Title: Combined NSSL and GTRI Lightning Mapping Array Data

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1.0 Data Set Description

- Introduction: Lightning Mapping Array (LMA) sensors were deployed at pre-designated locations for each IOP. The array consisted of up to 8 GTRI sensors (Units N-X), 8 NSSL sensors (Sites 1-8) and 1 TTU sensor, as listed in each Level 1 file header. The network was operated by Georgia Tech Research Institute, National Oceanic and Atmospheric Administration / Office of Atmospheric Research / National Severe Storms Laboratory and OU / CIWRO staff with invaluable assistance from SUNY Oswego faculty and students. Data set includes Level 1 (VHF sources) files. Raw station files (Level 0) uploaded separately.
- Creation date: 27 June 2023
- Data update: 4 August 2023
- Data Status: Final
- Time period: All data between 26 September 2022 - 2 April 2023 from the combined LMA network. During the period of 5 November 2022 to 2 February 2023 the LMA network contained both NSSL and GTRI sensors, the period outside of that, only GTRI sensors.

- Physical location of the measurements: All sensor locations centered around 43.59, -75.72 as listed in each Level 1 file header surrounding the New York Tug Hill Plateau
- Data file intervals: 10 minutes

2.0 Instrument Description

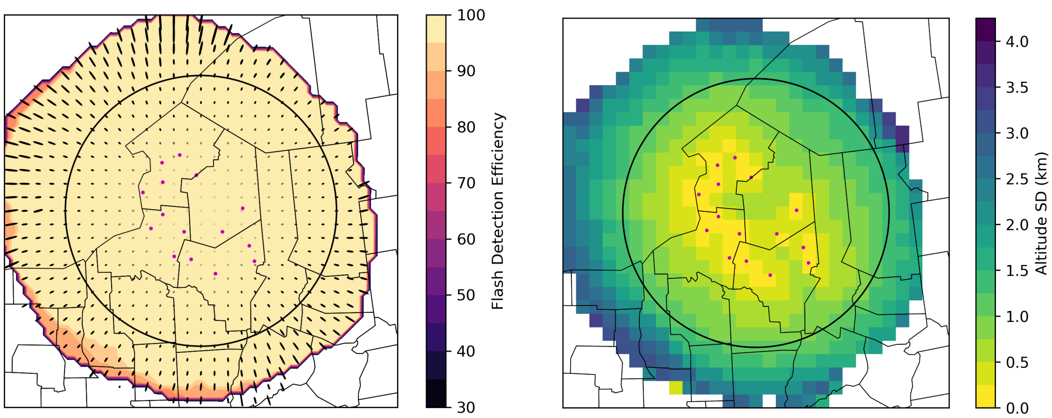
- Each sensor records the timing and amplitudes of passively-received VHF (60-66 MHz for NSSL sensors, 76-82 MHz for GTRI sensors) emissions by lightning (and any other sources) in 80 microsecond windows. Using time of arrival techniques, the sources of these emissions map out the three dimensional structure of lightning flashes in space and time. The method of data collection and method for performance estimations below can be found in Thomas et al. 2004 and Chmielewski and Bruning 2016.
- Instrument photos:

GTRI sensor X at Adams Center, NY, 20 Sept 2022

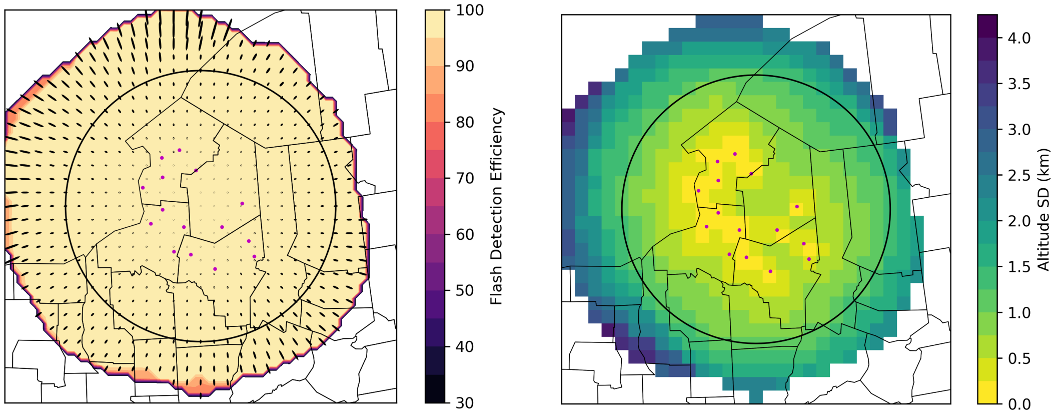
NSSL sensor B at installation at Mohawk Hill, NY, 7 Nov 2022

NSSL sensor D at Camp Aldersgate, Greig, NY during LEE, 20 Dec 2022

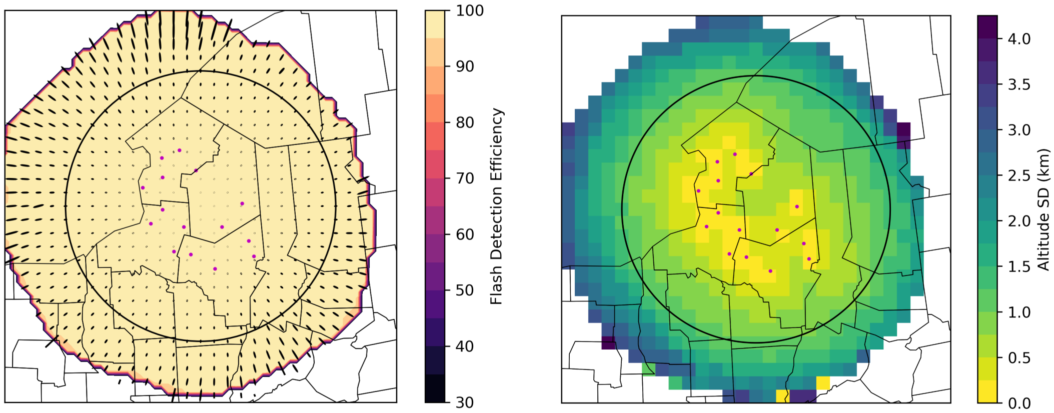
- Estimated network performance per IOP:



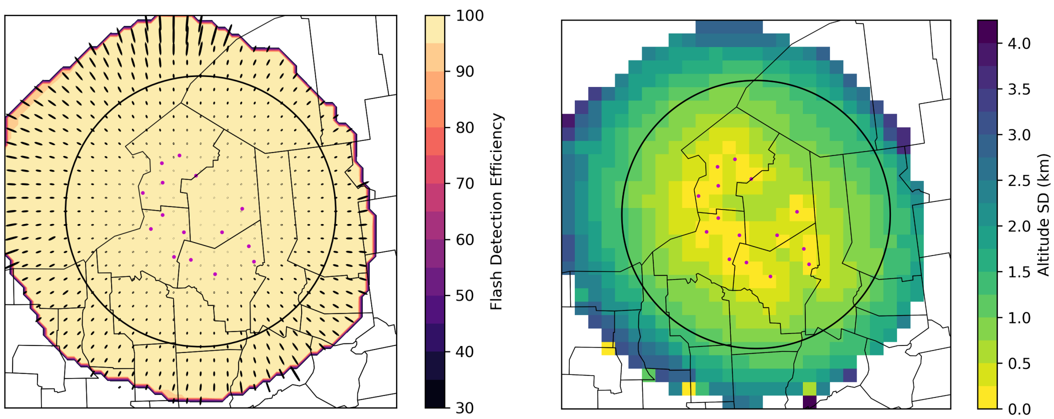
IOP1, 13 November 2022, 1000-1700 UTC. Left: Estimated flash detection efficiency based on local VHF noise thresholds and covariance ellipse of horizontal errors based on instrument uncertainty for sources with at least 5 stations contributing and a source at 1.5 km MSL with sensors active during the IOP period (pink points). Right: Altitude standard deviation based on instrument uncertainty. 100 km radius from the centroid of the array shown on both images.



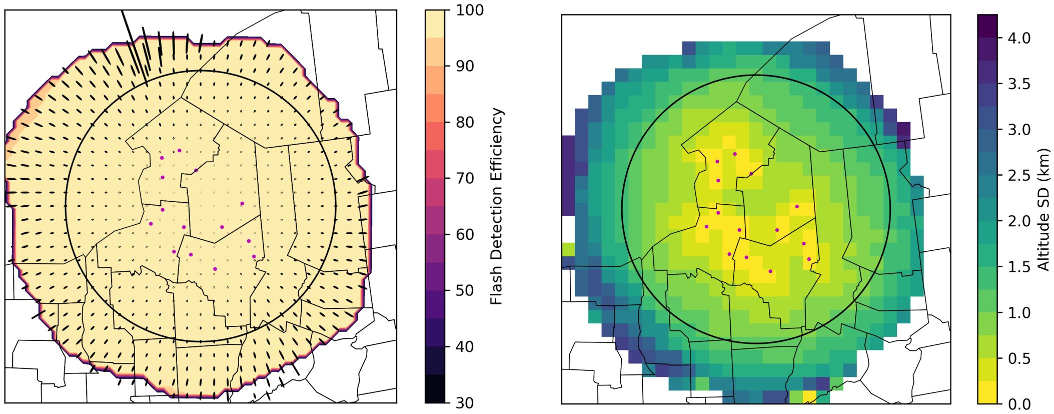
IOP2a, 17 November 2022, 0800-1600 UTC



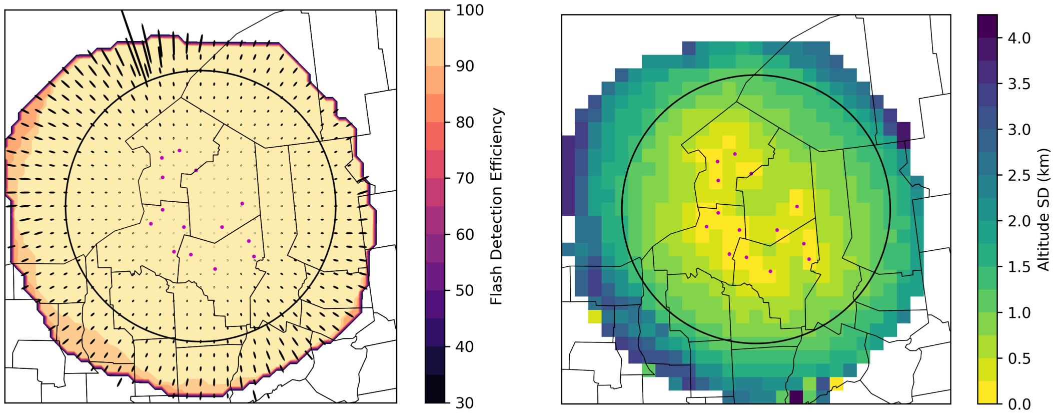
IOP2, 18-19 November 2022, 1900-0600 UTC



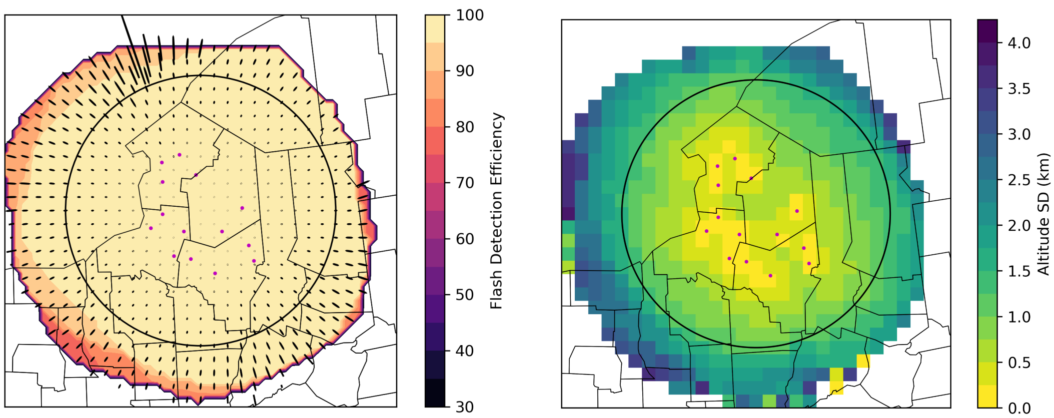
IOP3, 20 November 2022, 1000-2230 UTC



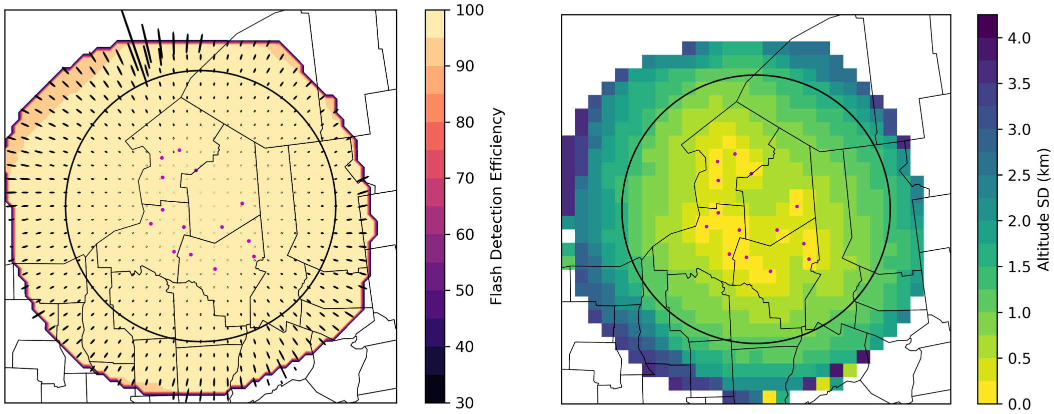
IOP4, 17-18 December 2022, 2300-1500 UTC



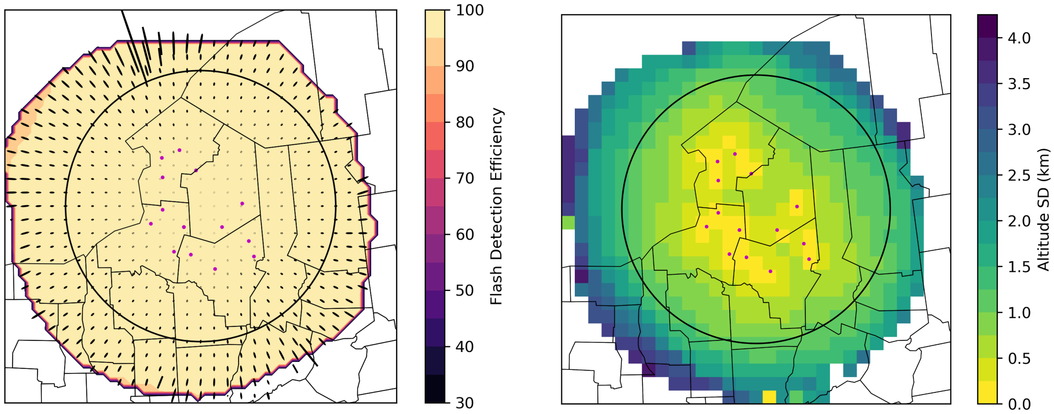
IOP5, 19 December 2022, 1000-1800 UTC



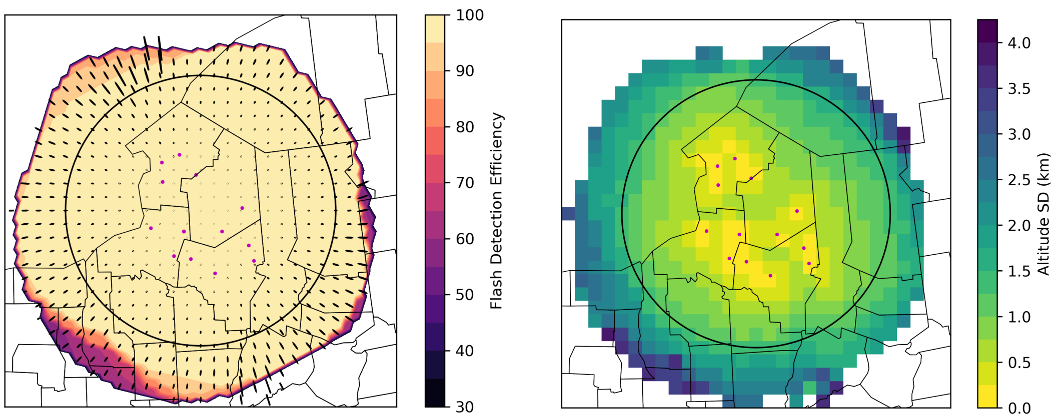
IOP6, 24 January 2023, 1600-2200 UTC



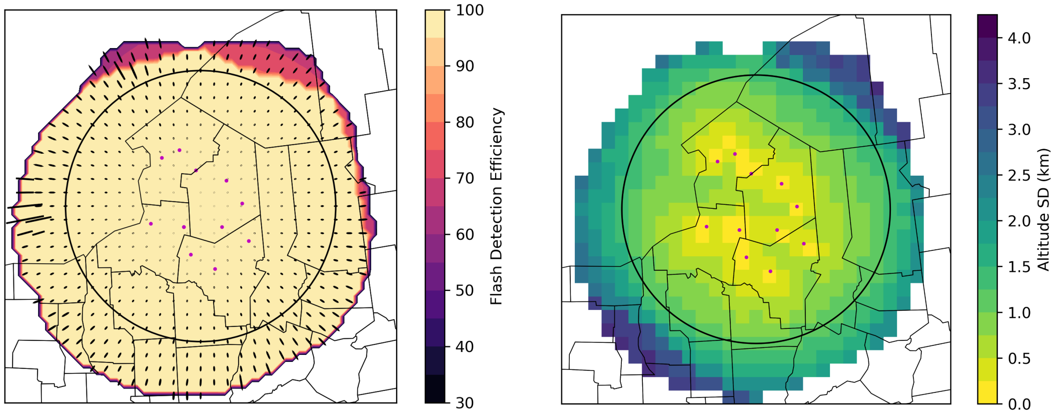
Extratropical Thundersnow case, 25-26 January 2023, 1900-0000 UTC



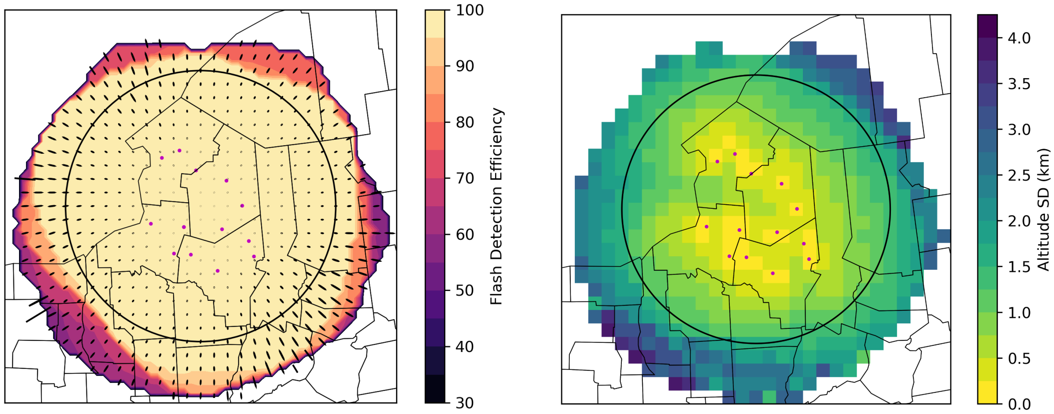
IOP7, 27 January 2023, 0500-0700 UTC



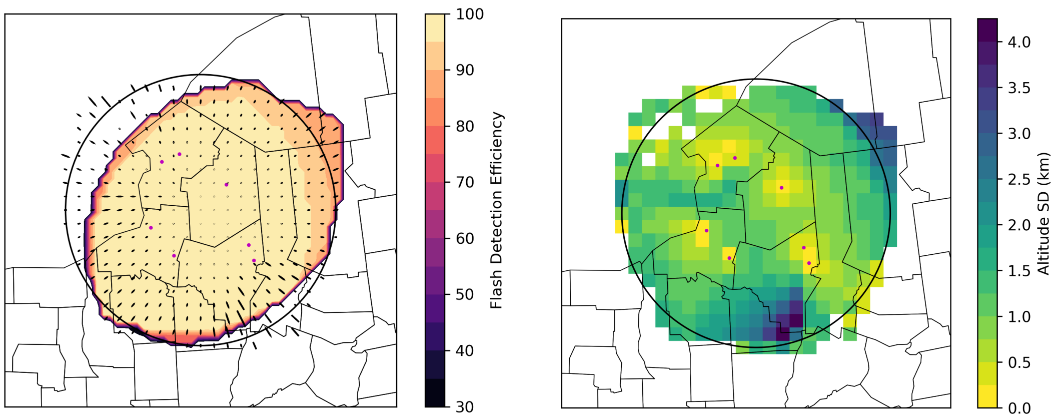
IOP8, 28 January 2023, 1500-1700 UTC



IOP9, 31 January 2023, 0600-1000 UTC



IOP10, 1-2 February 2023, 1100-0000 UTC



IOP11 (GTRI sensors only), 2-3 February 2023, 2200-0330 UTC

3.0 Data Collection and Processing

- Data was collected from each sensor remotely throughout the project period and processed regularly.

- All data from was processed using lma_analysis v10.14.5R with a minimum of 5 contributing stations per solution unless otherwise noted in the file header.

4.0 Data Format

All Level 1 data is stored in tabular, fixed-width formatted files compressed with gzip within the YYYY/MM/DD directories by date during the project period. Fixed width formatting described in each file header. Each file contains 10 minutes of VHF events observed by the LMA and is titled following a LYLOUT_YYMMDD_HHMMSS_0600.dat.gz naming convention. Each file has a series of header lines at the top of the file including analysis version, active stations, analysis criteria, summary information, creation date and formatting information. Data is preceded by a "*** data ***" line. If no data is found, either through lack of weather or sensor issues, only the file header will be present in the file.
** Column Names and Descriptions **
0: Time of VHF event – UTC second of the day
1: lat – decimal degrees
2: lon – decimal degrees
3: altitude – in meters above MSL
4: Reduced Chi^2 – Reduced chi^2 of the Marquart least squares solution for the VHF event
5: power – emitting power of the VHF event in dBW
6: mask – bitwise mask of the contributing stations to the VHF event solution in the order given by the Stations mask order line.

5.0 Data Remarks

- PI's assessment of the data:
    - During two periods, persistent cloud cover impacted the ability for the batteries to recharge during the day and caused intermittent sensor outages at various locations until batteries could be replaced, roughly: 25 Dec-10 Jan; 31 Jan-2 Feb. All sensors contributing to a single 10 minute period are noted in each file header.
    - NSSL sensors A, B and E were damaged in a high wind event on 30 Nov 2022. Sensors A and B were repaired and operational on 15 Dec 2022. Sensor E was temporarily placed at a different location and returned to its original site 25 Jan 2023.
    - NSSL sensor G at Redfield, NY experienced internal hardware failures starting on 6 Dec 2022, so sensor E was placed at the Redfield, NY location from 16 Dec-25 Jan 2023 while sensor G was undergoing repairs. Sensor G was replaced 25 Jan 2023.
    - GTRI sensor N at Duflo Airport experienced hardware issues and was sent back to GTRI for repairs. It was offline between 5 Oct 2022-10 Jan 2023. It was back online 11 Jan 2023-11 Feb 2023.
    - Maintenance of individual GTRI sensors was ceased by 1 March, so array solutions may become sporadic and after that date.
- Dataset updated 4 Aug 2023 for 05-15 November time period to include all stations

6.0 References

- Chmielewski, V. C., and Bruning, E. C. (2016), Lightning Mapping Array flash detection performance with variable receiver thresholds, J. Geophys. Res. Atmos., 121, 8600–8614, doi:10.1002/2016JD025159.
- Thomas, R. J., Krehbiel, P. R., Rison, W., Hunyady, S. J., Winn, W. P., Hamlin, T., and Harlin, J. (2004), Accuracy of the Lightning Mapping Array, J. Geophys. Res., 109, D14207, doi:10.1029/2004JD004549.

7.0 Appendix

- Keywords: Atmospheric Electricity, Lightning, Lightning Mapping Array, Thunderstorm

- Alternate data access: Data are also archived at https://data.nssl.noaa.gov/thredds/catalog/WRDD/OKLMA/deployments/LEE/catalog.html

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