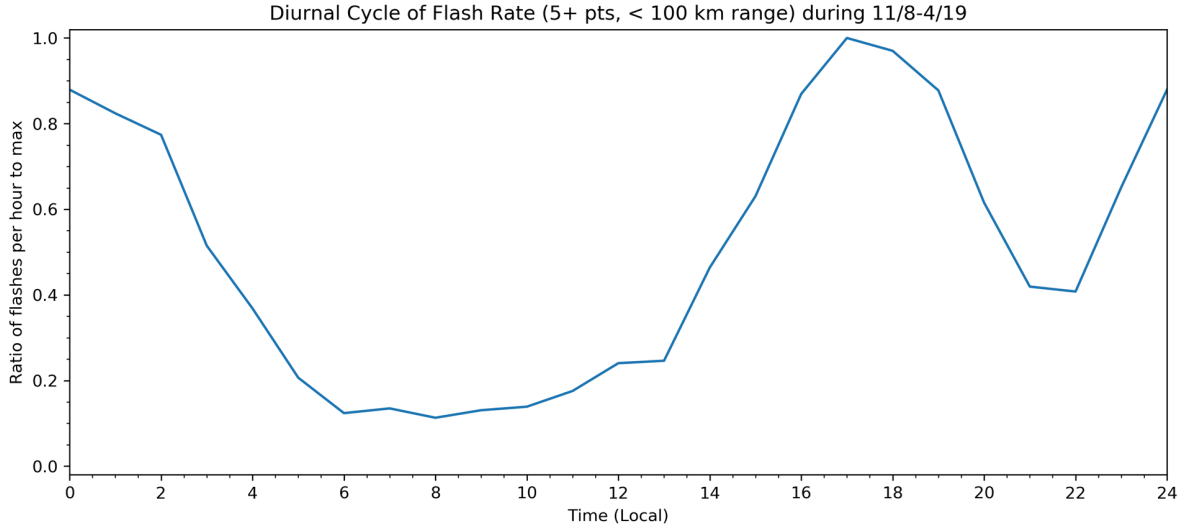
Diurnal Cycle



- Bimodal diurnal distribution – 5p & 12a peaks, 6-8a minimum

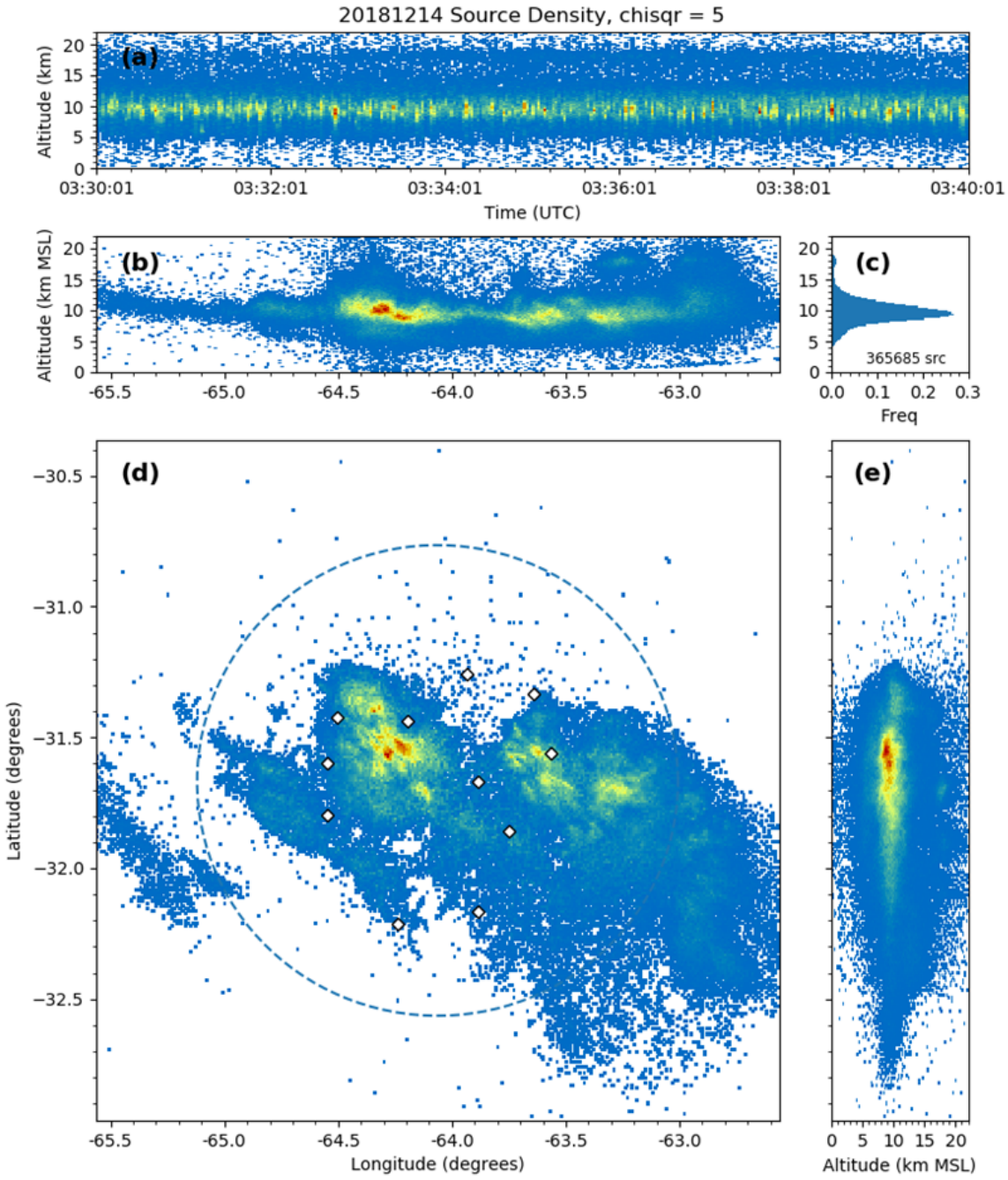
Top 20 Lightning Days

Rank	Date	Total flashes
1	01/25/2019	167174
2	12/14/2018	162276
3	03/04/2019	116888
4	01/02/2019	97863
5	02/24/2019	93115
6	02/22/2019	90617
7	02/10/2019	74360
8	02/11/2019	72495
9	11/11/2018	67177
10	11/12/2018	64517
11	03/08/2019	56528
12	01/09/2019	55938
13	01/23/2019	51256
14	01/26/2019	46306
15	01/29/2019	45207
16	12/27/2018	43310
17	01/06/2019	40193
18	03/31/2019	33707
19	02/08/2019	27157
20	02/09/2019	26478

- Active lightning days occurred across all deployment months except April 2019
- Variety of max available stations (7-11) represented in top-20 days

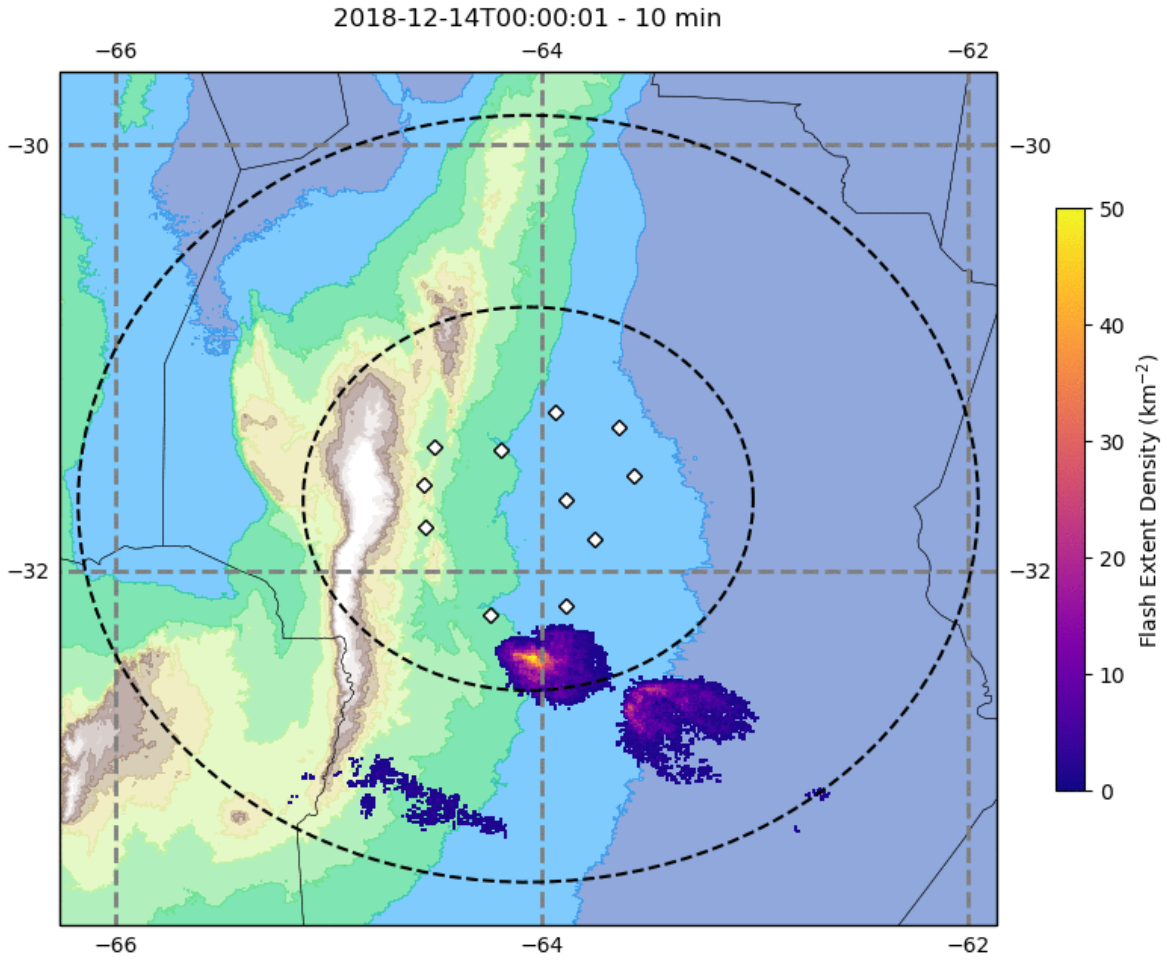
12/14/2018 MCS

Source Density Example



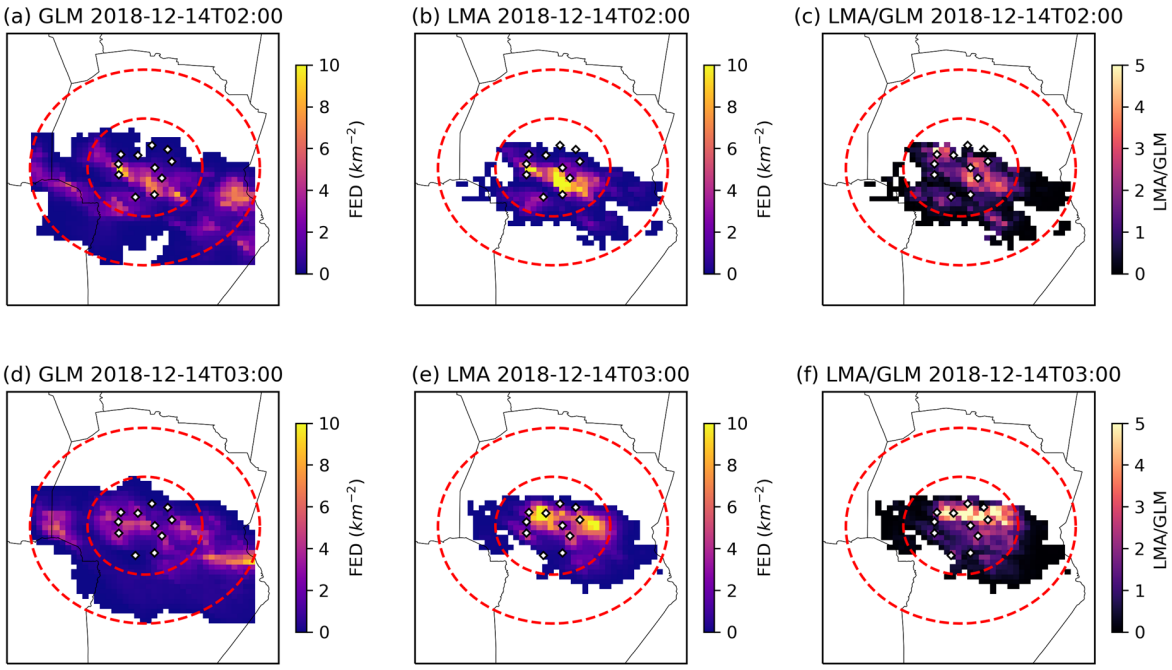
Around 0330 UTC, flash rate was near maximum and overshooting tops (OTs) were apparent in LMA data

Flash Extent Density Animation



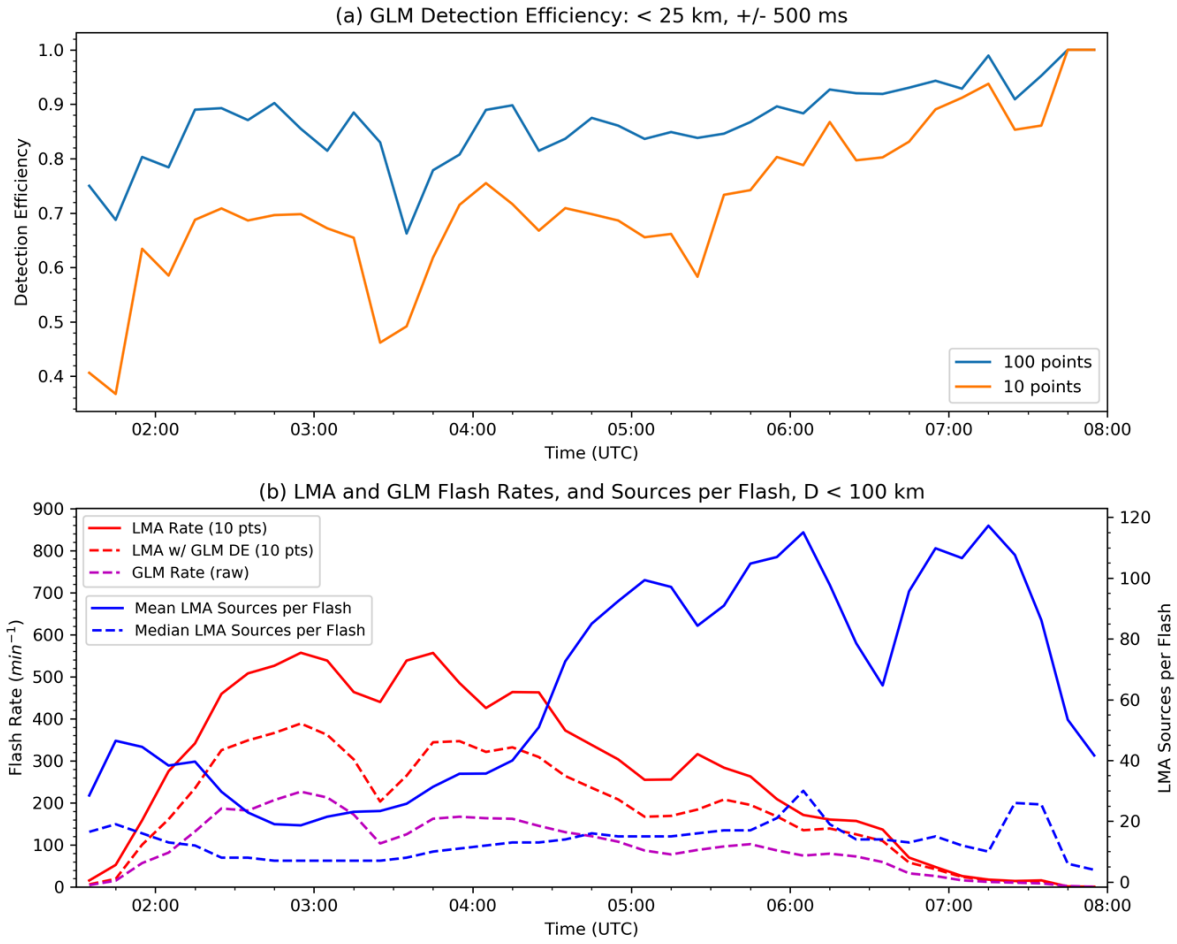
Long-lived event that developed and intensified near center of network

GLM vs. LMA Flash Extent Density



LMA flash extent density generally much greater than GLM in active cores, but GLM indicates how LMA detection efficiency declines beyond 100 km

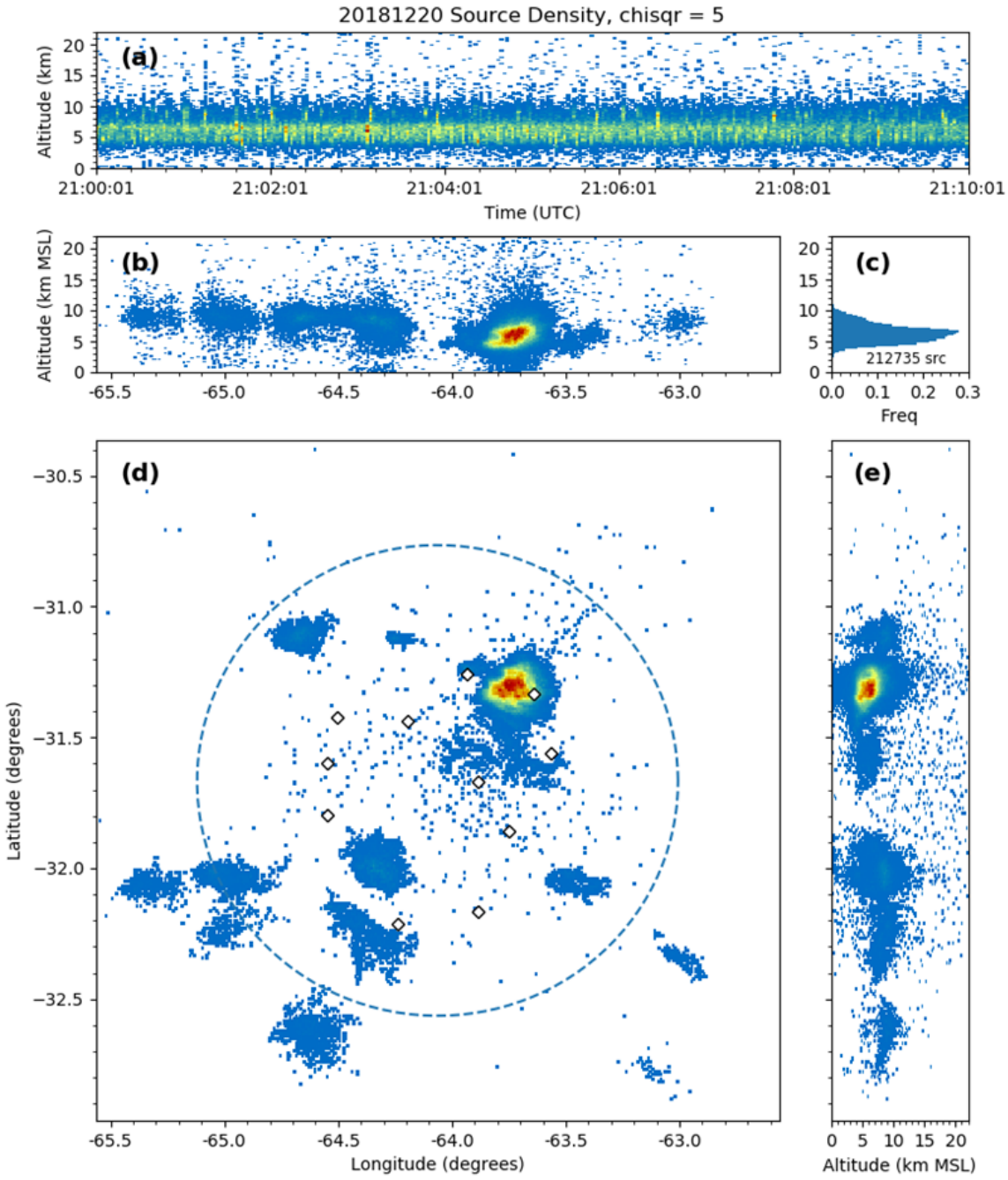
GLM Detection Efficiency vs. Flash Size



GLM detection efficiency and LMA flash rate both decline during OT period, but when flashes grew in size late in the storm GLM detection efficiency approached 90%

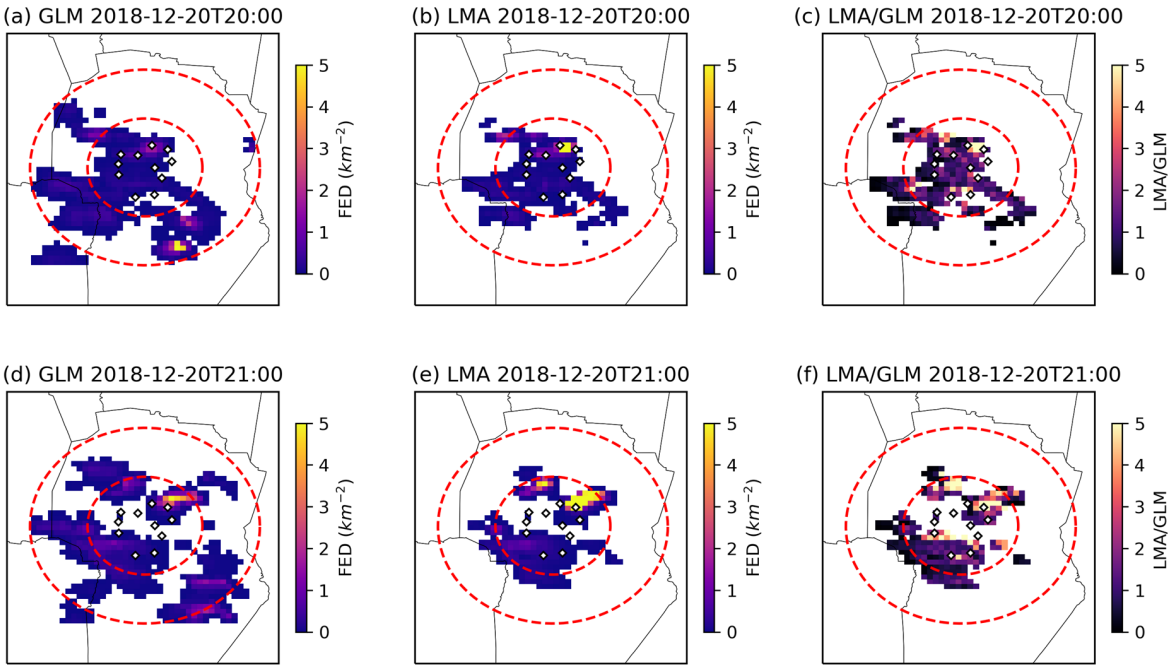
12/20/2018 ANOMALOUS STORM

Source Density Example



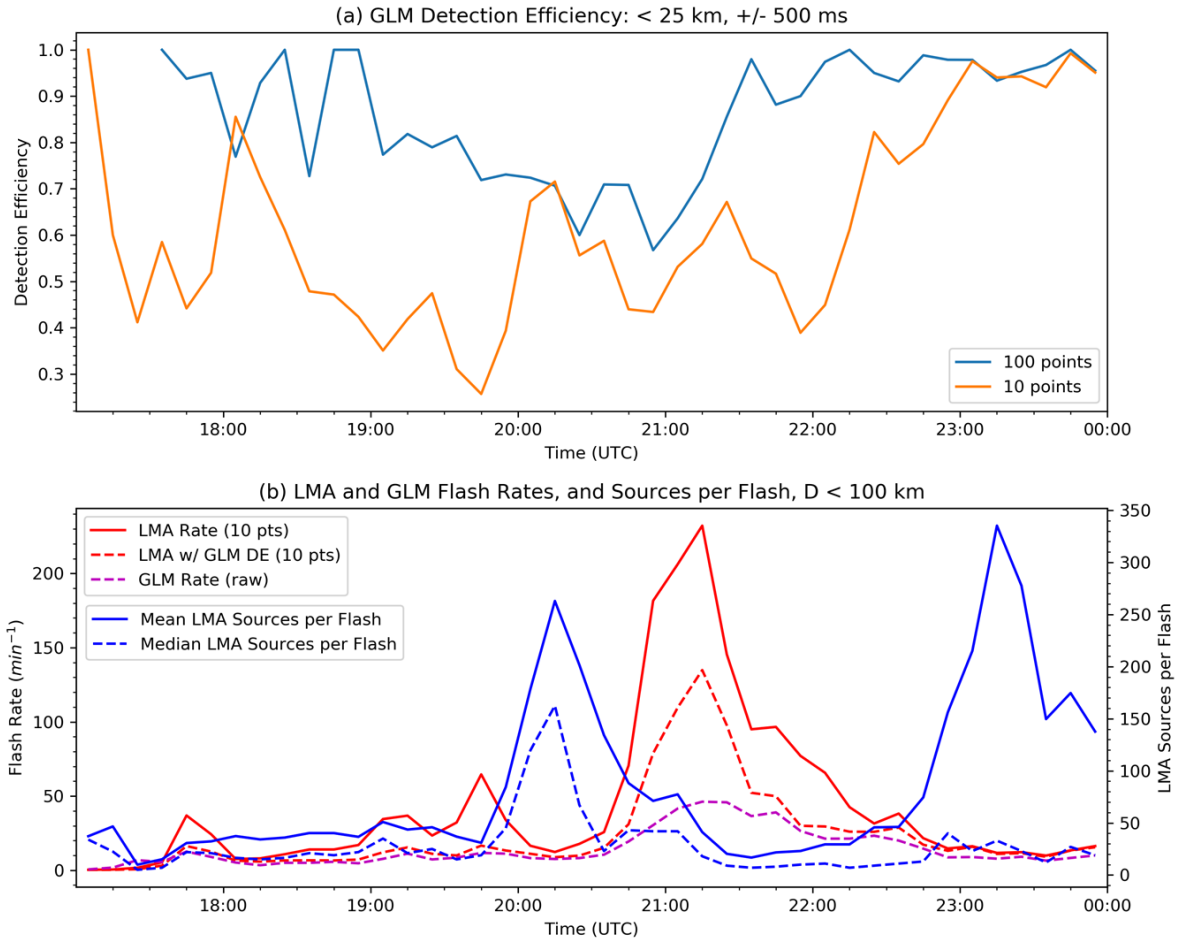
LMA source density was maximized near 6 km altitude during portions of this event, indicating anomalous lightning activity

GLM vs. LMA Flash Extent Density



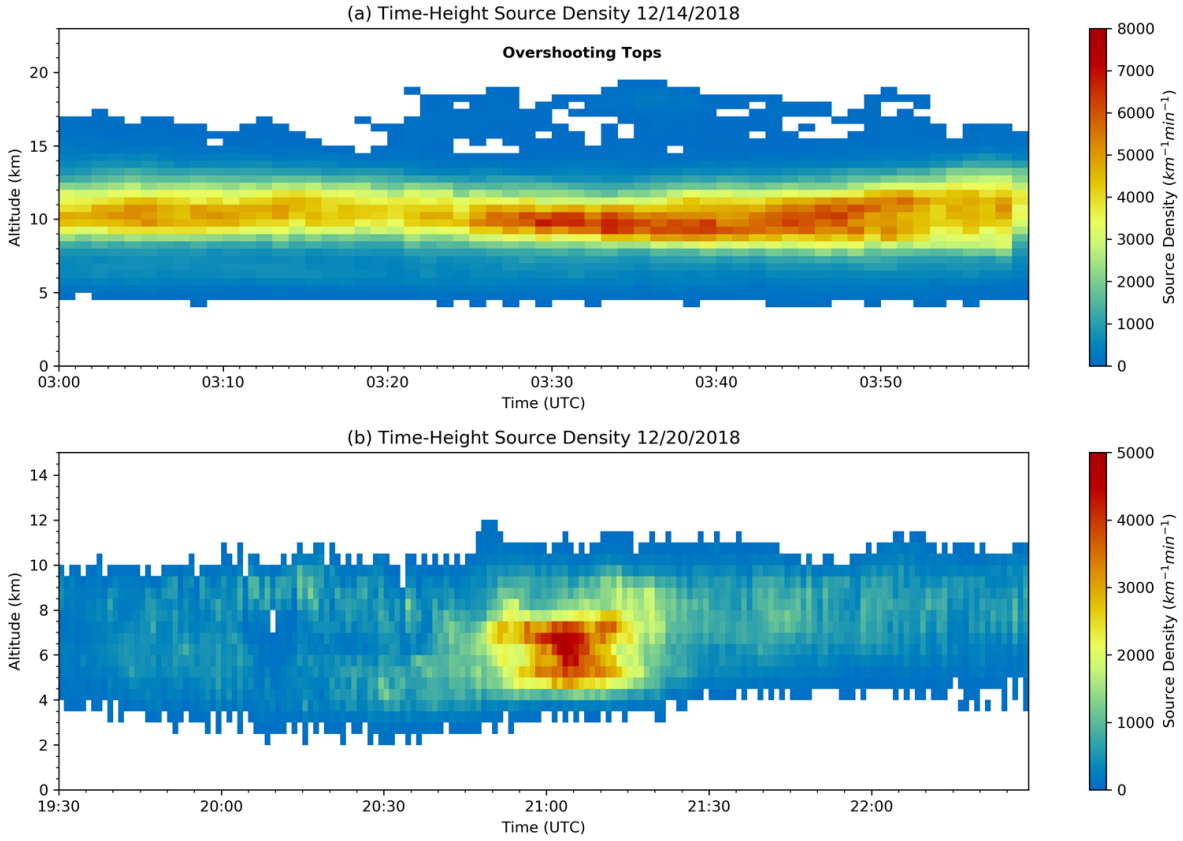
LMA flash extent density generally much greater than GLM during the peak anomalous period

GLM Detection Efficiency vs. Flash Size



Even large-flash detection efficiency for GLM declines during anomalous period, but GLM detection efficiency also affected by flash size

LMA Source Altitude Time-Height (12/14 & 12/20)



Both cases demonstrate how GLM detection efficiency is significantly affected by storm evolution and flash type!

ABSTRACT

During November 2018 through April 2019, an 11-station NASA lightning mapping array (LMA) was installed in the Cordoba region of Argentina, in support of GOES-16 Geostationary Lightning Mapper (GLM) calibration and validation, as well as the Remote sensing of Electrification, Lightning, And Mesoscale/microscale Processes with Adaptive Ground Observations (RELAMPAGO) field campaign. This region of Argentina is well known for frequent, intense thunderstorms and severe weather.

The LMA was monitored remotely via the Internet throughout its deployment, but due to bandwidth limitations no real-time data were available. Custom GOES-16 imagery provided by NASA SPoRT assisted with monitoring of thunderstorm cases. Occasional site visits were done to obtain data disks, perform routine maintenance, and troubleshoot problems.

During the deployment the network captured lightning in a variety of storm modes, including ordinary and severe multicells, supercells, and mesoscale convective systems. Many examples of normal-polarity thunderstorms, as well as a few examples of anomalously charged thunderstorms, were observed. Long (100+ km) horizontally stratified lightning flashes, as well as lightning in overshooting tops, also were frequently observed. Supporting research radar observations were available through January 2019, with operational radar coverage available after that time. Some cases featured supporting ABI meso scanning.

This presentation will report on the LMA deployment in context with the RELAMPAGO field campaign, show results from some representative case studies, and will provide initial comparisons to GLM observations.