Use of the National Lightning Detection Network for Transmission Interests within an Energy Company

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Energy Delivery Transmission Operations

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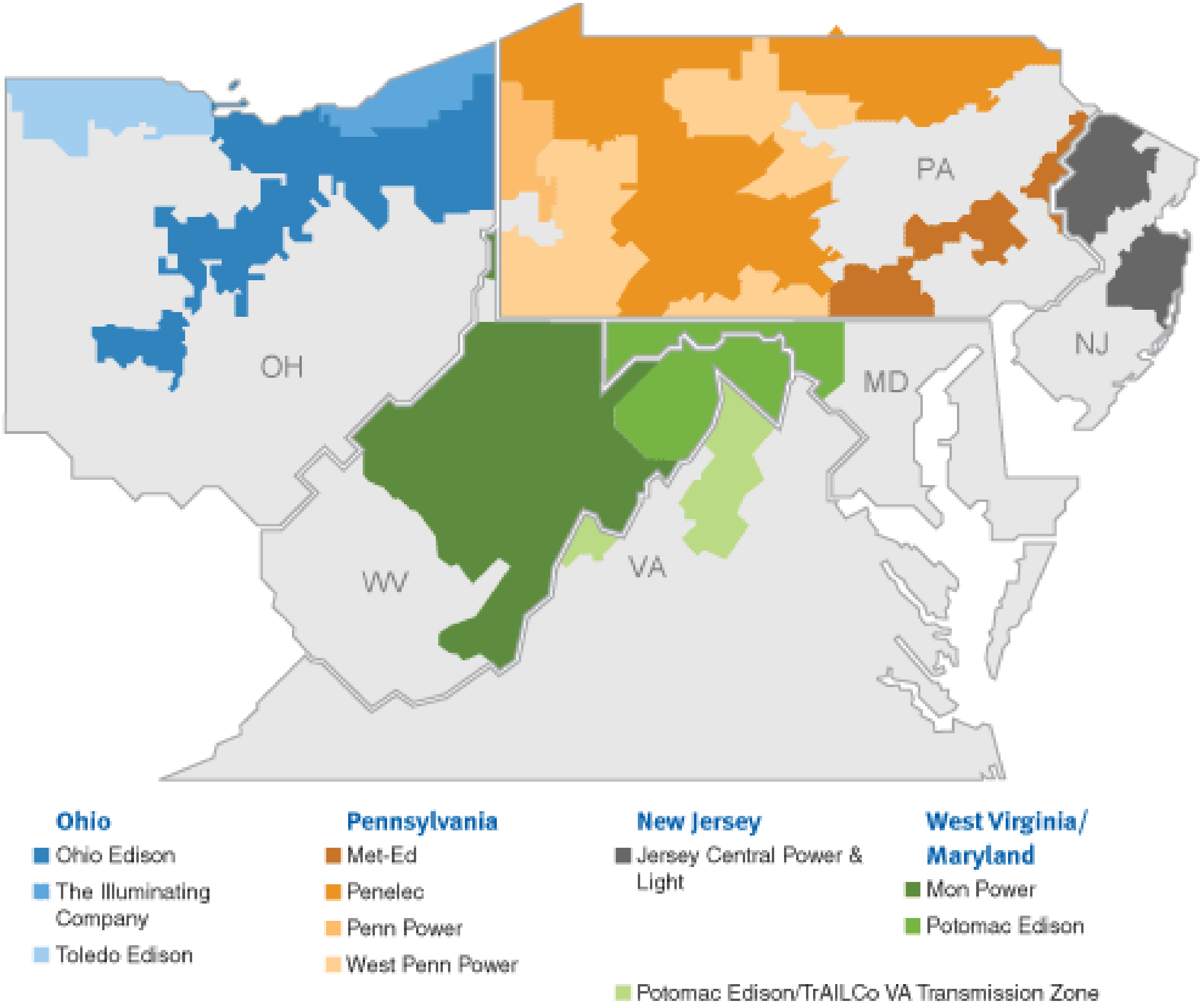
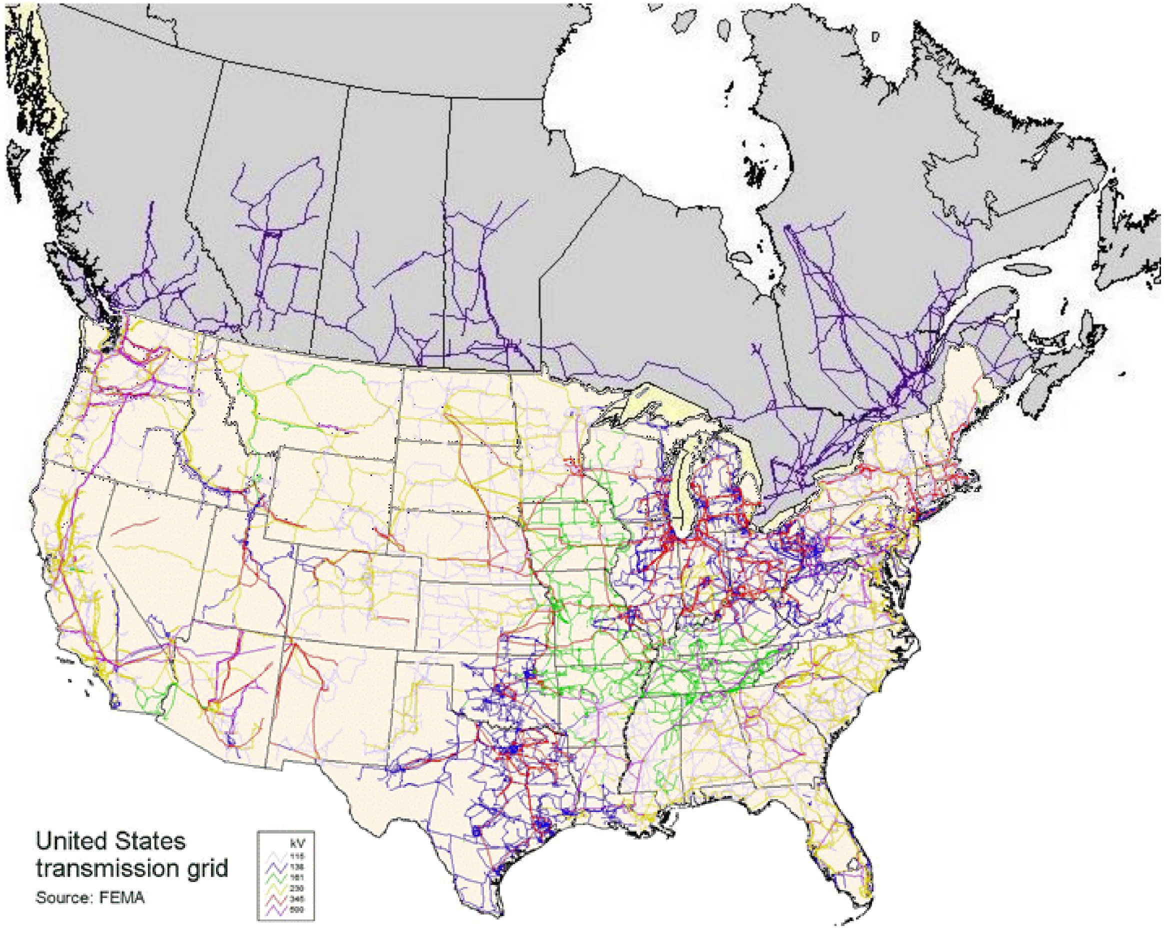
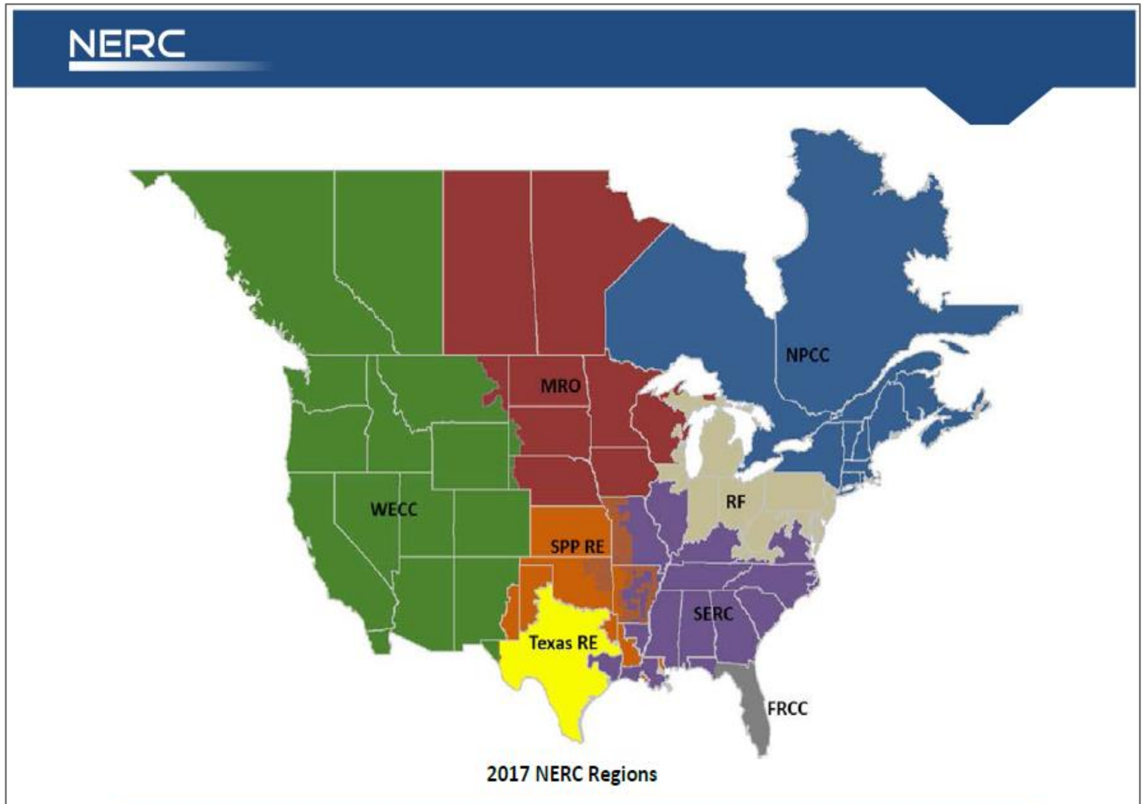
FirstEnergy Corp.

- Headquartered in Akron, OH
- Generate, Distribute, and Sell Power
- 6 million customers served mainly in 5 states (technically 6)
- 269,000 miles distribution lines
- 24,000 miles of Transmission (TX) lines
- 16,000 MW generation portfolio shrinking and consists of Fossil (63%), Nuclear (25%), and Renewable (12%)



Bulk Electric System (BES) and Governance Body





NERC Regional Entities

Texas RE Texas Reliability Entity	FRCC Florida Reliability Coordinating Council	MRO Midwest Reliability Organization	NPCC Northeast Power Coordinating Council, Inc.
RF ReliabilityFirst	SERC SERC Reliability Corporation	SPP RE Southwest Power Pool, RE	WECC Western Electricity Coordinating Council

Quick Lightning Refresher

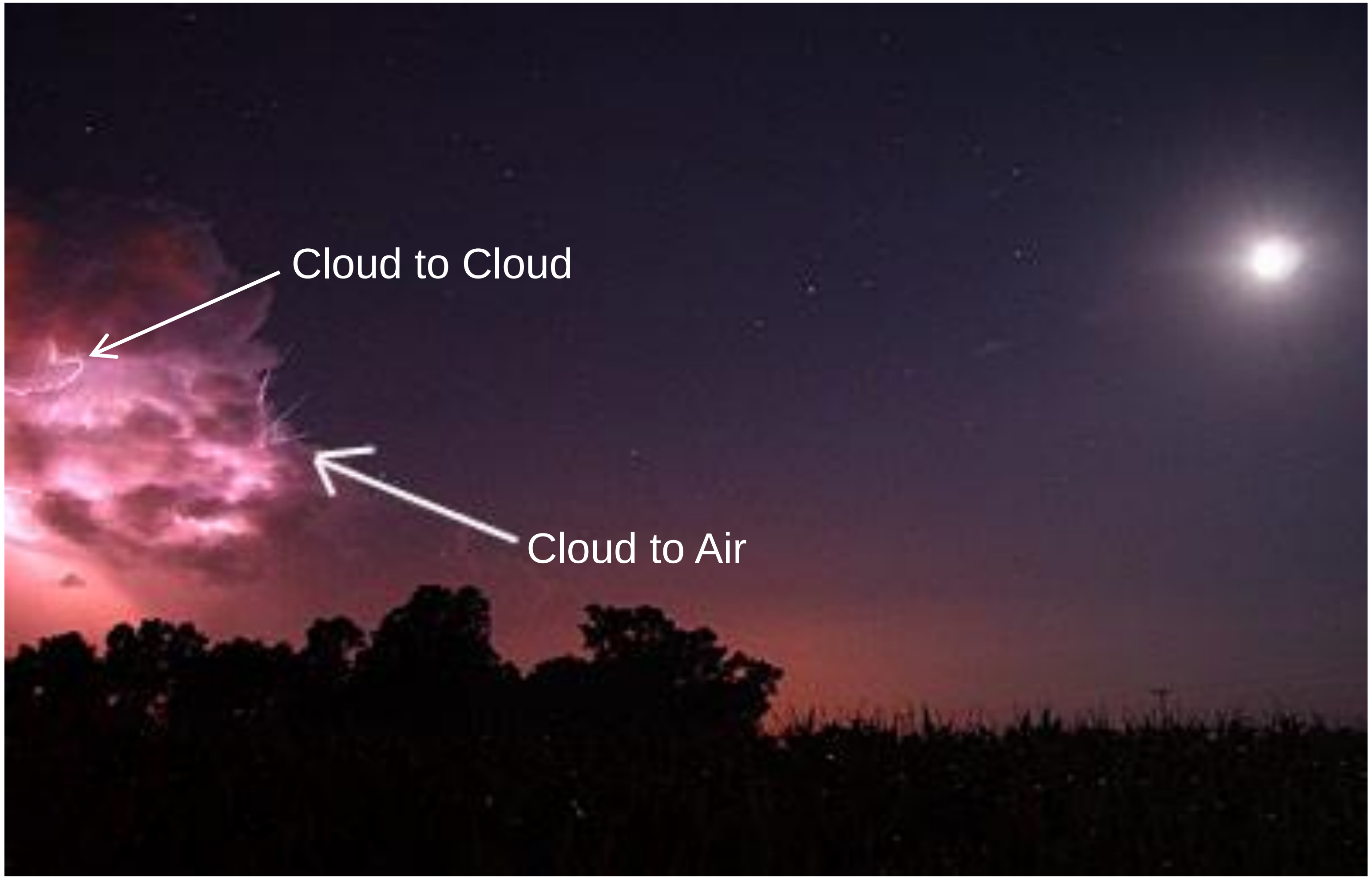
Basic Lightning Types

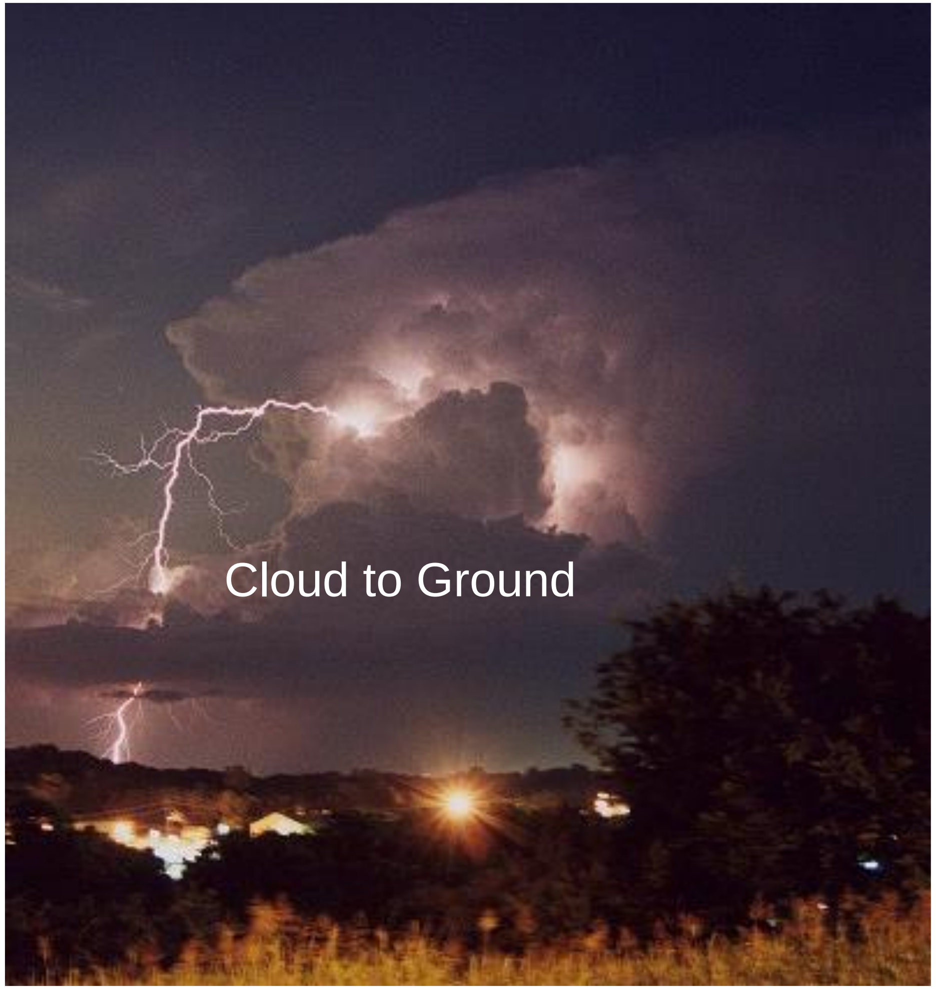
I. Cloud to Cloud, Cloud to Air, Cloud to Ground (CG)

II. 25% tend to be CG

Two Polarities

- Positive (tend to be more energetic)
- Negative (tend to occur more frequently)



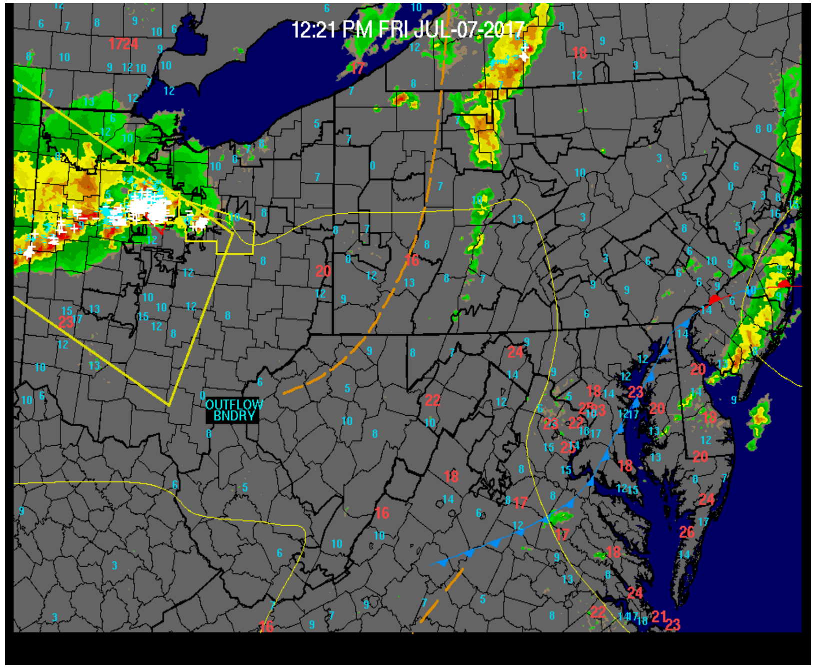


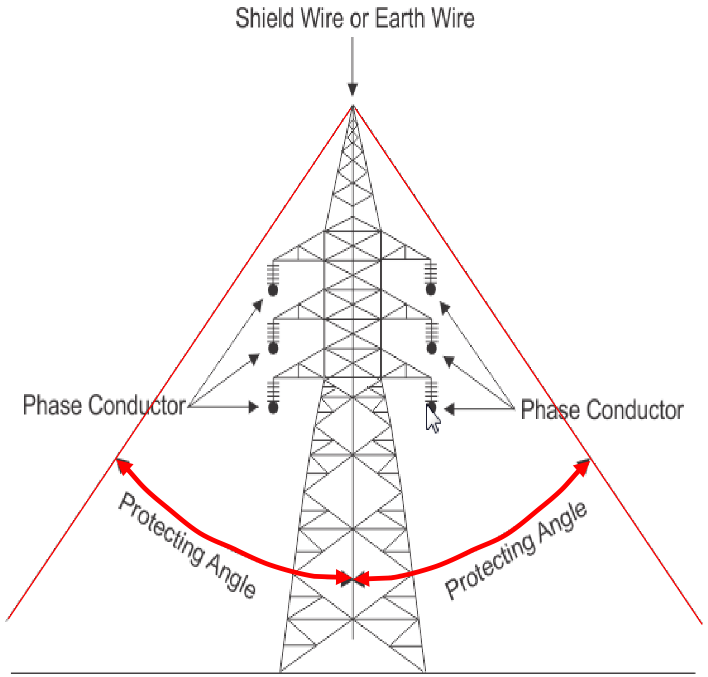
Other Lightning Types

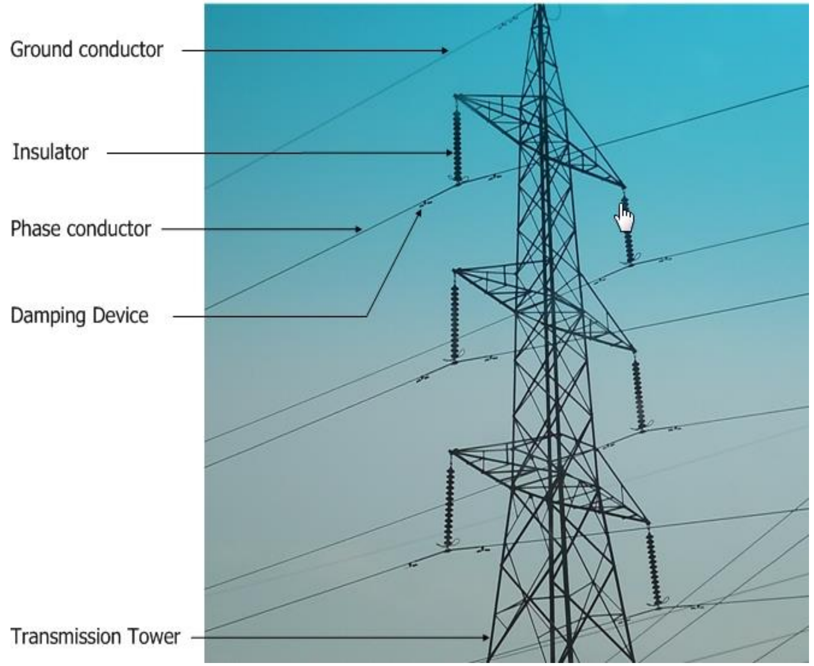
CS: Cloud-to-Stadium

Impacts of CGs on TX and Mitigation Strategies

- CG impacts are typically localized and automatically isolated by sectionalizing equipment
- More wide spread impacts with larger MCS-type systems occur (requires more resources for restoration)
- Although an outage on a key transmission wire feeding multiple substations CAN impact thousands of customers, regional blackouts like NYC in 1977 due to lightning are not likely







When CG's do cause a TX interruption…

- Every BES outage is investigated for a cause (filed to NERC)

- If weather is suspected, the time of the interruption ("trip") is matched to when damaging weather occurred (ice, wind, lightning)

- Damage assessment occurs if a strike was detected to occur at or near the location of the trip (repairs made if needed)

National Lightning Detection Network

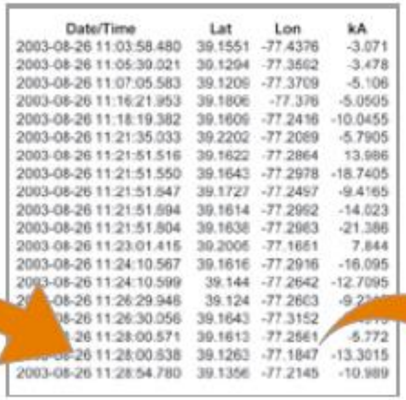
- **Operated by Vaisala since the early 90’s**
- **Super-national coverage (24/7)**
- **Ground strike location accuracy generally ~200m (+/- 50m)**

How the NLDN Works

U.S. NLDN consists of the latest advanced ground-based lightning sensor technology from Vaisala.

Sensors instantly detect the electromagnetic signals produced when cloud and cloud-to-ground lightning occurs.

Sensors send raw data via satellite or internet to the Network Control Center (NCC) in Tucson, Arizona.



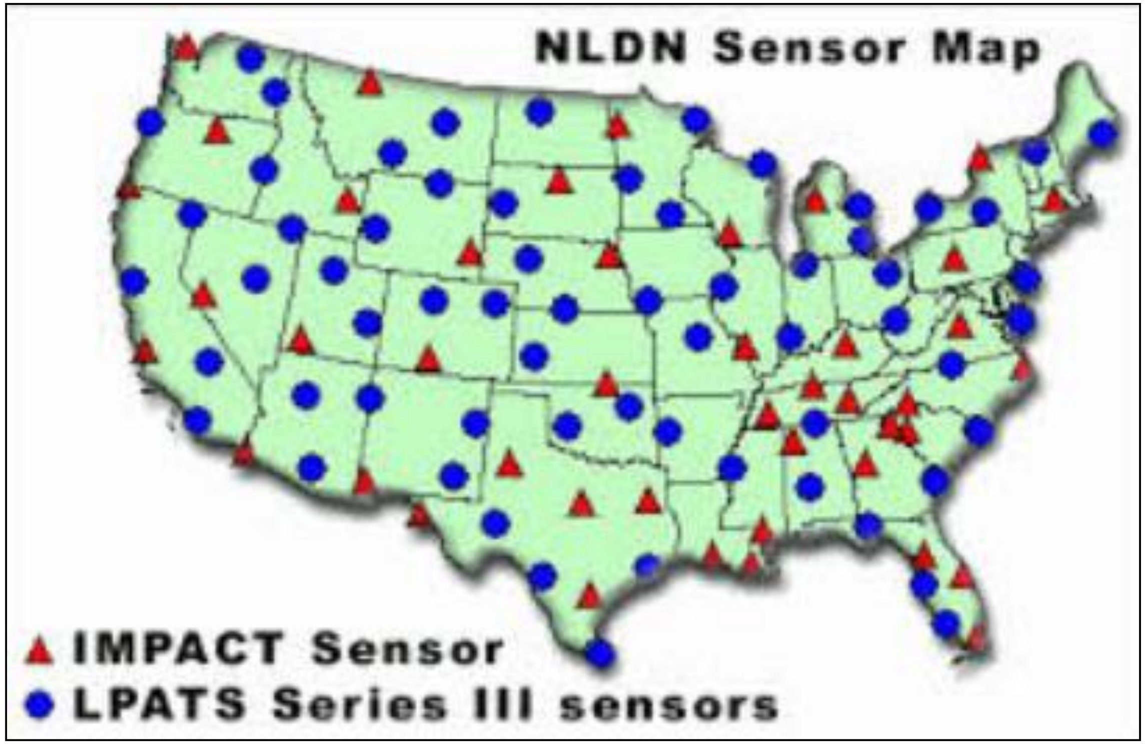
Date/Time	Lat	Lon	kA
2003-08-26 11:03:58.480	39.1551	-77.4376	-3.071
2003-08-26 11:05:30.021	30.1294	-77.3562	-3.478
2003-08-26 11:07:05.583	39.1209	-77.3709	-5.106
2003-08-26 11:16:21.953	39.1806	-77.376	-5.0505
2003-08-26 11:18:19.382	39.1609	-77.2416	-10.0455
2003-08-26 11:21:35.033	39.2202	-77.2089	-5.7905
2003-08-26 11:21:51.516	39.1622	-77.2864	13.986
2003-08-26 11:21:51.550	39.1643	-77.2978	-18.7405
2003-08-26 11:21:51.547	39.1727	-77.2497	-9.4165
2003-08-26 11:21:51.594	39.1614	-77.2962	-14.023
2003-08-26 11:21:51.804	39.1638	-77.2963	-21.386
2003-08-26 11:23:01.416	39.2006	-77.1651	7.844
2003-08-26 11:24:10.567	39.1616	-77.2916	-16.095
2003-08-26 11:24:10.599	39.144	-77.2642	-12.7095
[illegible]-08-26 11:26:29.946	39.124	-77.2603	[illegible]
[illegible]8-26 11:26:30.056	39.1643	-77.3152	[illegible]
[illegible]-26 11:28:00.571	39.1613	-77.2661	-5.772
[illegible]-26 11:28:00.538	39.1263	-77.1847	-13.3015
2003-08-26 11:28:54.780	39.1356	-77.2145	-10.989

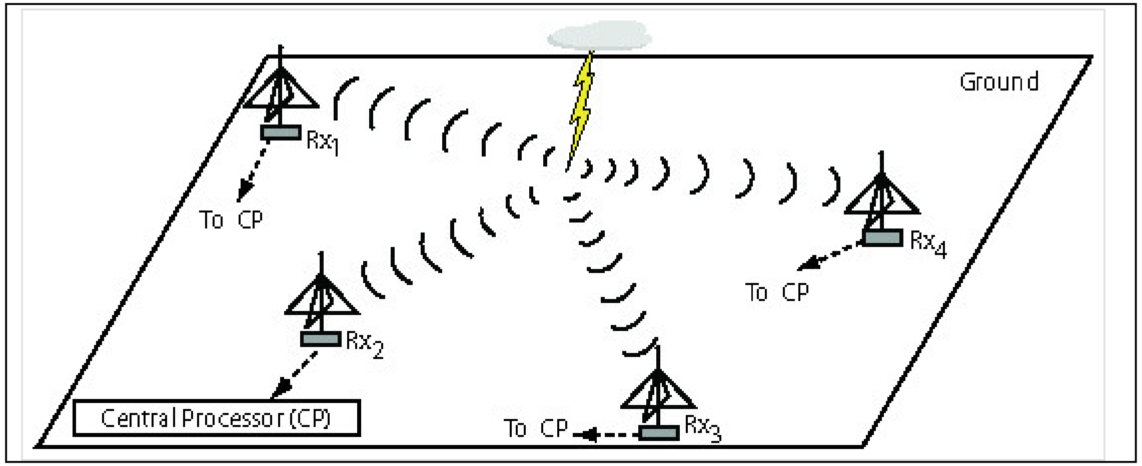
Within seconds, the NCC’s central analyzers process information on location, time, type, polarity, and amplitude of each lightning event.

Lightning information is sent to users across the country.

FALLS Application

- "Fault Analysis Lightning Location System"
- Vaisala-made GIS-based PC application
- Each cloud to ground strike location IS ONLY AN ESTIMATE
- The "best estimate" location is correlated to the potentially impact FE asset to establish likelihood a given fault was lightning-related





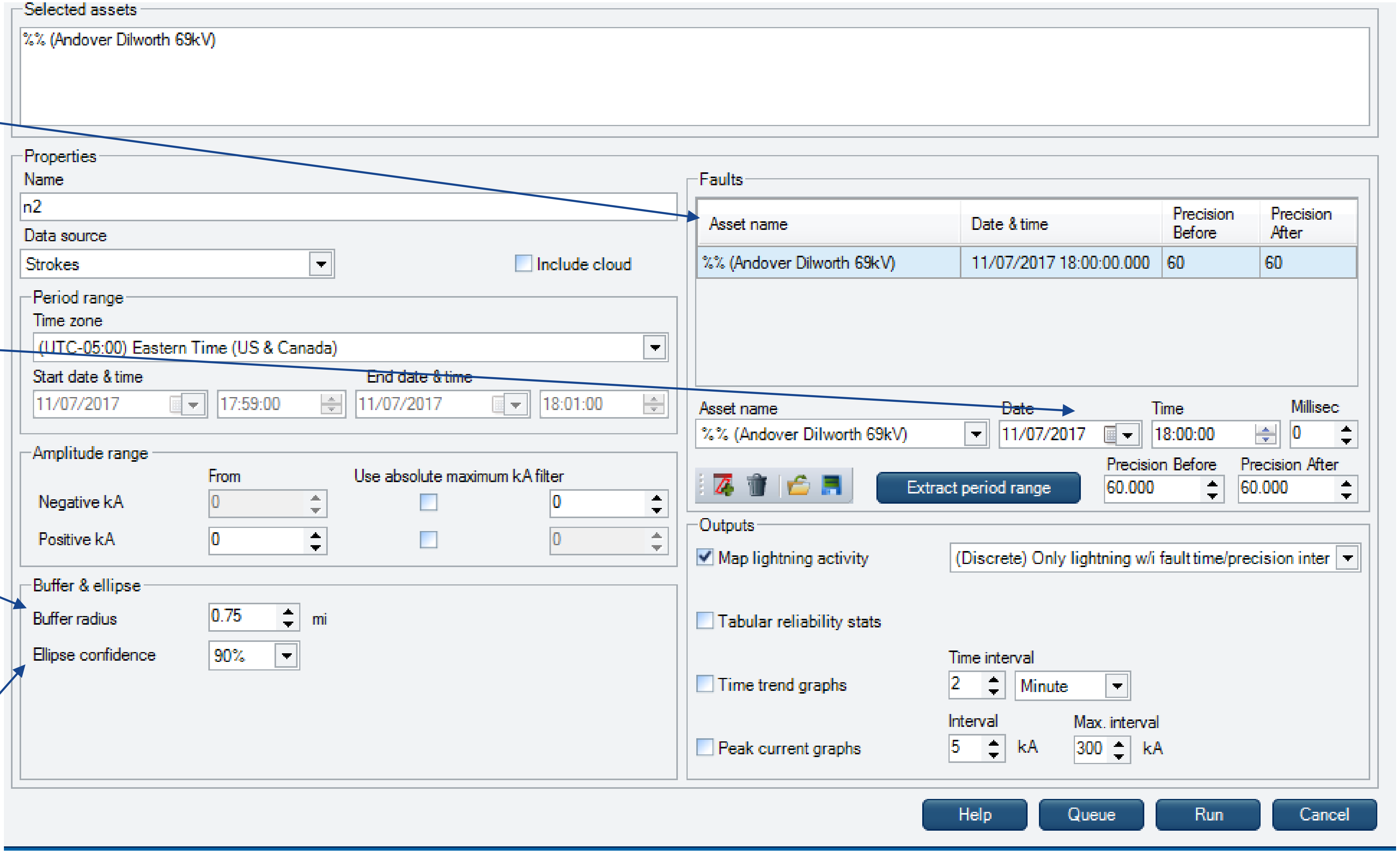
Notable FALLS Settings

TX Line

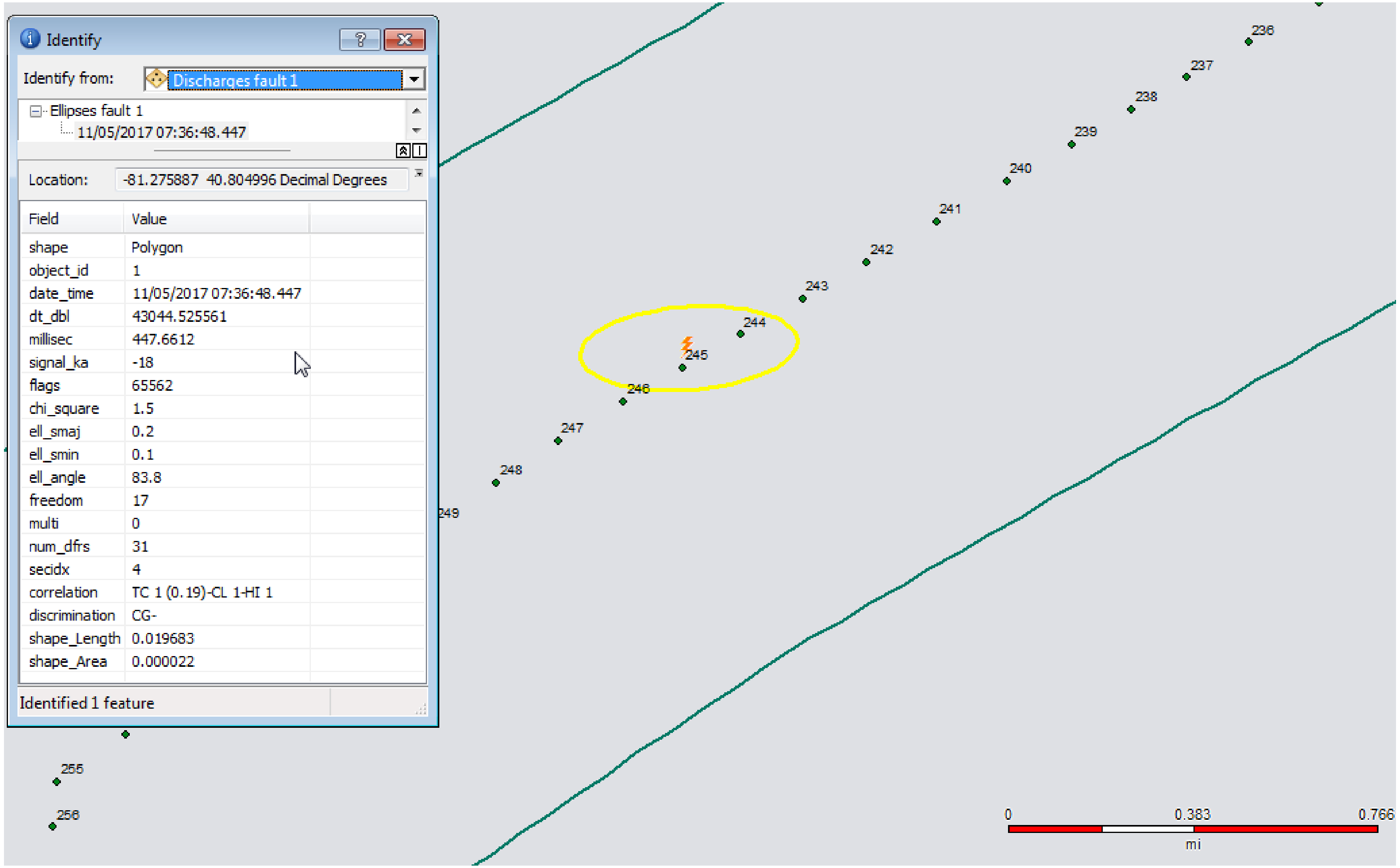
Time of Fault (Trip)

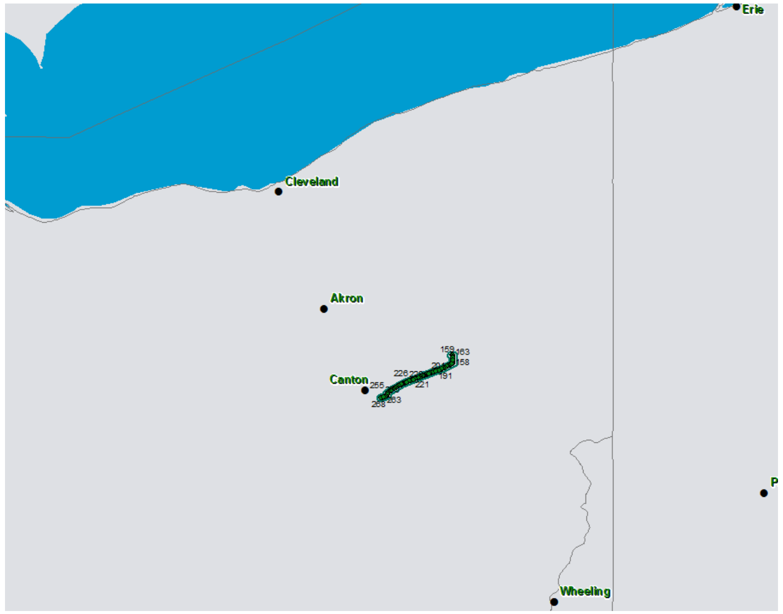
Proximity to TX line

Location Confidence



138kV Line Trip at 2017 11 05 (07:36)

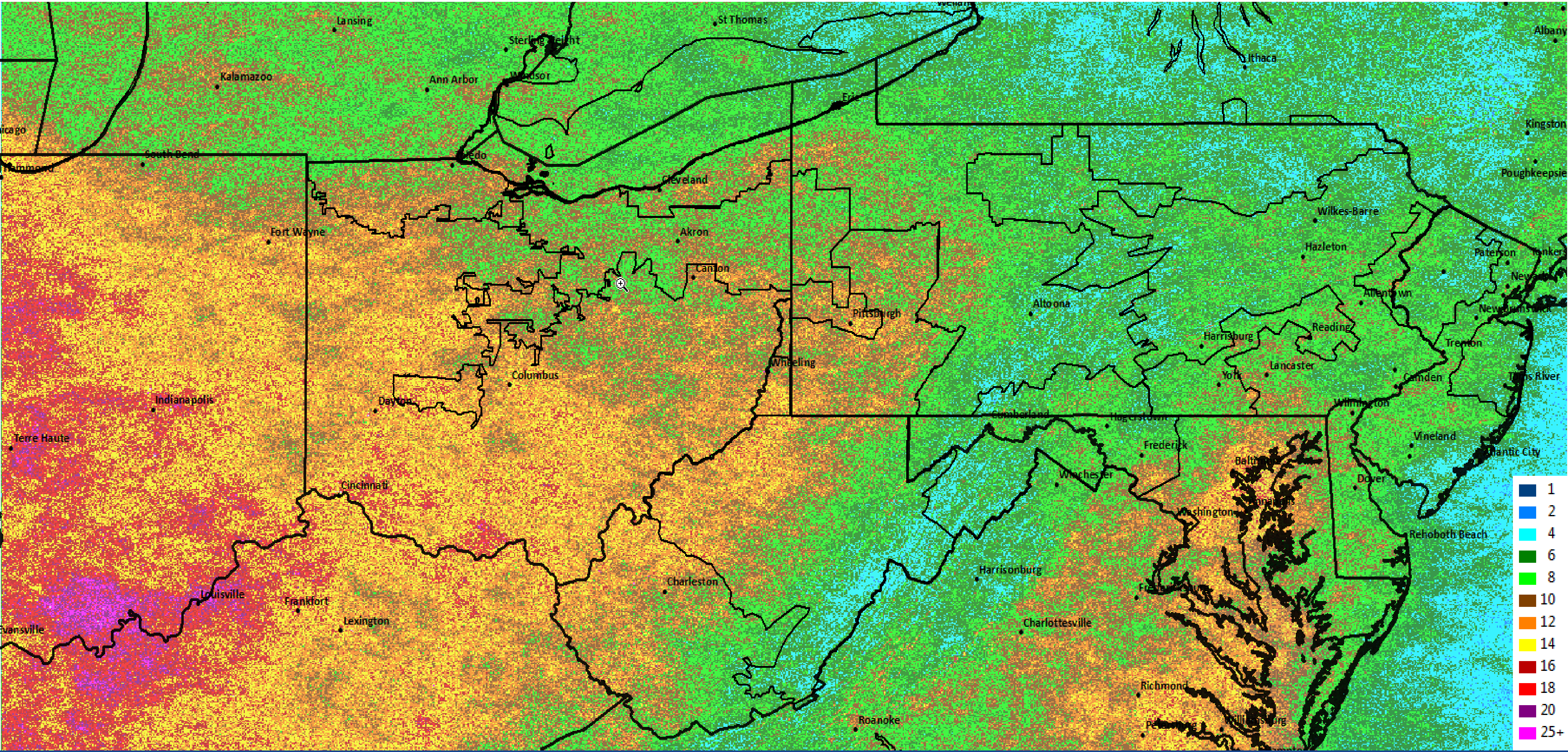




This trip <u>was</u> most likely associated with the lightning strike depicted. A patrol was dispatched to assess for damage.

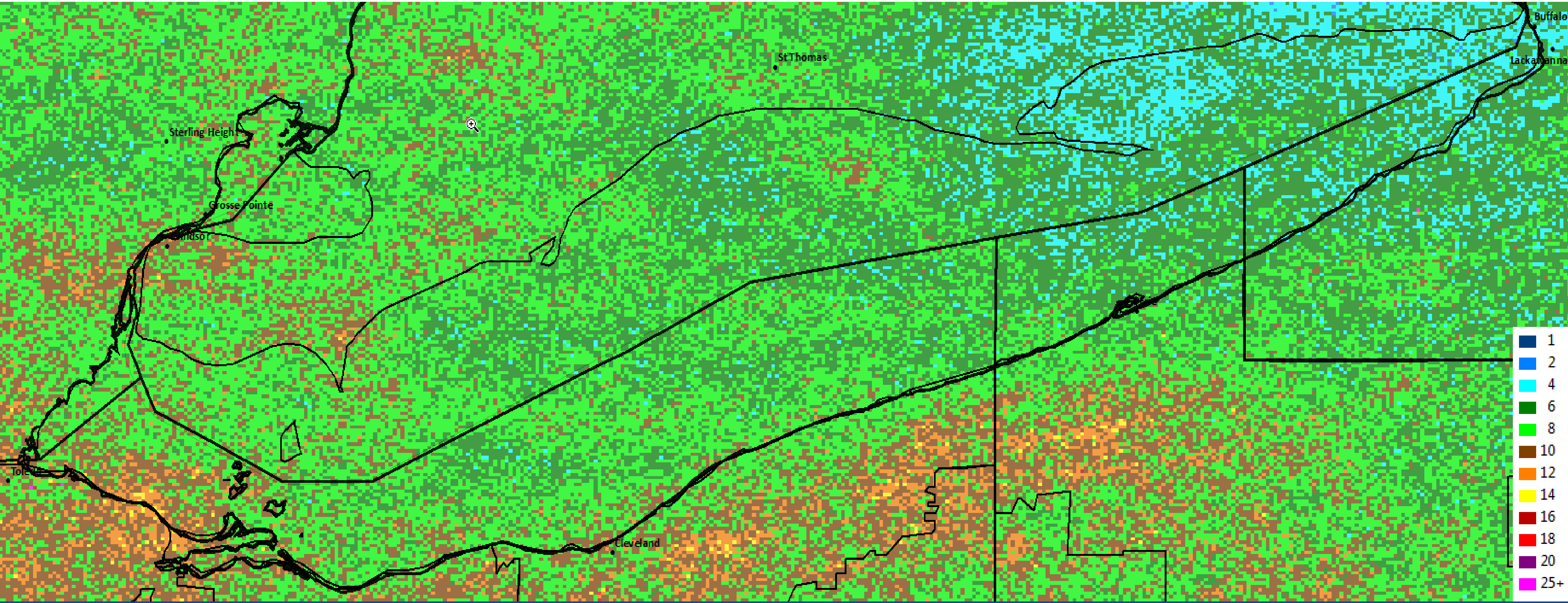
(Note the .75 mi buffer in green and the 90% location confidence ellipse in yellow)

Other Analysis Capabilities: Annual Avg CG/sq-mi (1999-2017)



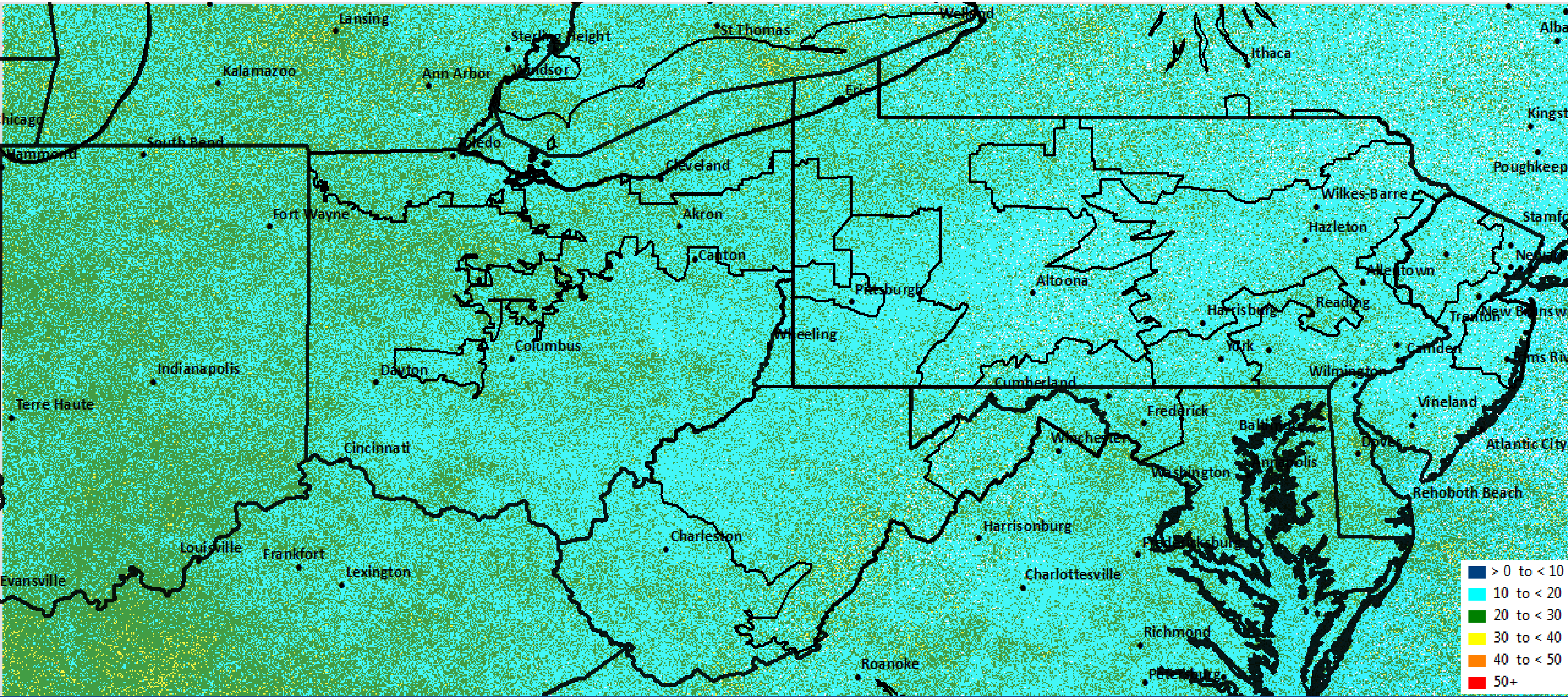
Lake Erie Zoom: Annual Avg CG/sq-mi (1999-2017)

- Less northeast, more (2-3x) southwest
- Possible event-skewed maximum north-central

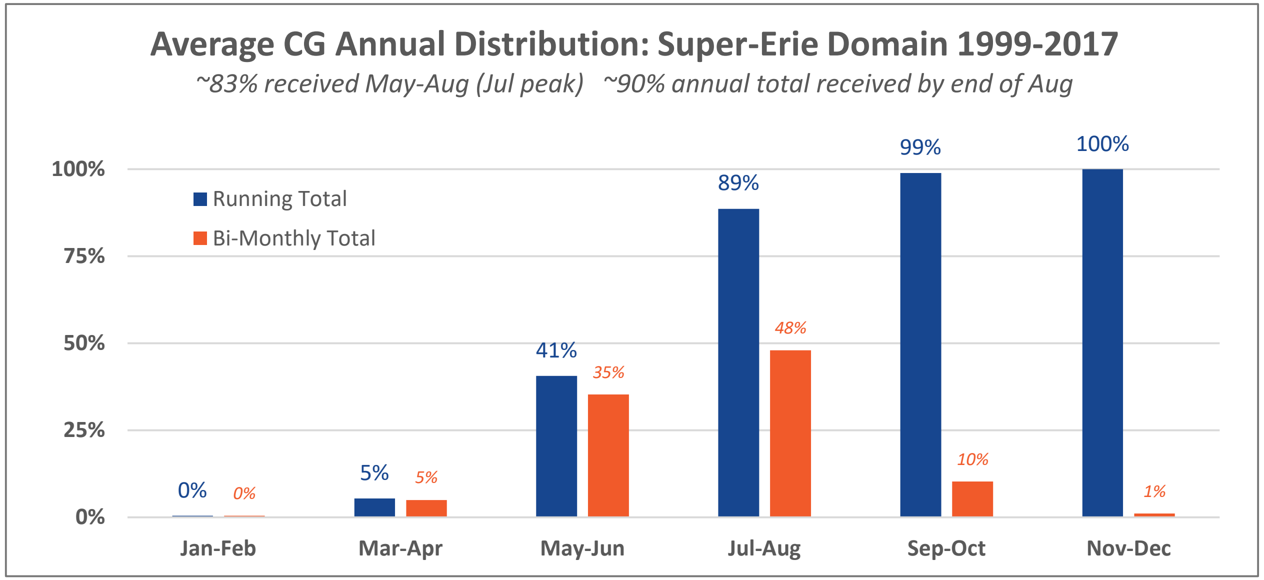


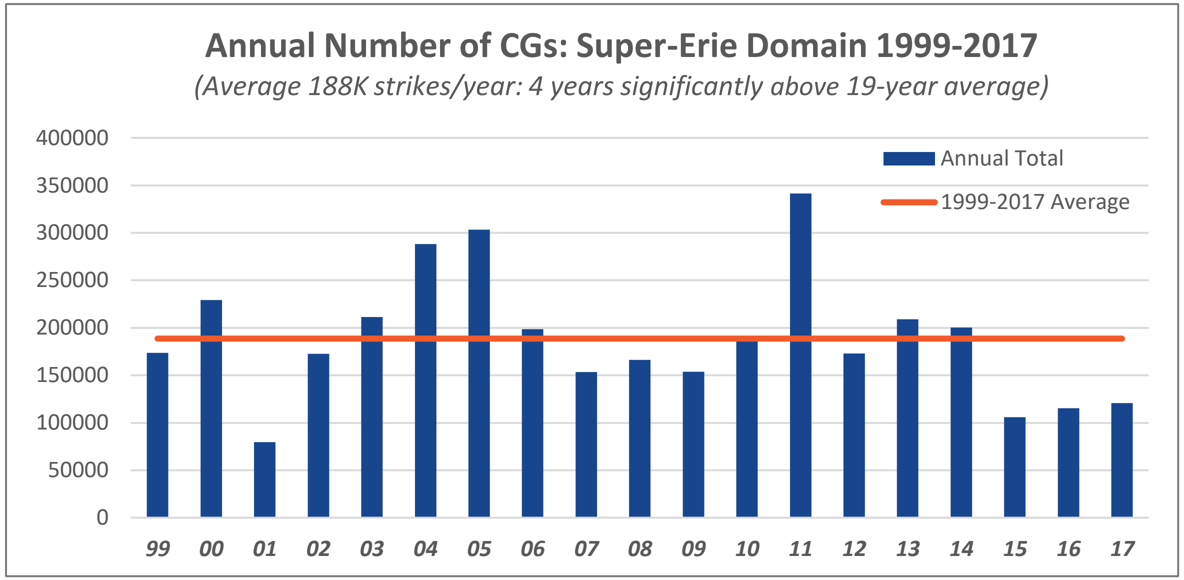
% Positive Polarity Analysis: Annual Avg (1999-2017)

Generally 25% or less with relative increase east to west (max still over Lake Erie)

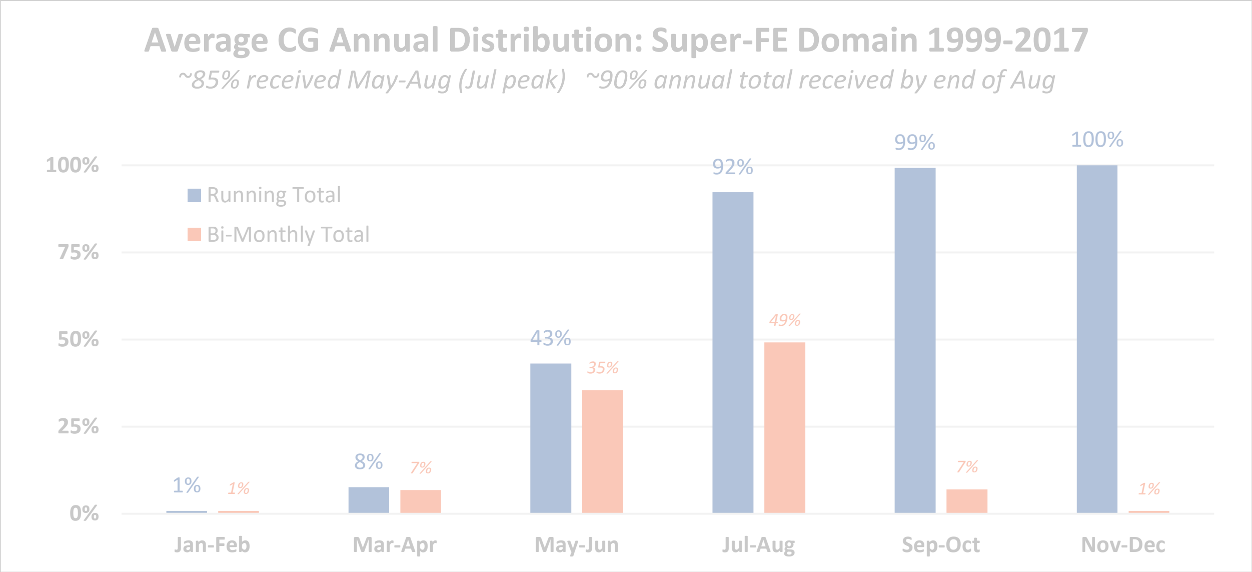


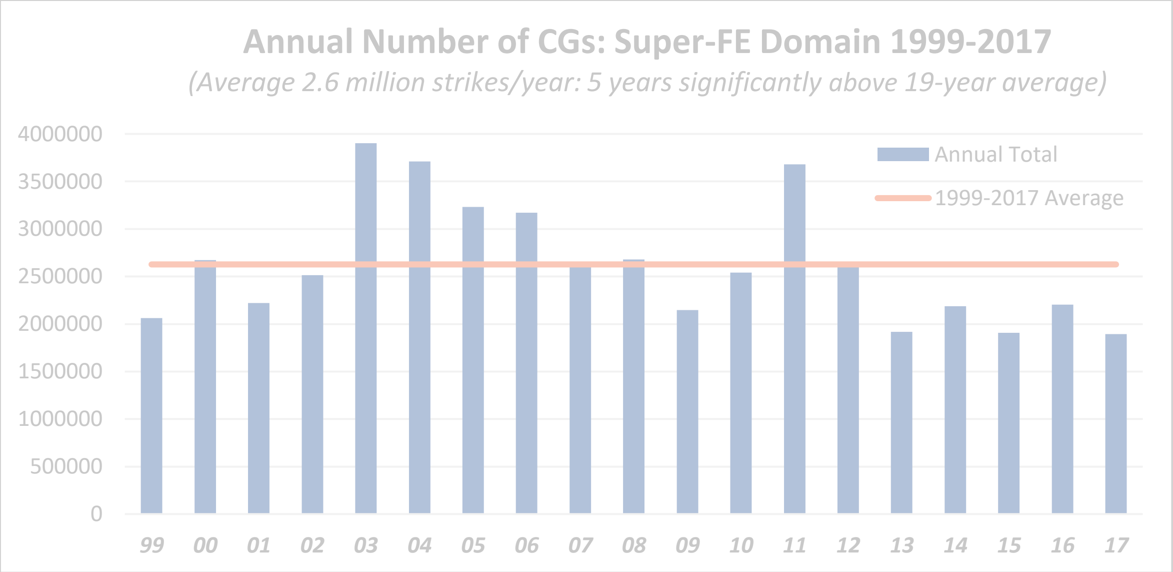
Quick Stats - 1999-2017





(90% CGs are <u><</u> 35-40 kA, only ~8% are positive)





Thank You
(Q&A)

FirstEnergy

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