An Analysis and Climatology of the November 5, 2017 Tornado Outbreak and QLCS Event

Cory Mottice[1], Nick Greenawalt[2], & Zach Sefcovic[2]

[1] National Weather Service – Glasgow, MT

[2] National Weather Service – Cleveland, OH

26th Annual Great Lakes Operational Meteorology Workshop

May 1, 2018

Part I: A Meteorological Overview of the Event and Utilizing NROT to Improve QLCS Tornado Detection

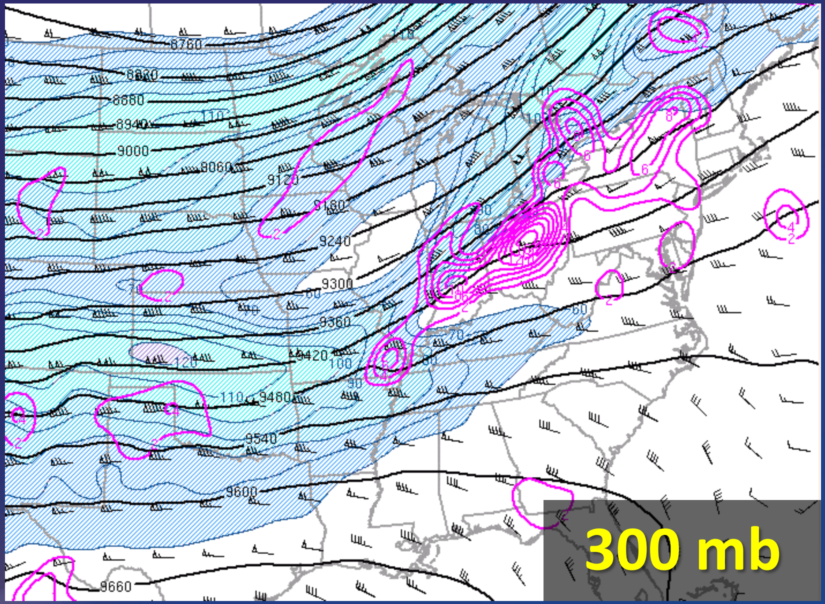
Presented by: Nick Greenawalt

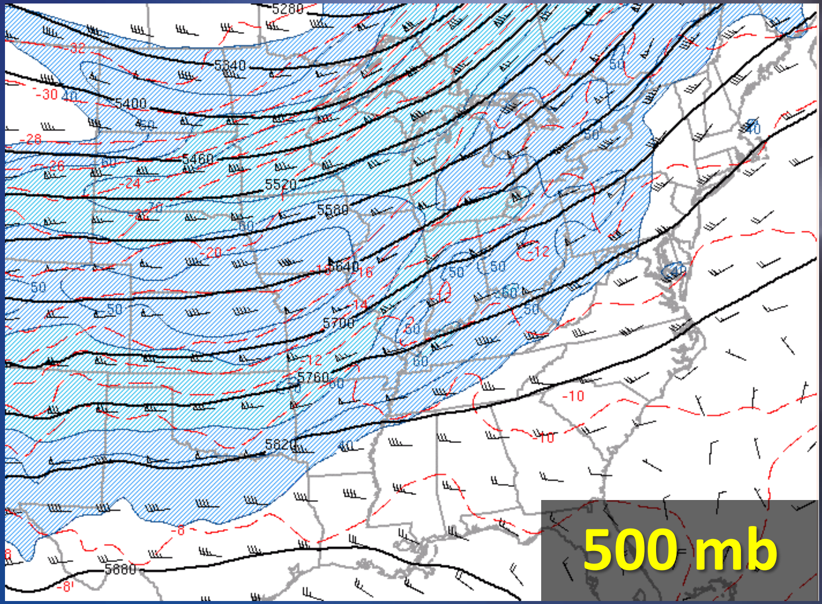
Nov. 5th, 2017 Event Overview

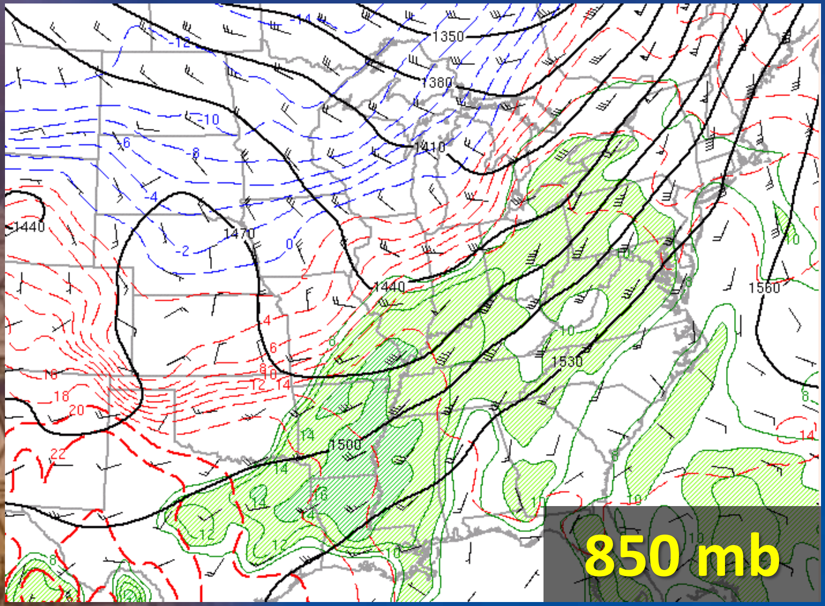
- 14 Confirmed Tornadoes (3 EF-2, 9 EF-1, 2 EF-0)
  - 10/14 had a TDS
  - TDS appeared, on avg, just 1 min after touchdown
- Widespread significant wind damage
  - Macroburst traveled ~110 miles with max width of ~13 miles and max winds of 105 mph (measured)
- Average Echo Top Height of 29,000 feet

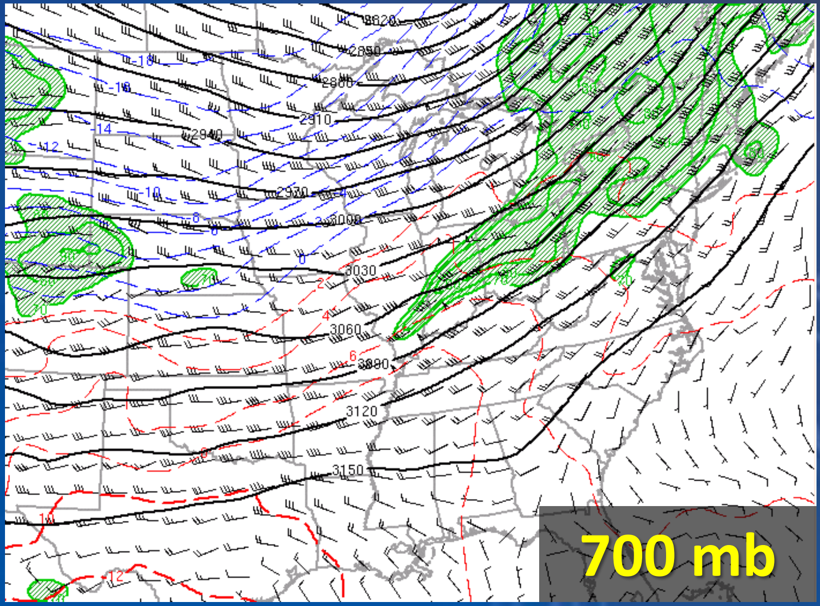
00Z

Upper Analysis

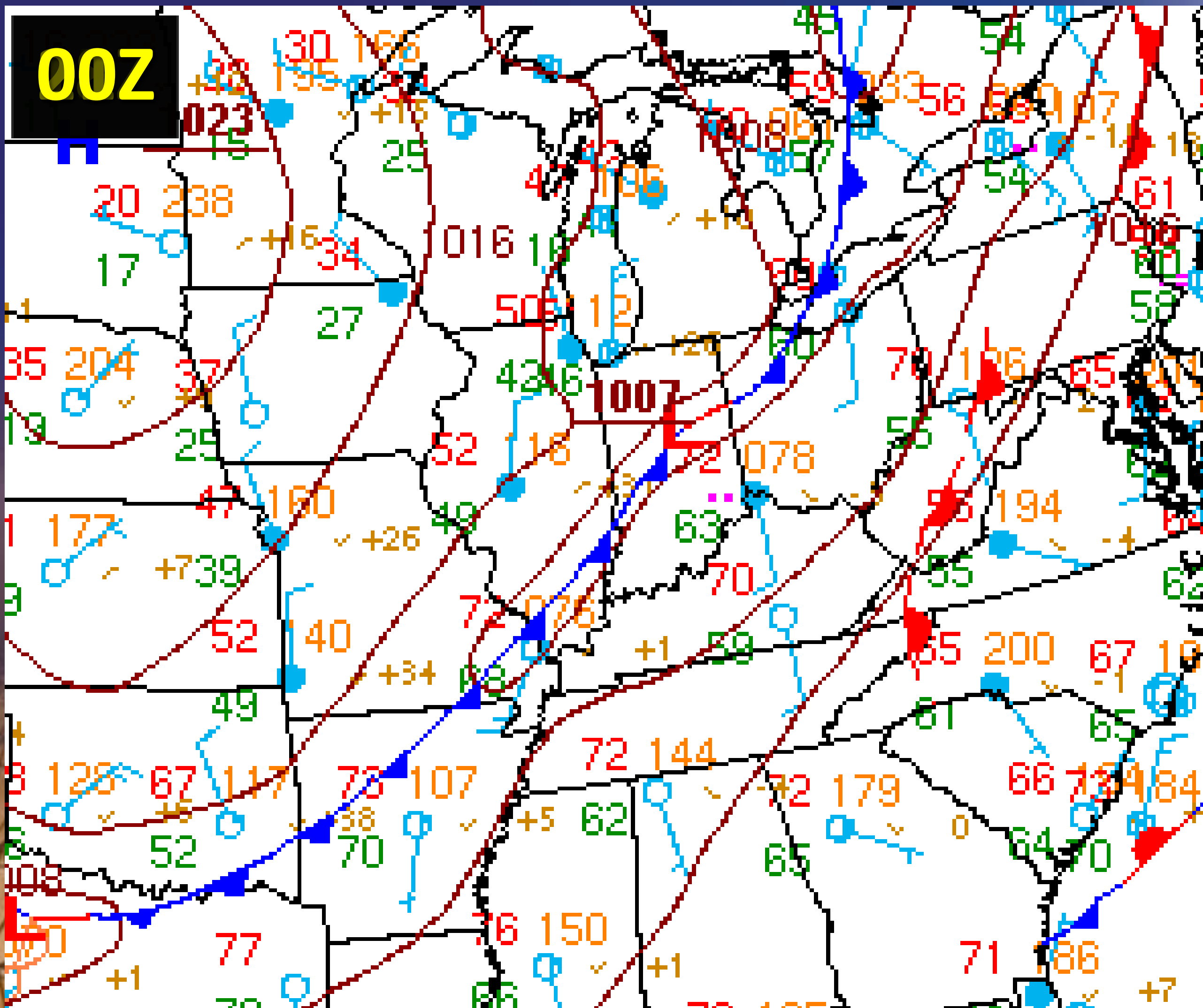






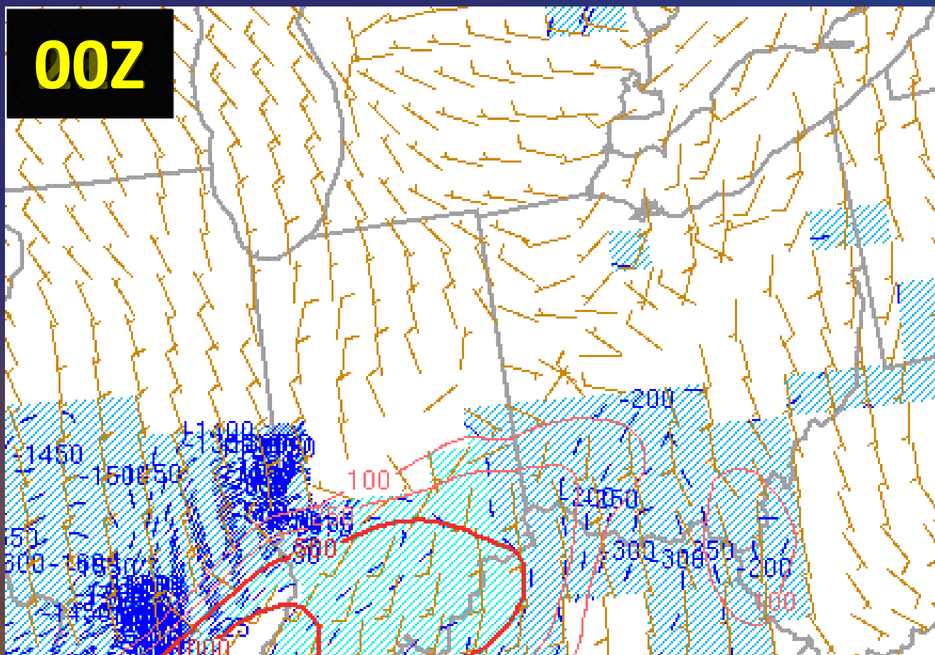


Surface Analysis



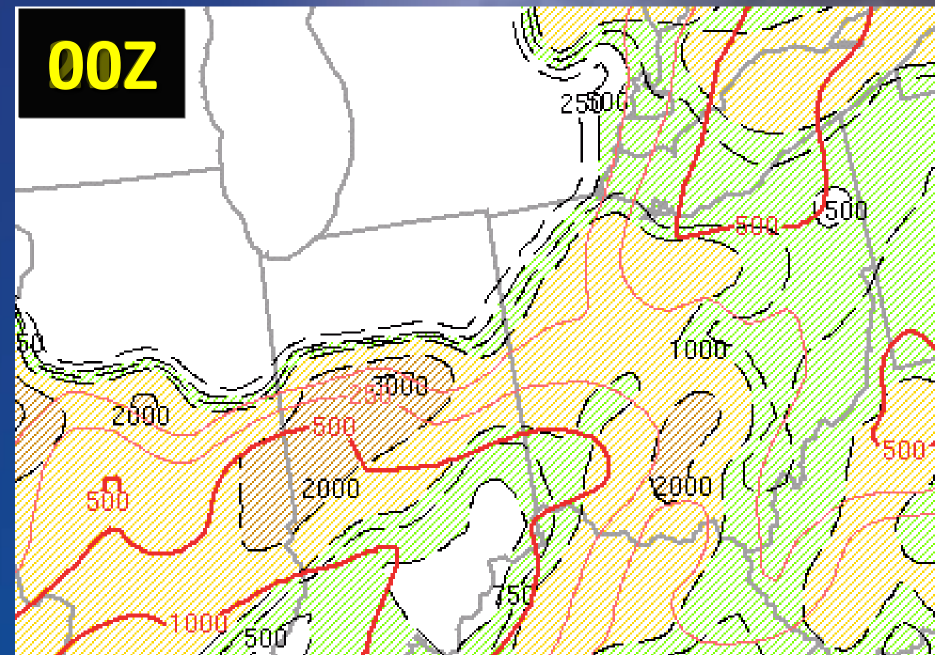
Region fully entrenched in the warm sector, cold front approaches from the west

Surface Based CAPE



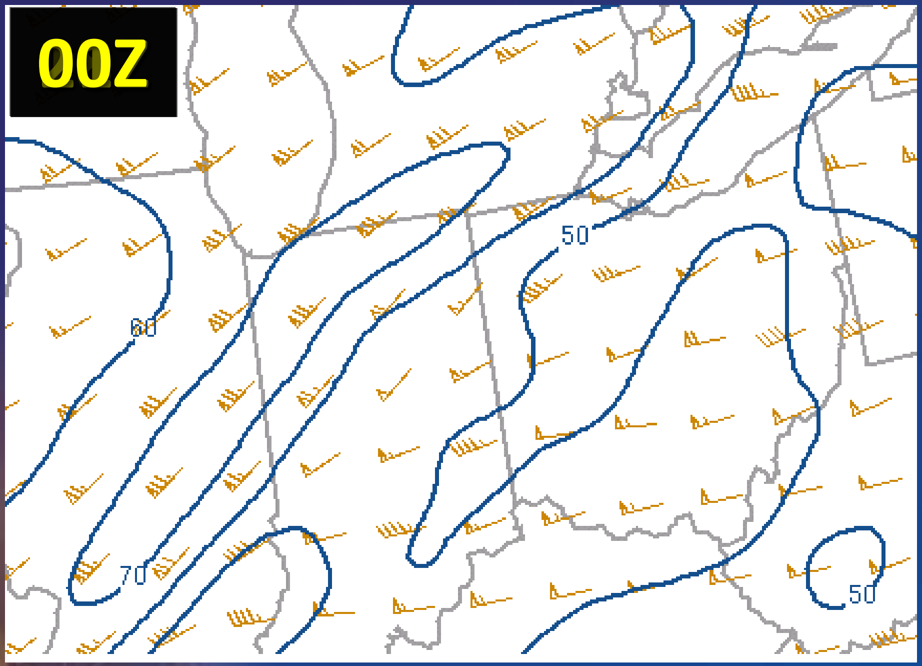
500-1000 j/kg peak in the early afternoon, stabilization into the evening

Most Unstable CAPE



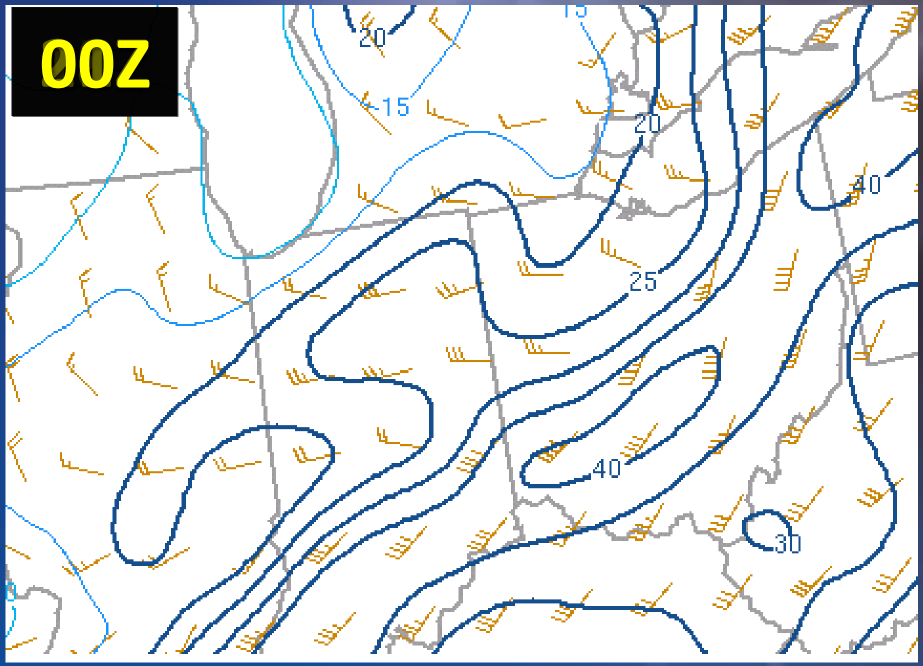
500-1000 j/kg peak in the early afternoon, similar values to SBCAPE

0-6 km Bulk Shear



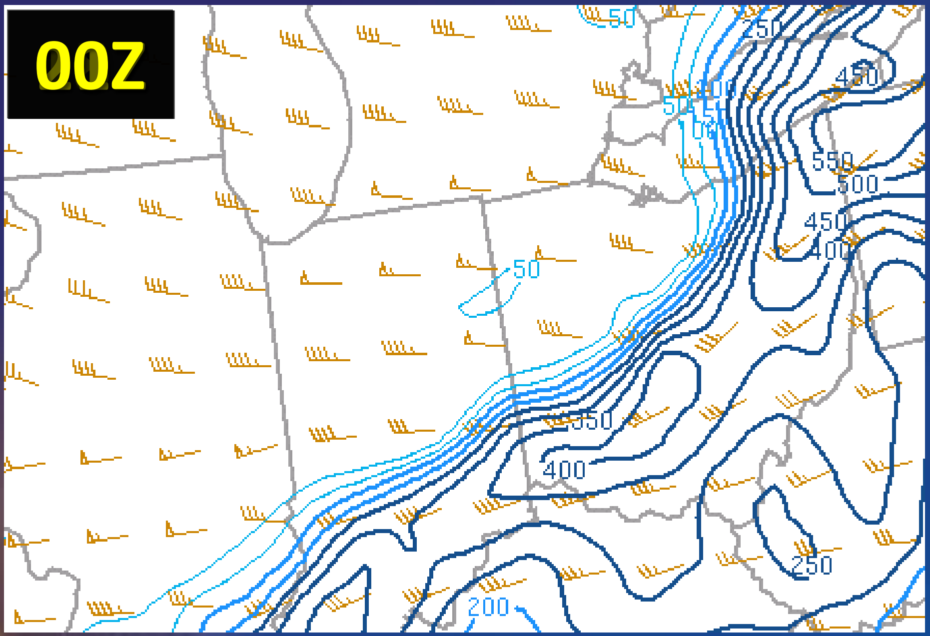
40 kts mid day increasing to 50-55 kts through early evening

0-1 km Bulk Shear



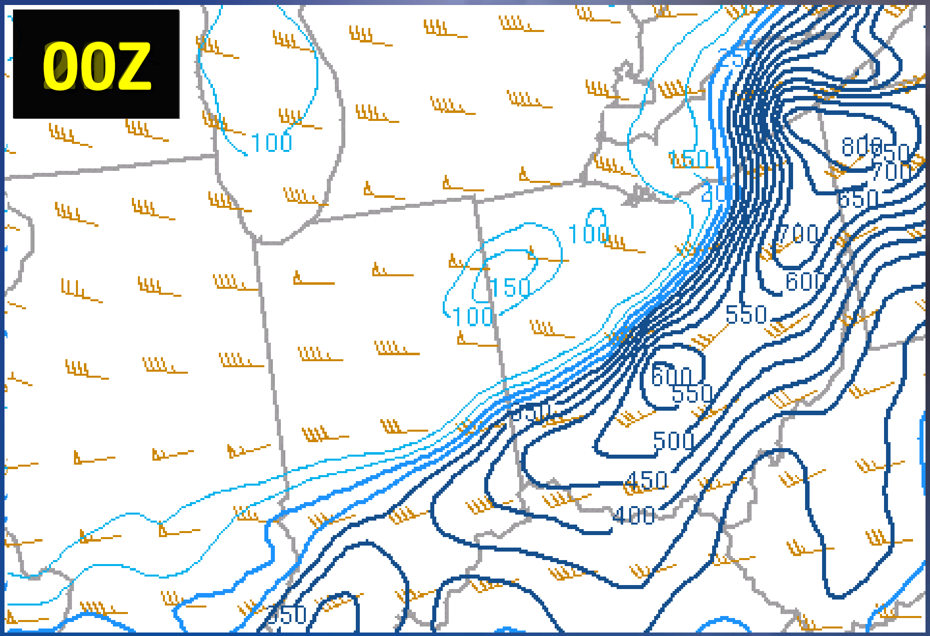
25 kts mid day, rapidly increases to 40-45 kts by early evening

0-1 km SRH



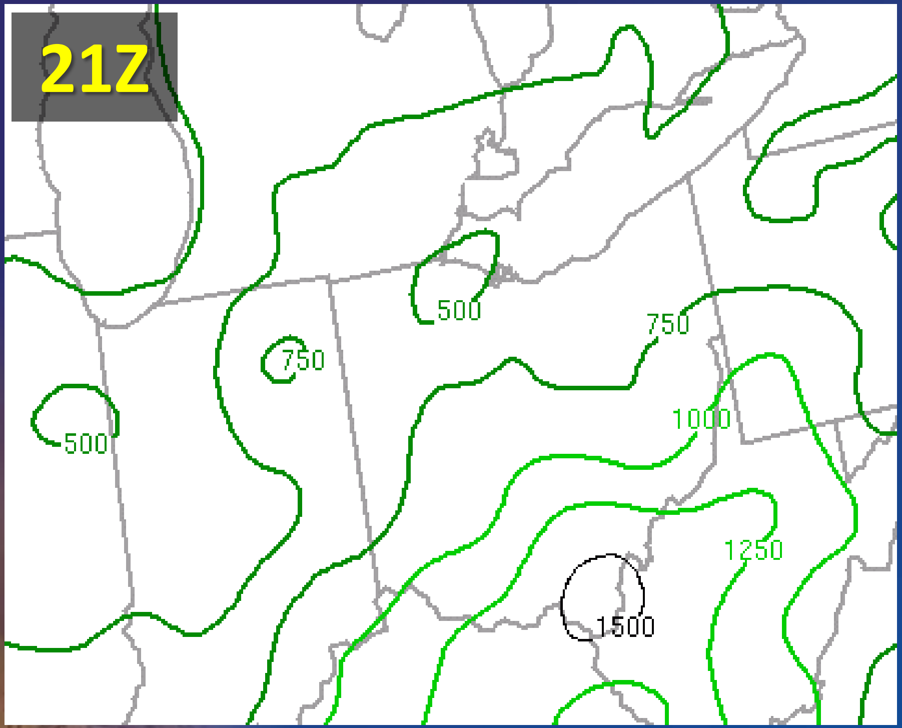
Increases to 400-500 m2/s2 through the afternoon

0-3 km SRH



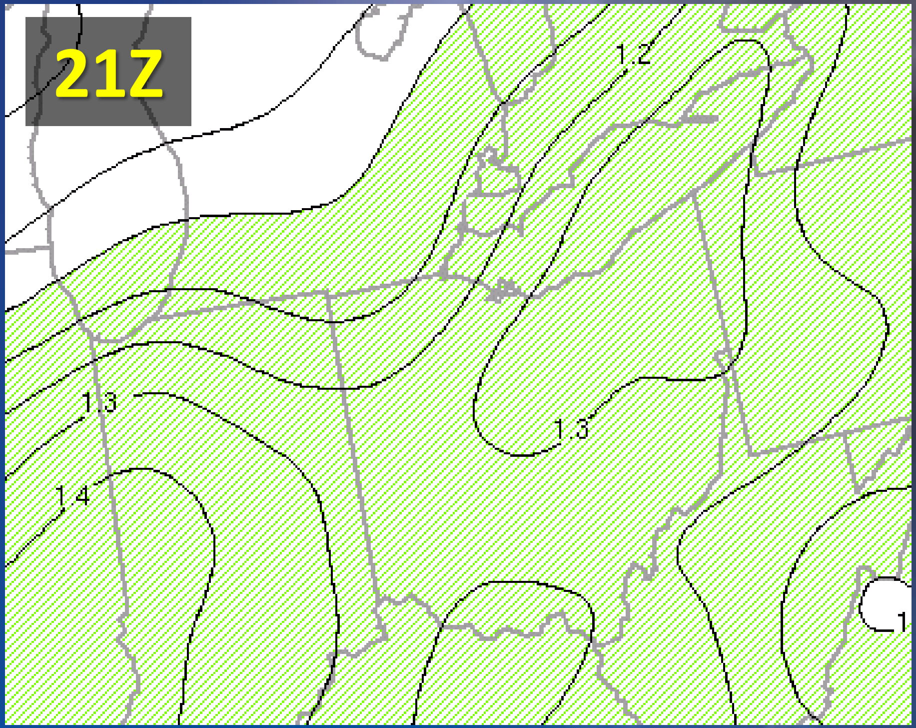
Increases to 550-800 m2/s2 through the afternoon/evening

LCL Height



500 m to 750 m through the afternoon and evening

Precipitable Water

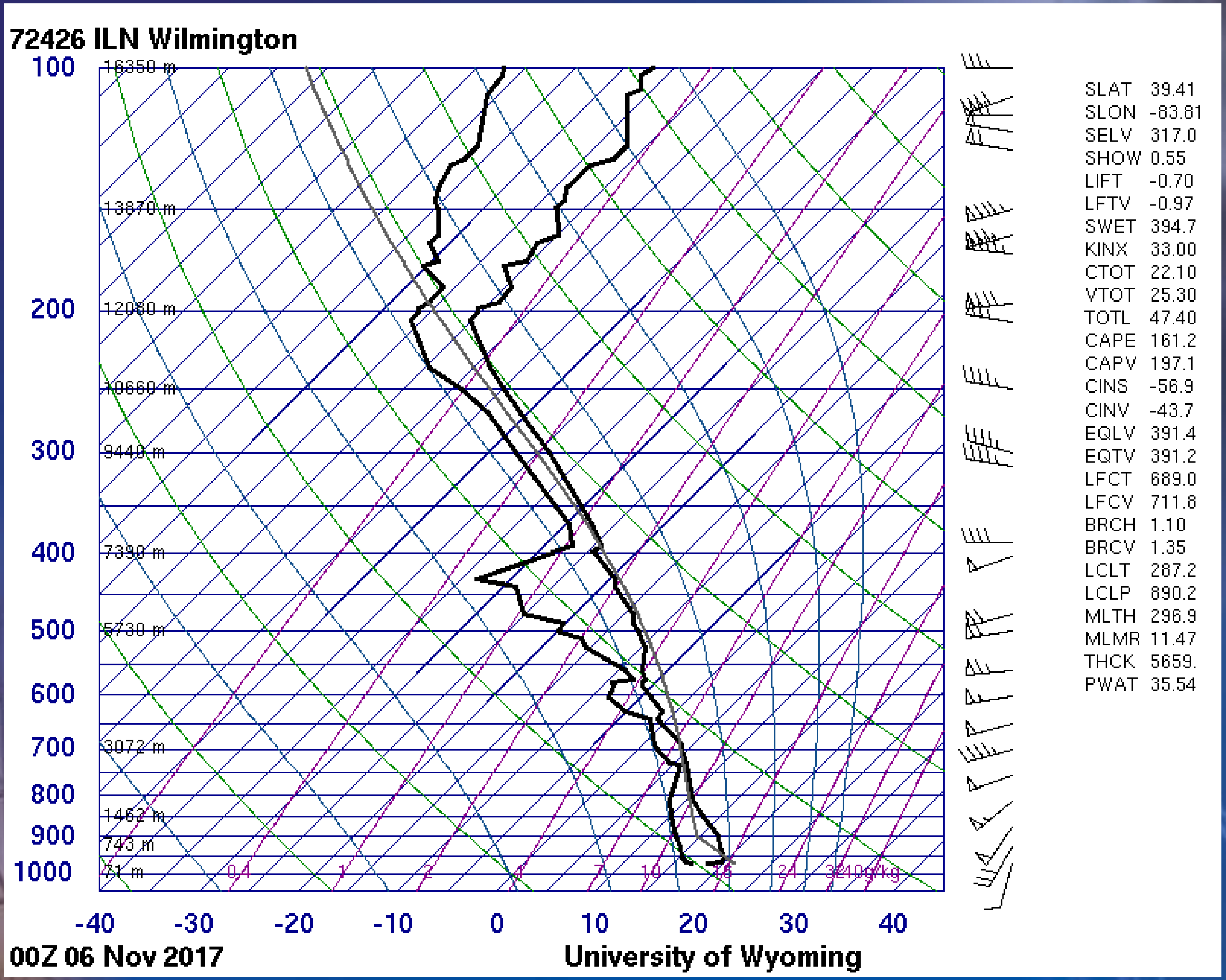


1.3 inches

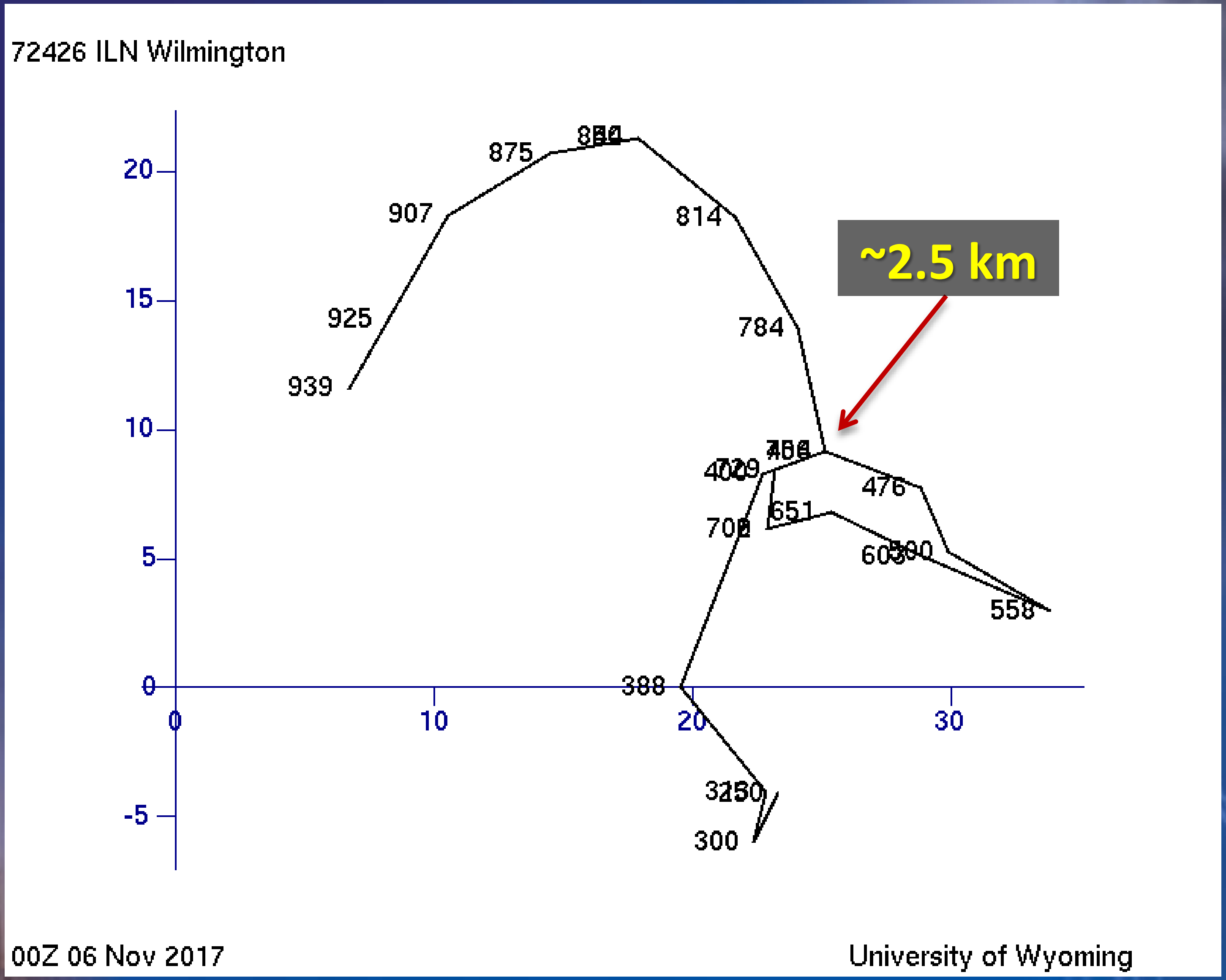
Approaching climatological maximum PWAT values for this time of year

ILN RAOB 00Z 2017Nov06: 1.4 inches

Sounding – ILN RAOB 00Z 2017Nov06



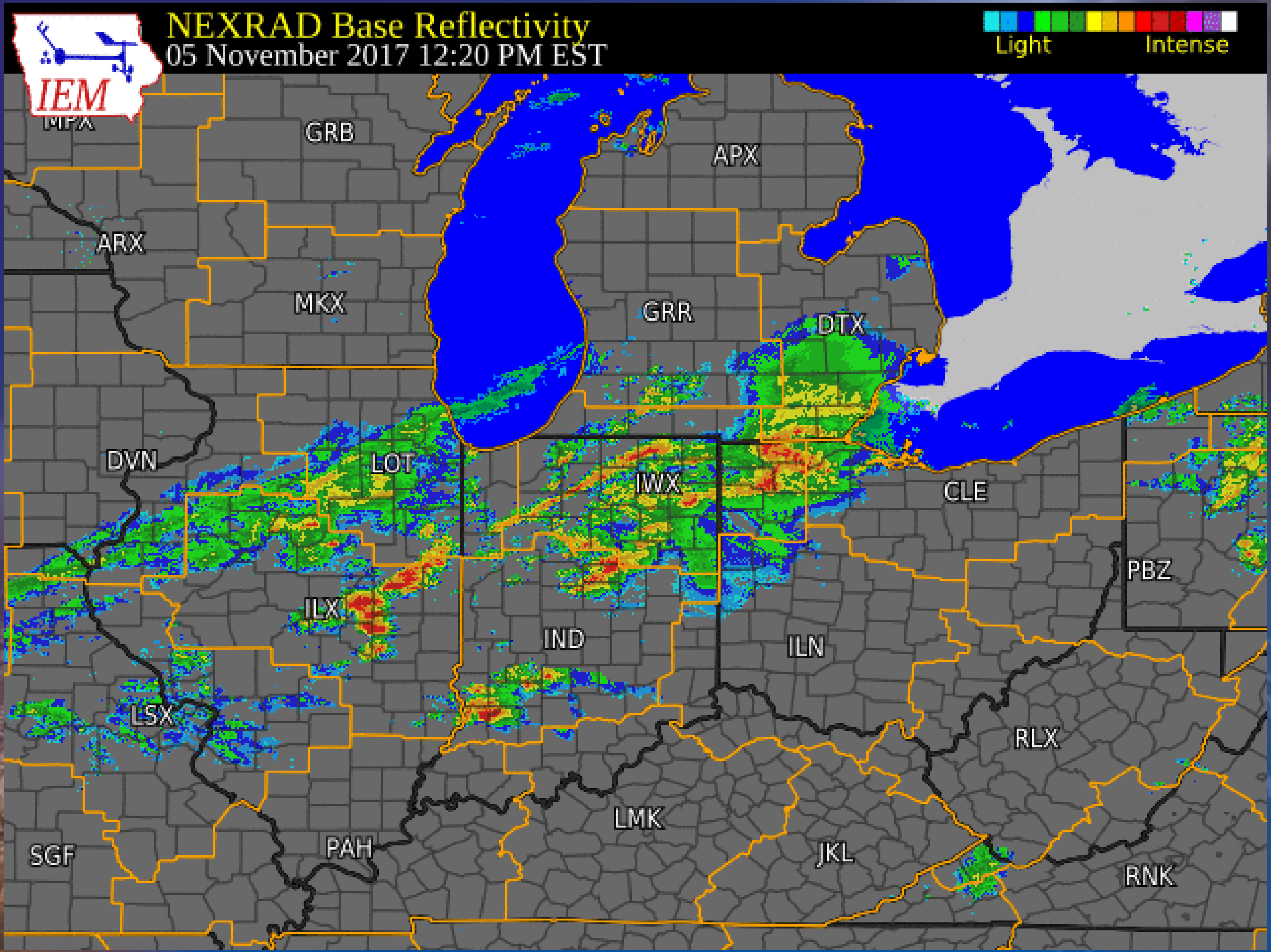
Hodograph – ILN RAOB 00Z 2017Nov06



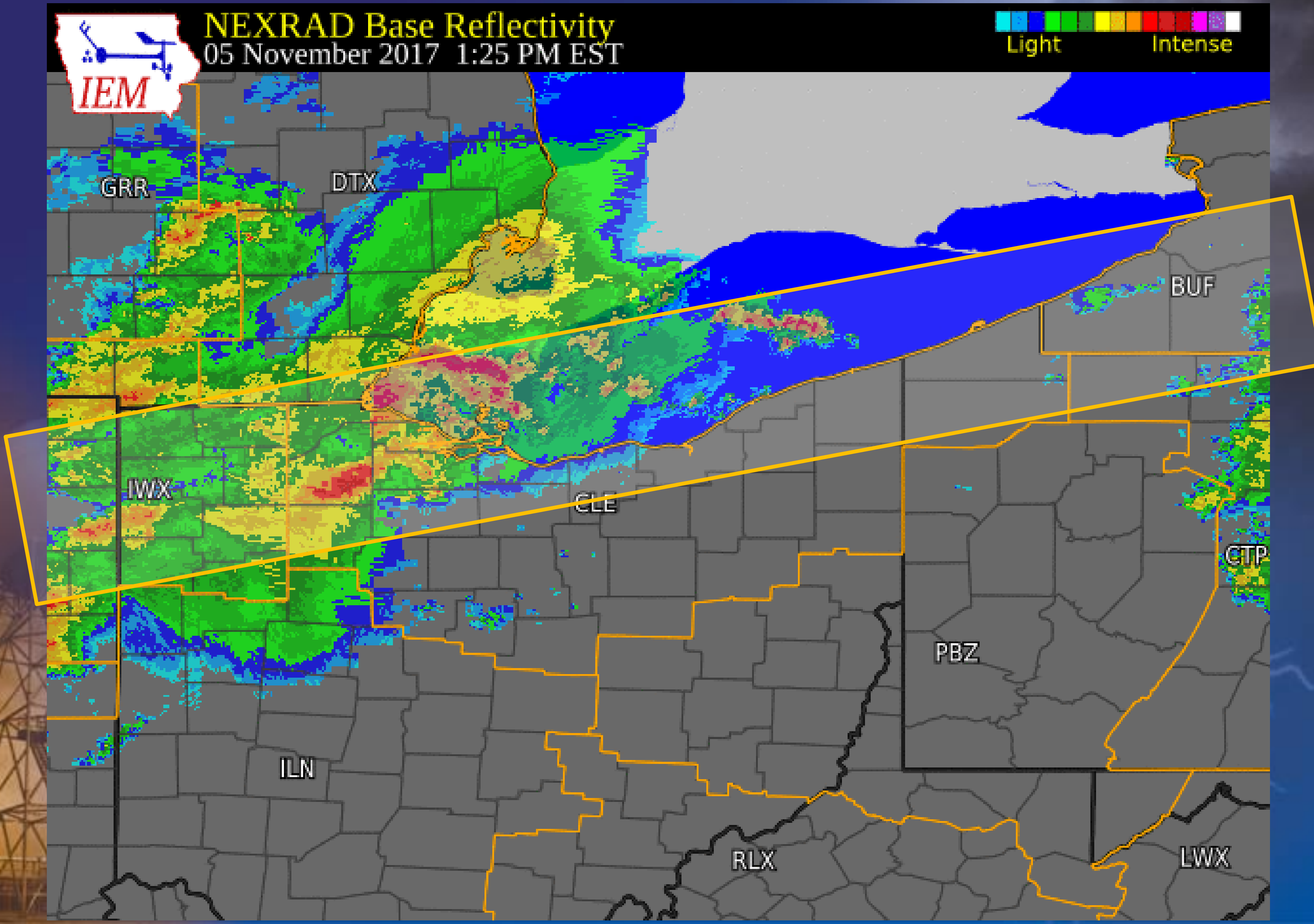
Low CAPE – High Shear QLCS Tornadoes

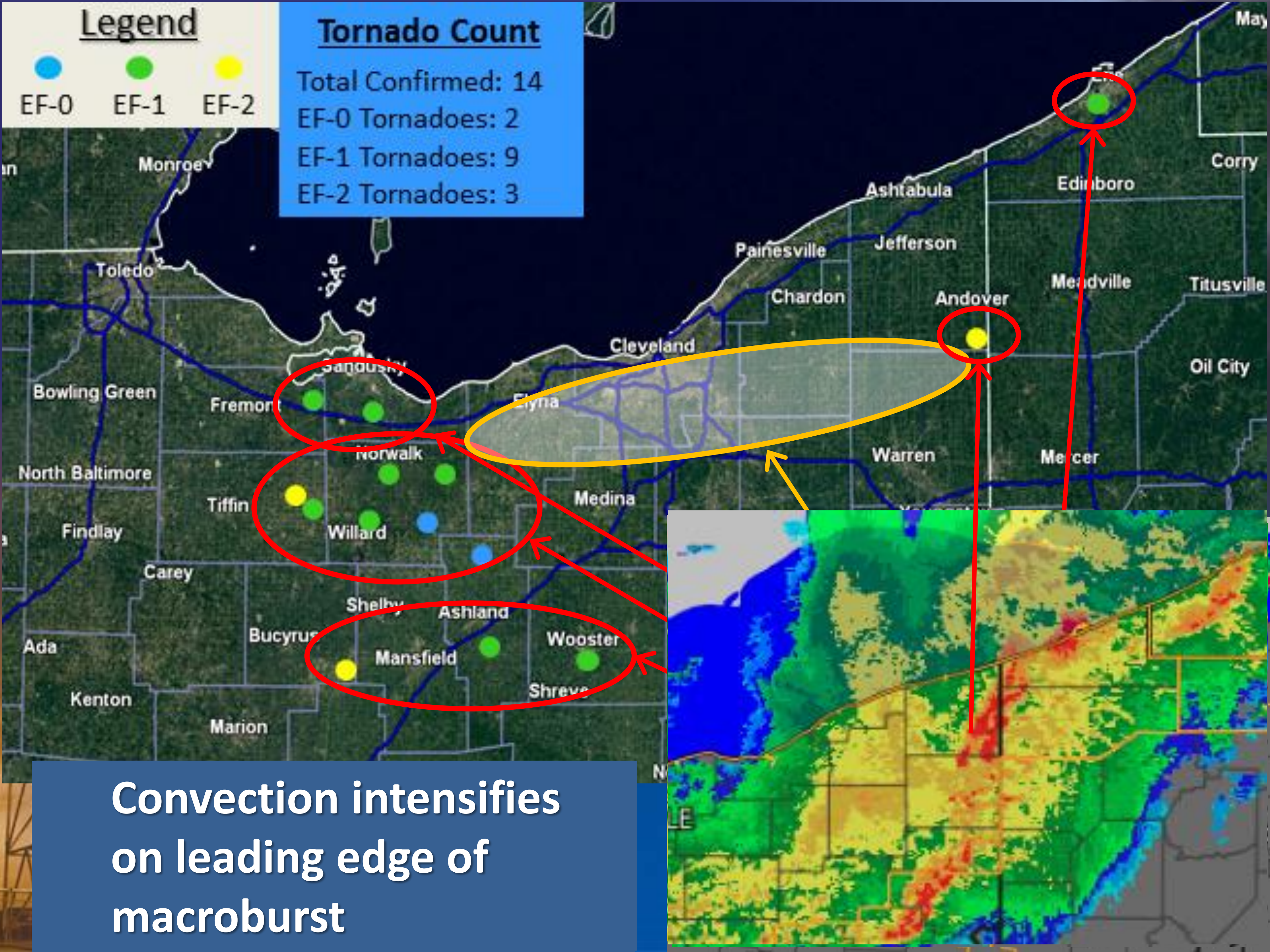
Parameter	WFO PAH Cool Season QLCS Tornado Study	November 5th, 2017
SBCAPE	100-600 j/kg	500-1000 j/kg
MUCAPE	300-800 j/kg	500-1000 j/kg
0-1 km Bulk Shear	15-25 kts	40-45 kts
0-6 km Bulk Shear	30-40 kts	50-55 kts
ML LCL	500-800 m	500-750 m
0-1 km SRH	200-550 m2/s2	400-500 m2/s2
0-3 km SRH	250-650 m2/s2	550-700 m2/s2

Radar Evolution



Influence of the Mesoscale Convective Vortex

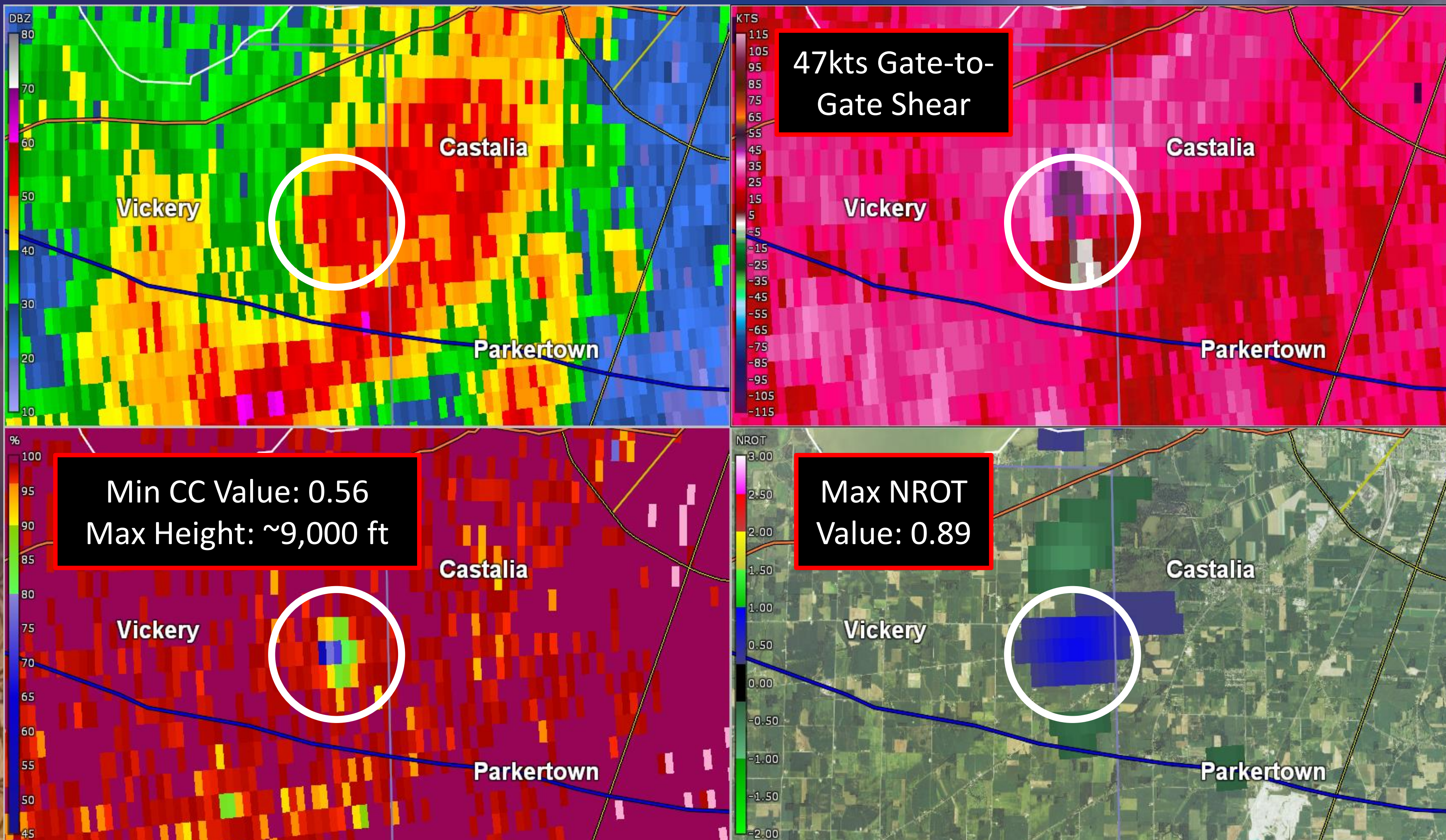




Convection intensifies on leading edge of macroburst

First Tornado (EF-1) – Sandusky County

2:23 PM EST [100 mph – 50 yards wide – 1.3 mile path length]



Multiple Tornadoes (EF-1) – Huron County

5:00 – 5:02 PM EST

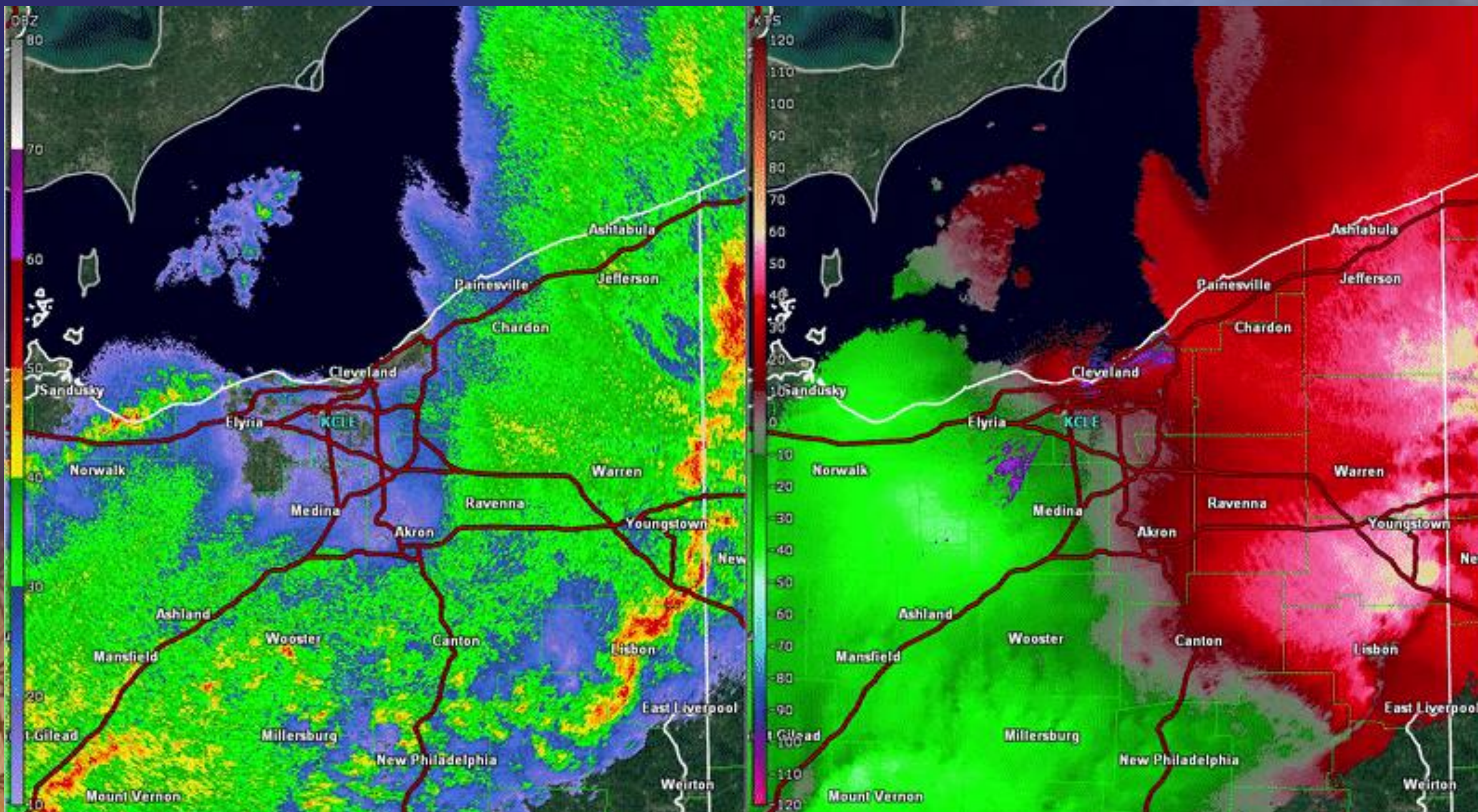
* Debris signature cluttered from debris from earlier tornado.

Hayesville Tornado (EF-1) – Ashland County

5:31 PM EST [110 mph - 200 yards wide - 2 mile path length]

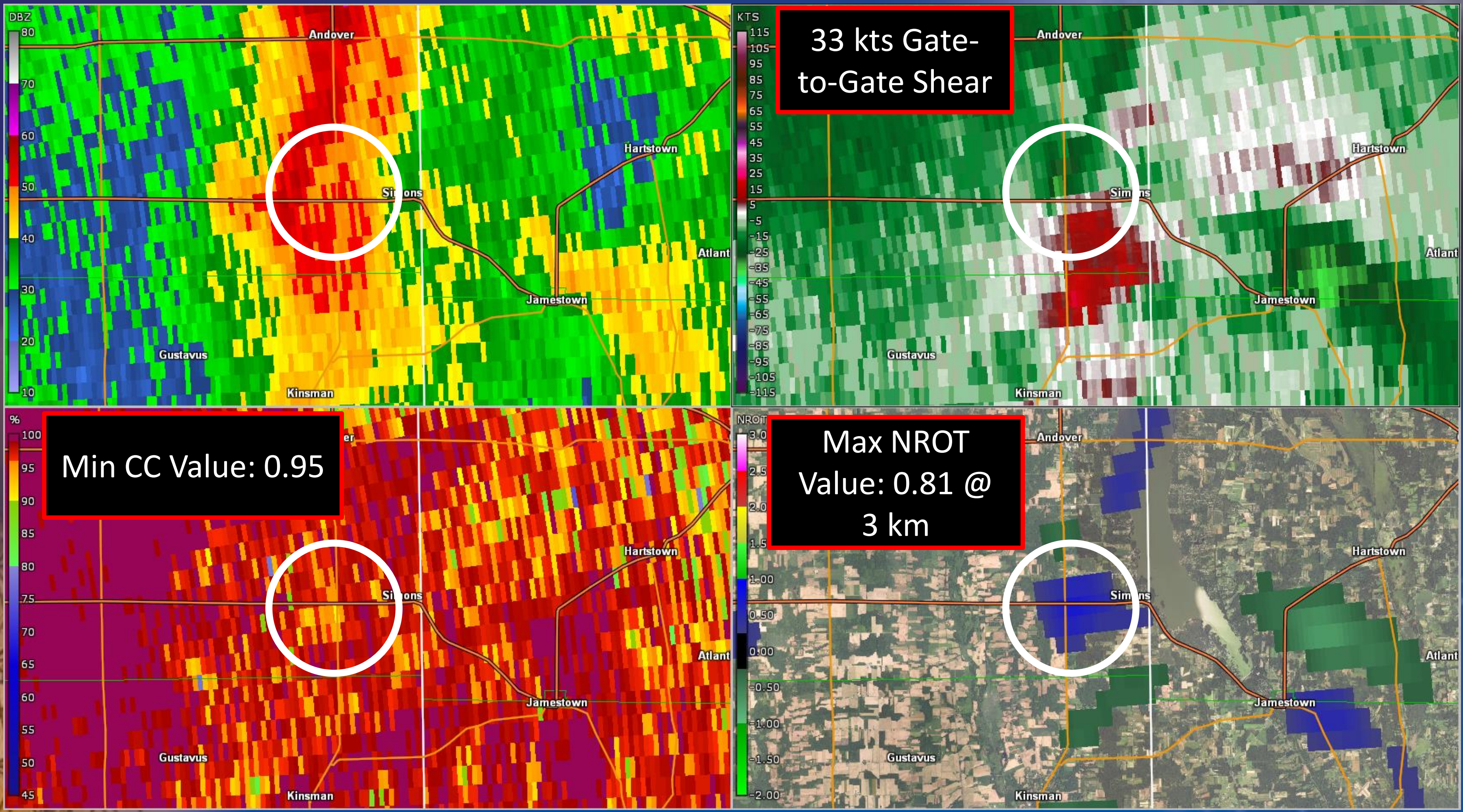
105 mph Macroburst

5:25 PM – 7:10 PM EST [traveled ~110 mi with a max width of ~13 mi]



Williamsfield Tornado (EF-2) – Ashtabula County

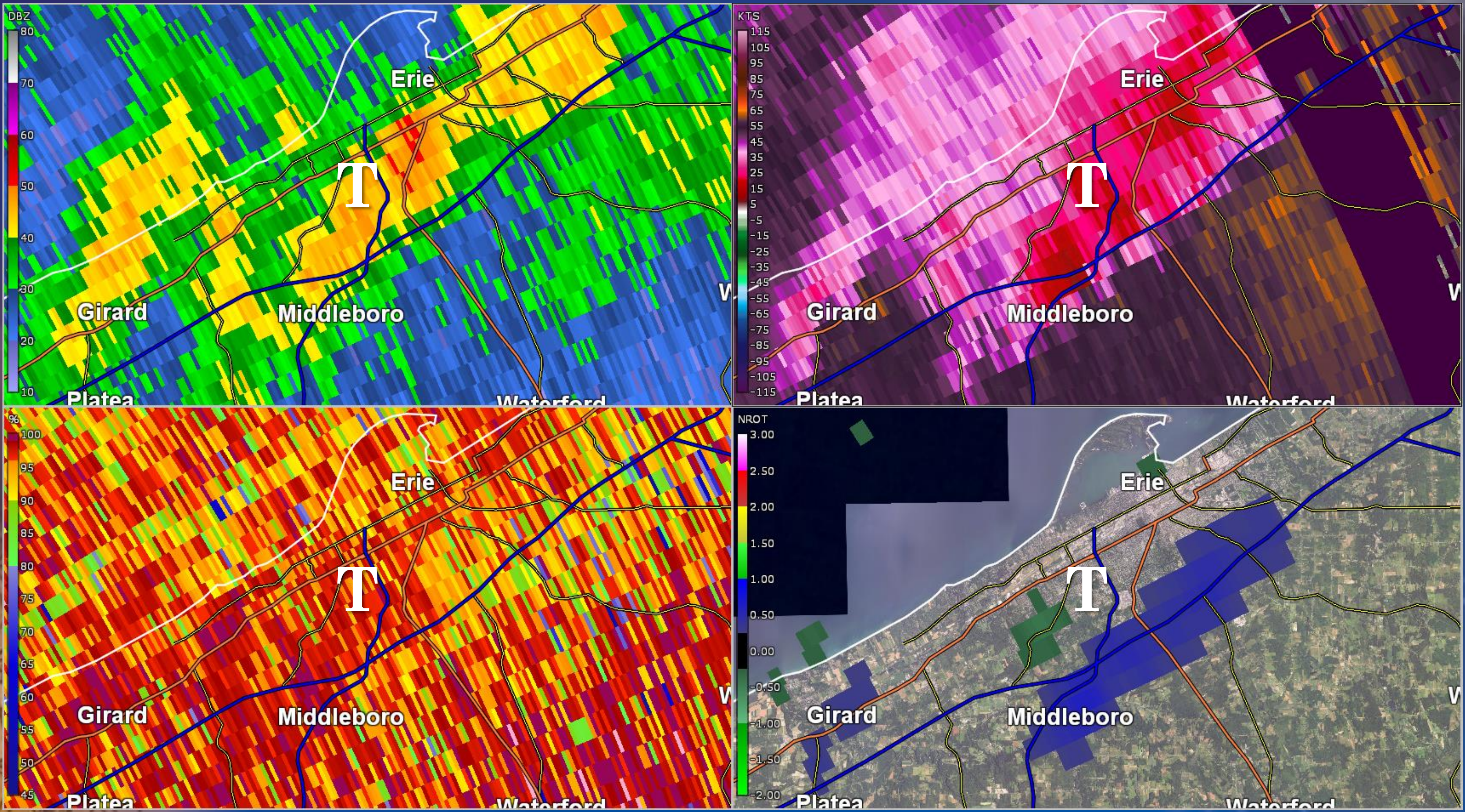
6:51 PM EST [127 mph - 200 yards wide – 6.7 mile path length]



Williamsfield Tornado (EF-2) – Ashtabula County

6:51 PM EST [127 mph - 200 yards wide – 6.7 mile path length]

There is a tornado ongoing at this time - Can you find it?

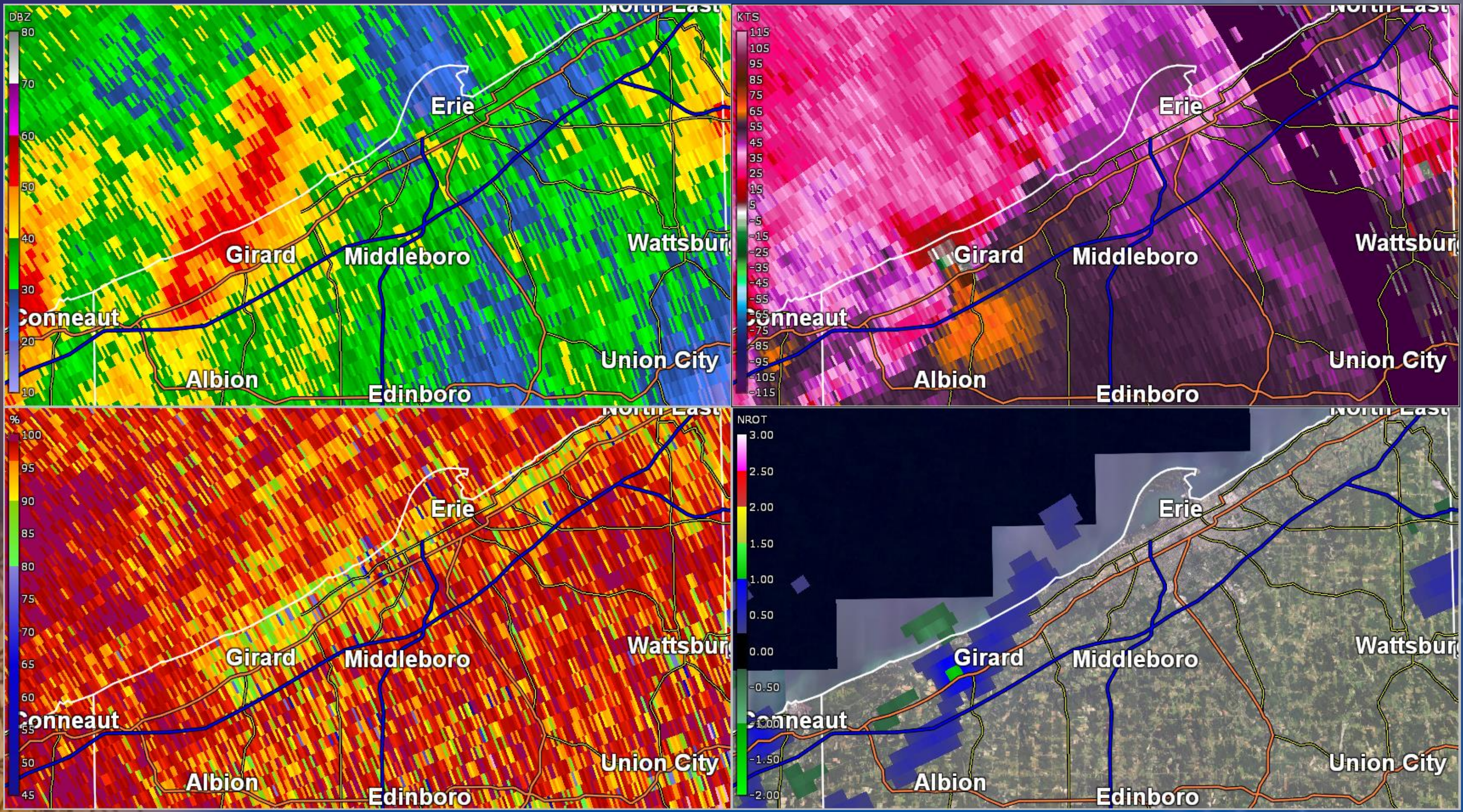


Erie, Pennsylvania 6:05 PM [90 mph – 100 yards wide – 2.4 mile path length]

Erie County PA Tornado (EF-1)

6:05 PM EST [90 mph - 100 yards wide – 2.4 mile path length]

NO tornado/damage occurred with this signature about 20 minutes later…



Observational Challenges Across NW PA

- Erie, PA is ~103 miles away from the KCLE radar and ~92 miles away from KBUF
- Minimum beam height ~10,000 ft
  - Most important part of storms not visible
- Sparse population outside of Erie -> lack of real time reports

Operational Considerations

- Real-time damage reports were limited
  - Tornadoes were difficult to see/rain wrapped
  - Event ramped up around/shortly after sunset
- Volume of phone calls was overwhelming at times
  - Only so many people can answer phones at any given time, 3 people were dedicated to this
  - Emphasis on reporting through digital means, especially delayed/marginal reports

Operational Considerations

- Sectorized warning operation strategy
  - 3 warning forecasters
  - Fast moving storms
  - Weaker/transient velocity couplets
  - Large area of widespread wind damage
- Event coordinator and mesoanalyst positions are critical during high-end, widespread and/or long-duration events

Normalized Rotation (NROT) Research

Motivation Behind This Study

- *Weak tornadoes (EF-0/EF-1) make up ~77% of all tornadoes.*
- *High rates of false alarm ratio and minimal lead time are primarily associated with these weak tornadoes due to their difficulty to detect on radar and short lifespan.*

Normalized Rotation (NROT) Research

Purpose

- *To assess the utility of the GR2 NROT parameter in aiding in the tornado warning decision for weaker tornadoes.*

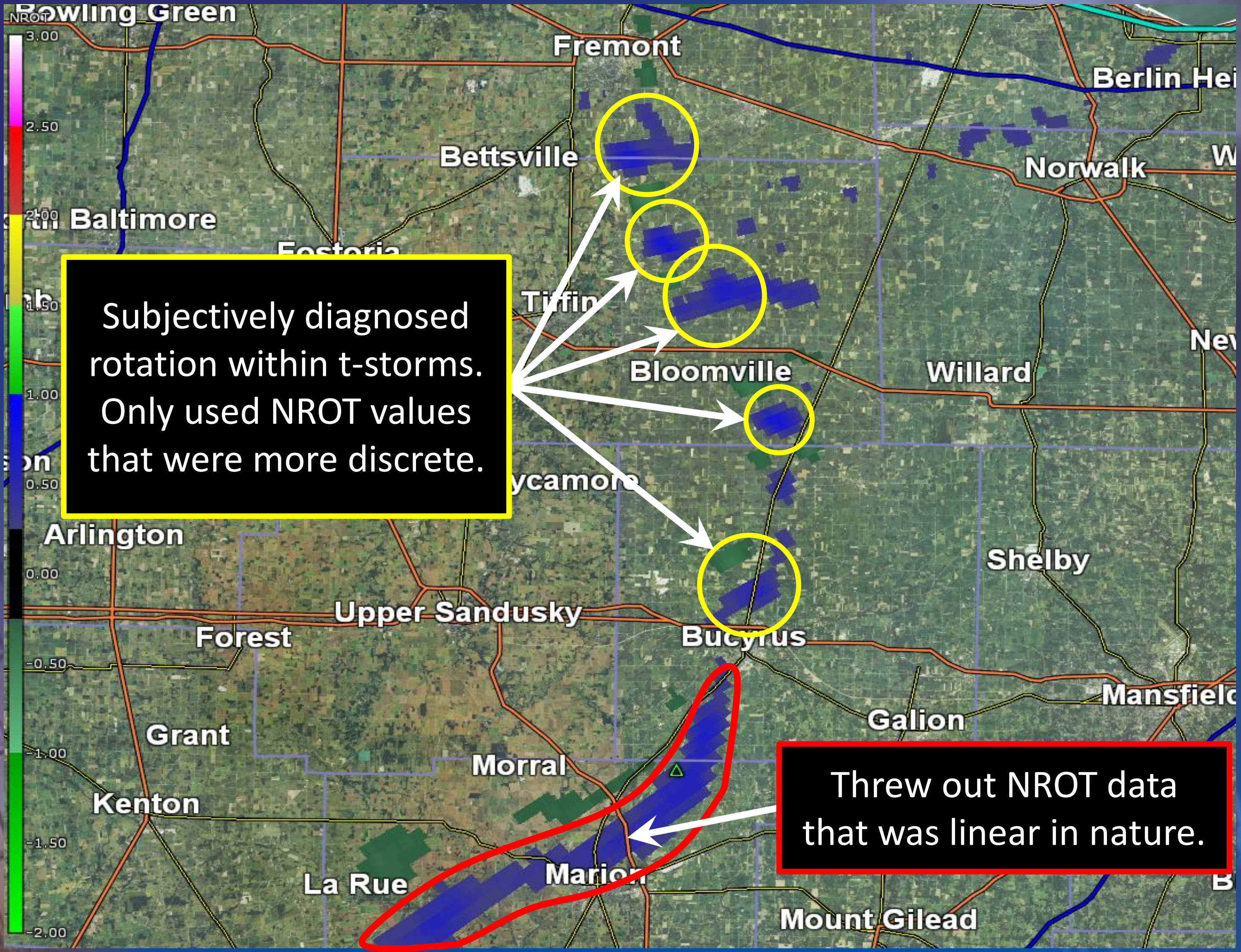
Goal

- *To determine a value of NROT associated with tornadogensis and determine if there is a pattern in the evolution of the NROT value leading up to the time of a tornado.*

Normalized Rotation Criteria Used

- Only used NROT values that were more discrete in nature (subjective)
  - NROT data must match up with a velocity signature
- Threw out NROT values that were linear in nature
- Did not use data beyond 80 NM from the radar
- Did not use data over water
  - Includes storms that originated over the water and then moved on land

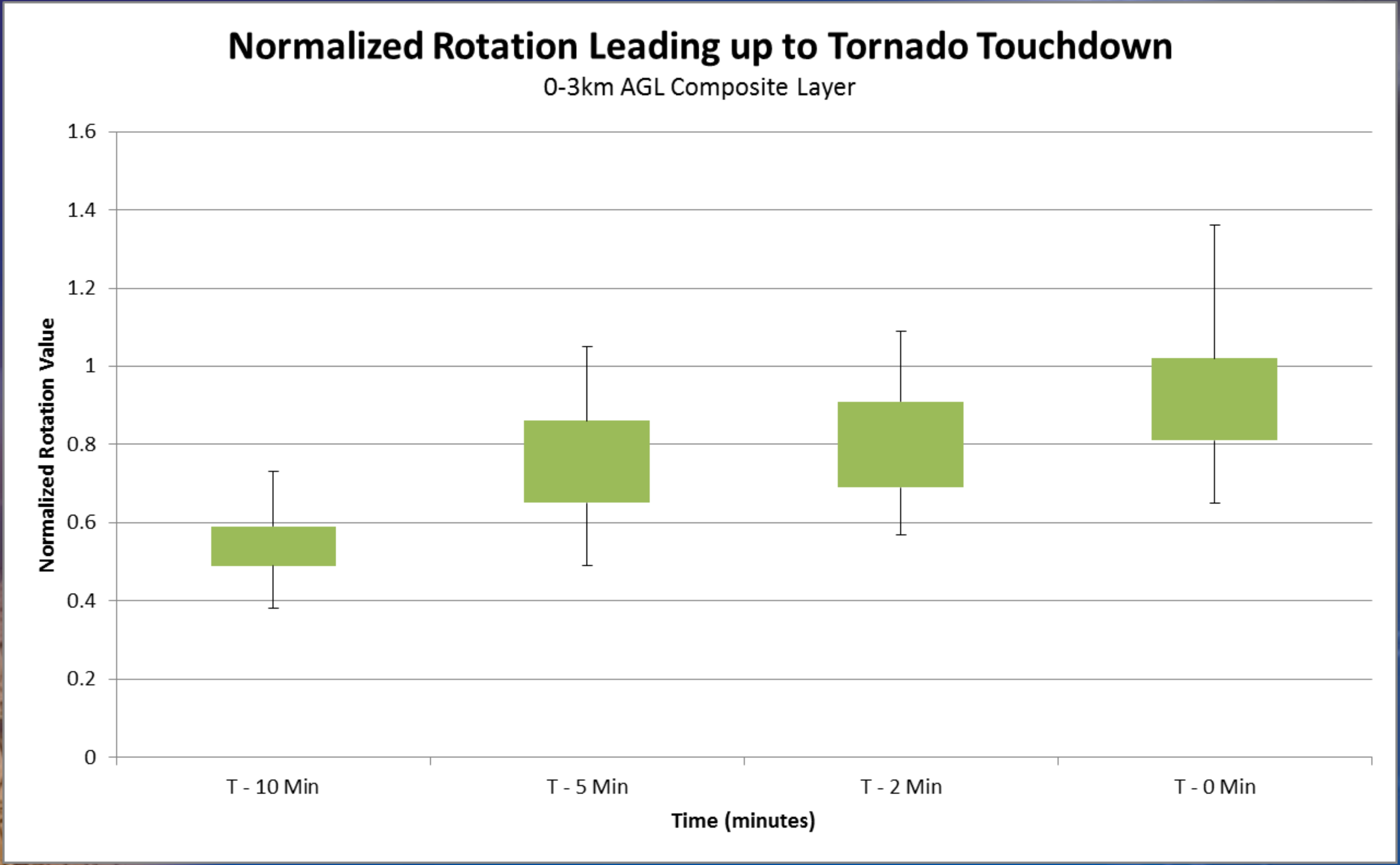
Normalized Rotation Criteria Examples



Process for Gathering Data

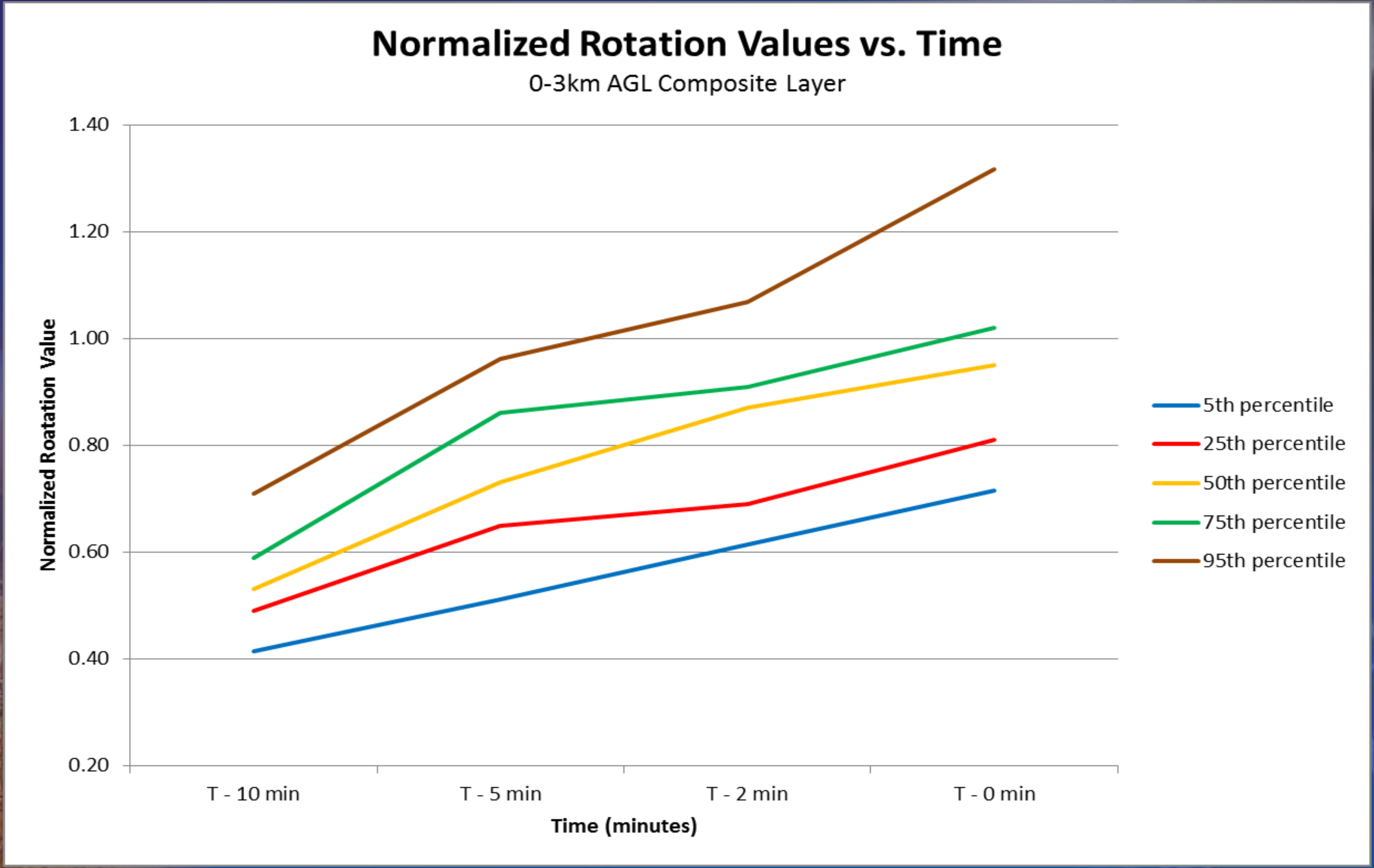
- Went through entire event scan by scan
  - Included all scans that were within 0-3 km AGL and used max NROT value from all tilts
- For every instance of a discrete max NROT value above certain thresholds, it was determined whether or not that area of rotation led to a tornado within 10 minutes
  - If it did, counted as a hit
  - If it did not, counted as a miss

Normalized Rotation Values vs. Lead Time



Normalized Rotation Values vs. Lead Time

(Percentiles)



Normalized Rotation Values vs. Time

(Percentiles)

Data from Previous Chart

Lead Time (min)	25% of Tornadoes	50% of Tornadoes	75% of Tornadoes	95% of Tornadoes
10	0.59	0.53	0.49	0.42
5	0.86	0.73	0.65	0.51
2	0.91	0.87	0.69	0.61
0	1.02	0.95	0.81	0.72

Can determine a threshold for Normalized Rotation that would capture a certain percentage of tornadoes.

Significant decrease in FAR between 0.7 and 0.8. Limited data in this event for values 1.00 and above.

NROT False Alarm Ratio

NROT Value	FAR
0.42 - 0.49	84%
0.50 - 0.59	65%
0.60 - 0.69	55%
0.70 - 0.79	38%
0.80 - 0.99	10%
1.00 and Up	12%

Normalized Rotation Values vs. Time

(How to Interpret)

0-3km AGL Normalized Rotation Composite Percentiles and Lead Times

Lead Time (min)	25% of Tornadoes	50% of Tornadoes	75% of Tornadoes	95% of Tornadoes
10	0.59	0.53	0.49	0.42
5	0.86	0.73	0.65	0.51
2	0.91	0.87	0.69	0.61
0	1.02	0.95	0.81	0.72

NROT False Alarm Ratio

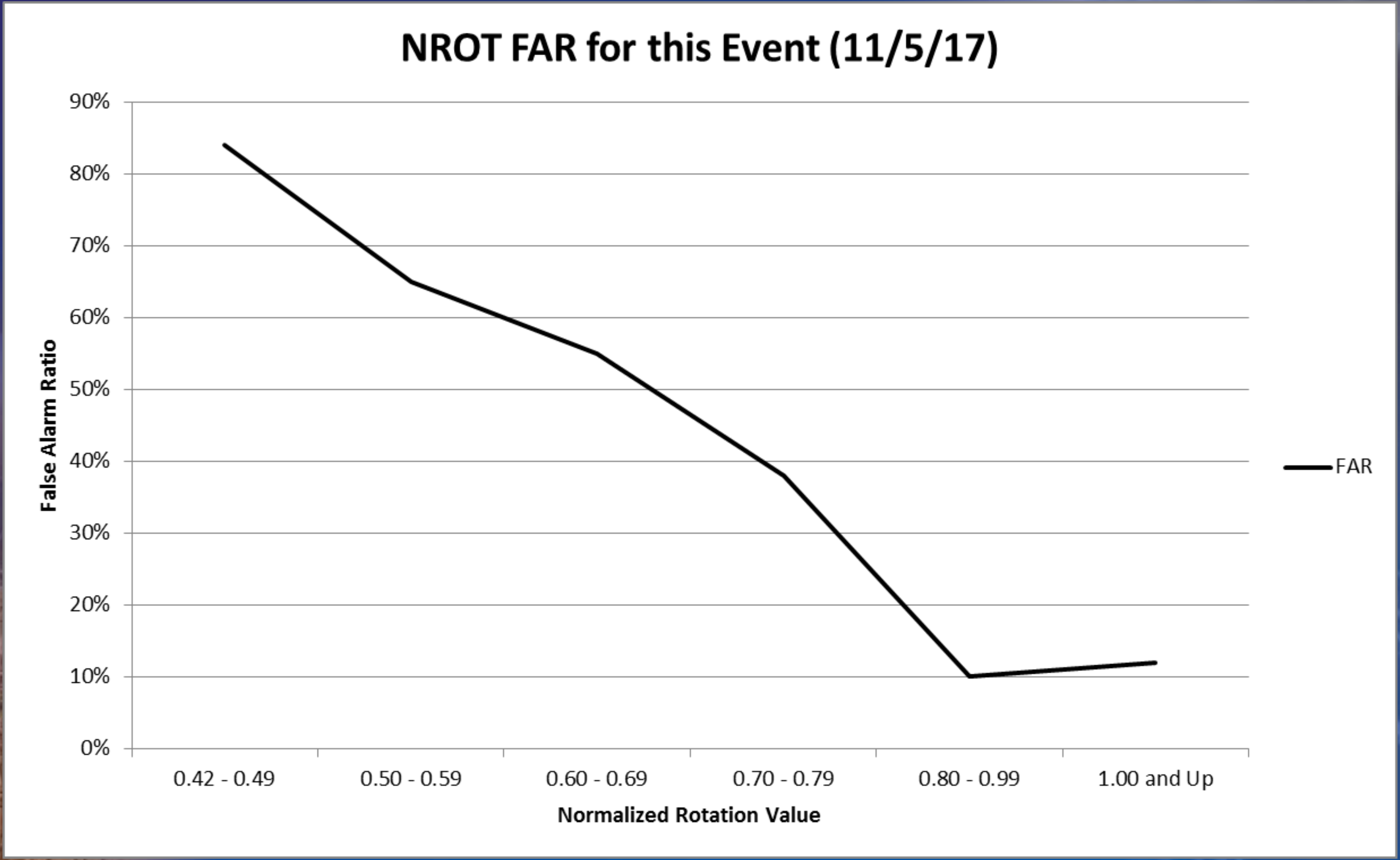
NROT Value	FAR
0.42 - 0.49	84%
0.50 - 0.59	65%
0.60 - 0.69	55%
0.70 - 0.79	38%
0.80 - 0.99	10%
1.00 and Up	12%

To capture 50% of tornadoes with a 10 min lead time you would use the NROT value of 0.53. → This leads to a false alarm ratio (FAR) of ~65%.

To capture 50% of tornadoes with a 5 min lead time you would use the NROT value of 0.73. → This leads to a false alarm ratio (FAR) of ~38%.

Normalized Rotation False Alarm Ratio

(For the Nov. 5th, 2017 Event Only)



Initial Key Findings on NROT for QLCS Tors

All below findings assume storms are located in a favorable tornadic environment and that the NROT values are discrete in nature and match up with a velocity signature.

Values 0.5 – 0.6 →
Start paying attention to storm for possible tornadic development.

Values 0.6 – 0.7 →
Monitor storm closely as a tornado may develop within next 5 min.

Values ≥ 0.8 →
Tornado possible at anytime.

**NROT data should only be used as another tool to help during issuance of tornado warnings. Tornado warnings should NOT be issued solely based on this data.

What's Next?

- Expand dataset to include many more QLCS events/tornadoes
  - Primarily across the Eastern US with high shear/low CAPE environments
- Break apart data set to evaluate NROT for different seasons
- Get composite NROT (0-3km) values into AWIPS
- Create custom color curve for NROT

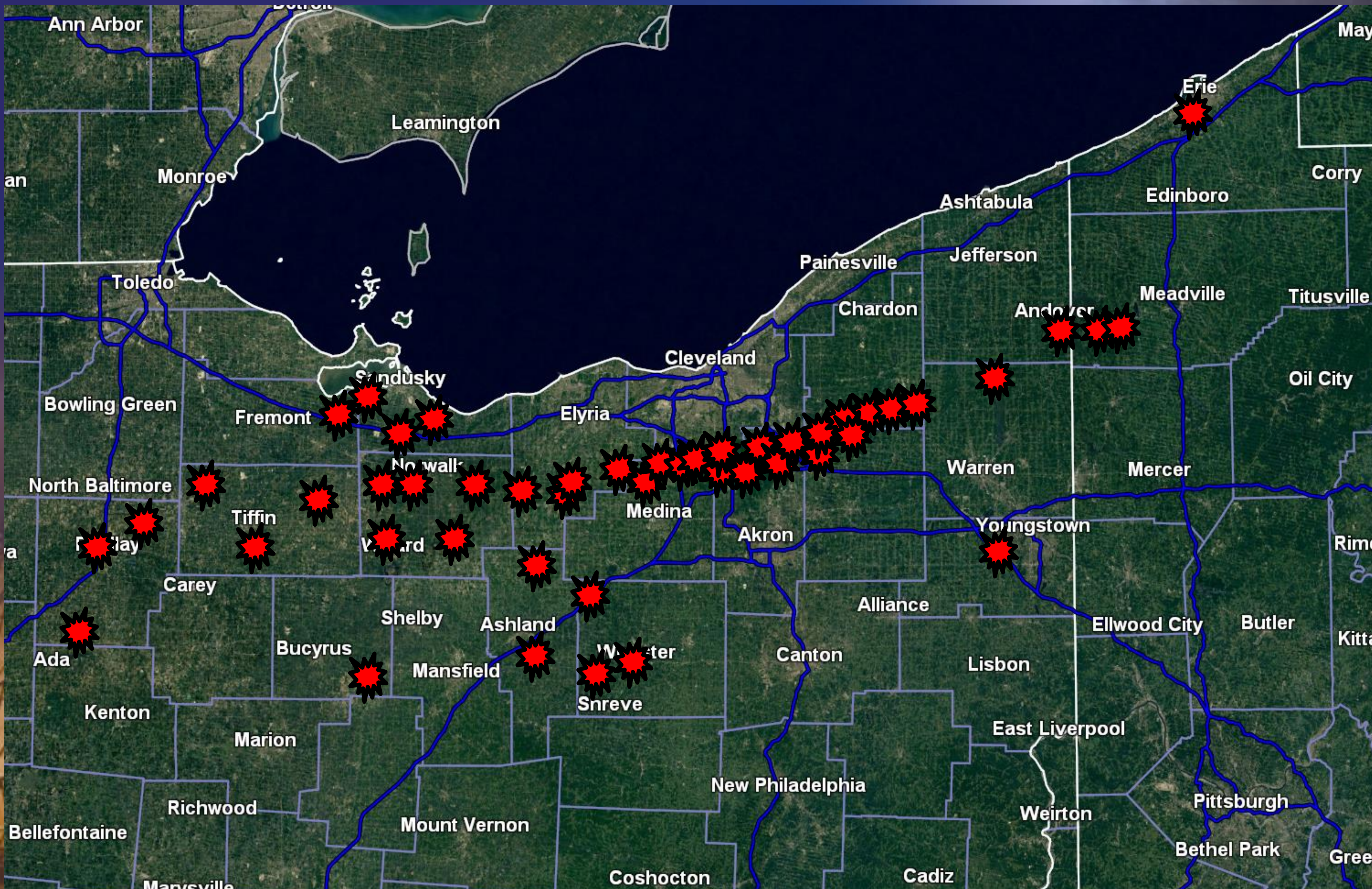
Part II: The Scope of the Event and Its Context in Ohio's Severe Weather Climatology

Presented by: Zach Sefcovic

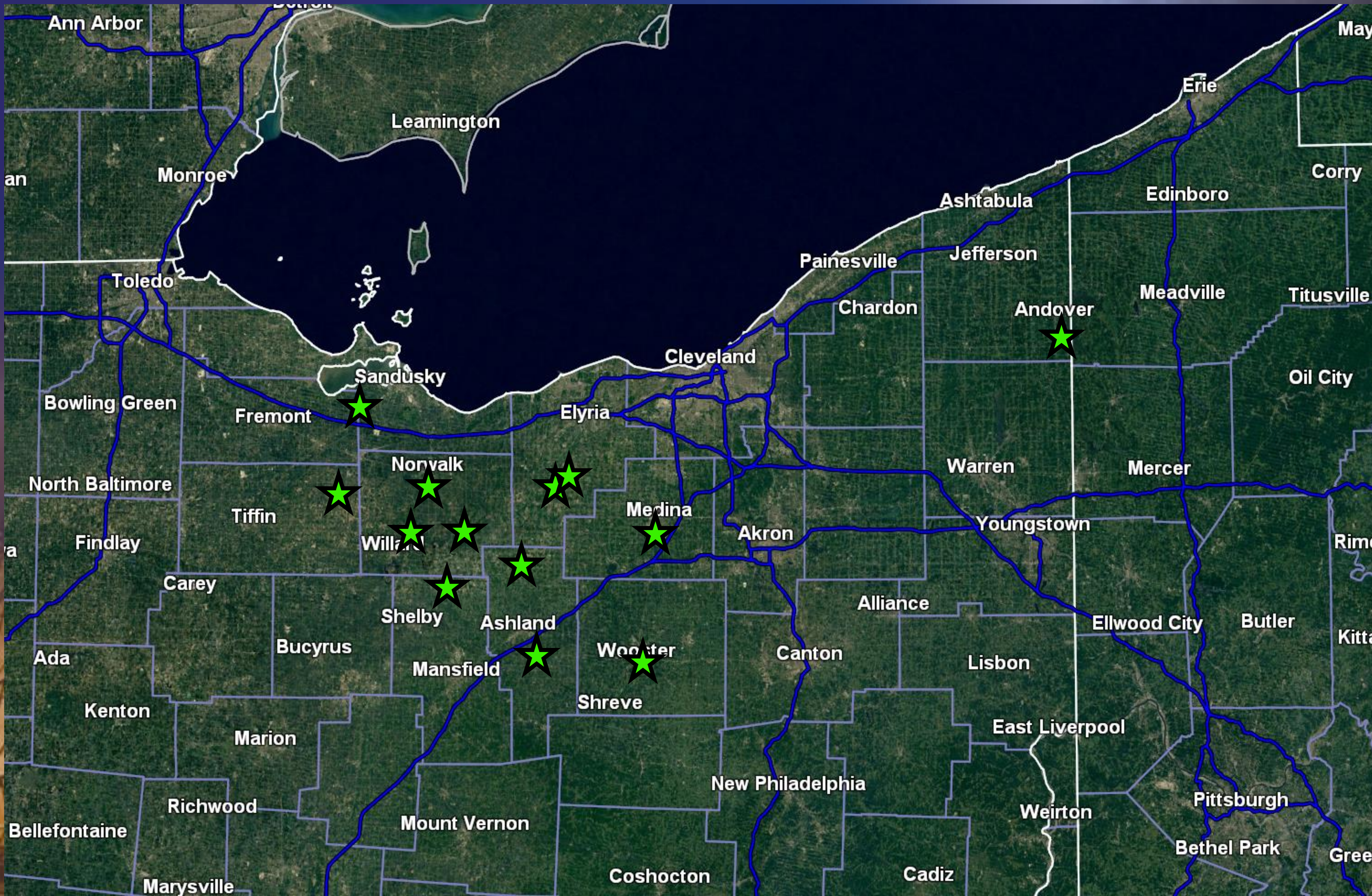
Challenges with the November 5th Event

- Late season event- Mindset toward winter
- First day of Standard Time (Early Sunset)
- Mixed bag of damaging winds and tornadoes
  - No clear-cut structure/"tornado touchdown" reports
  - Larger area of damage to buildings, barns, trees, power poles, etc.
  - WFO was swamped with storm reports and phone calls with a significant latency to real-time weather
  - Reports seemed generic at first until several reports become repetitive

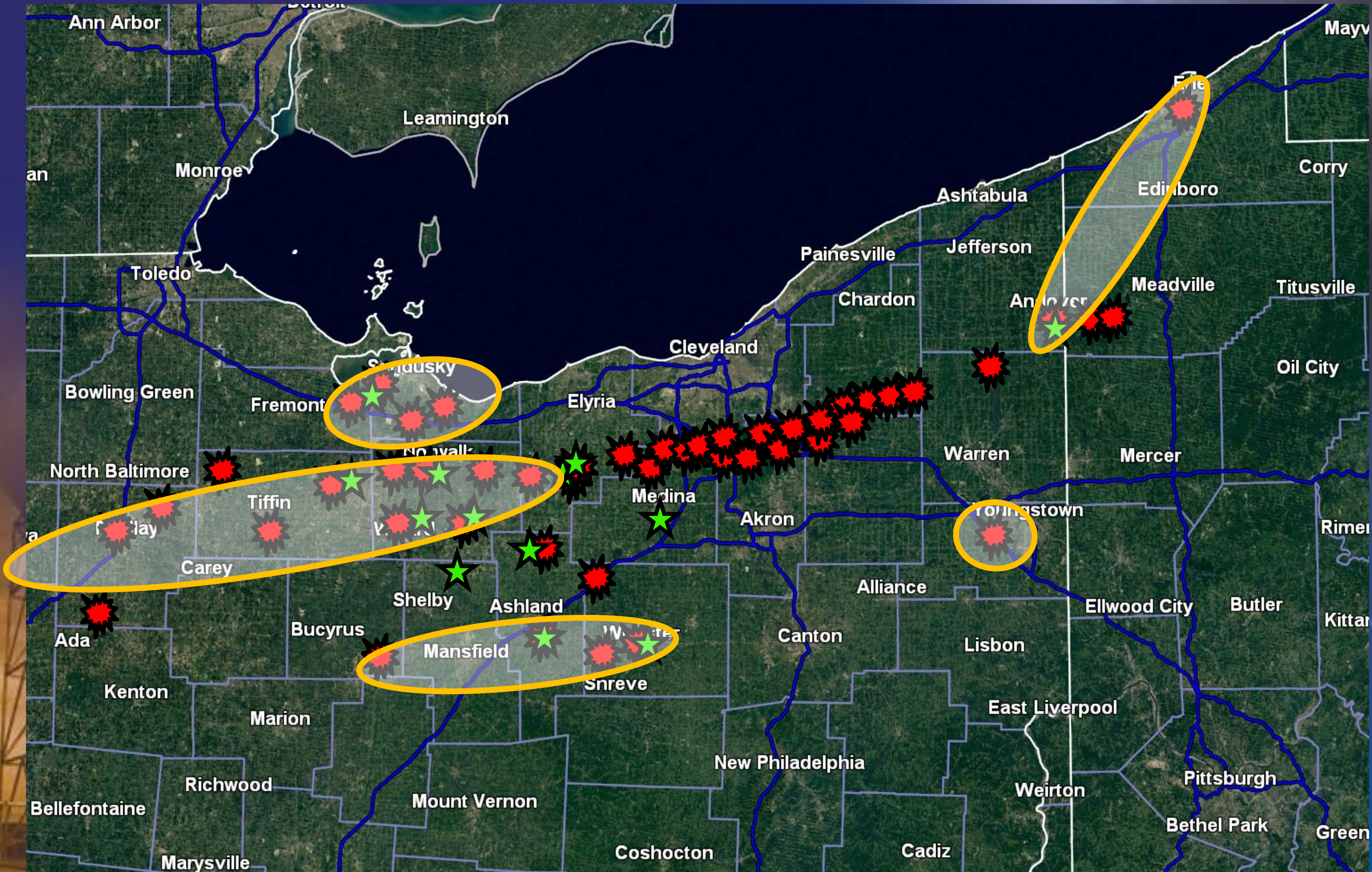
Map of Damage Reports



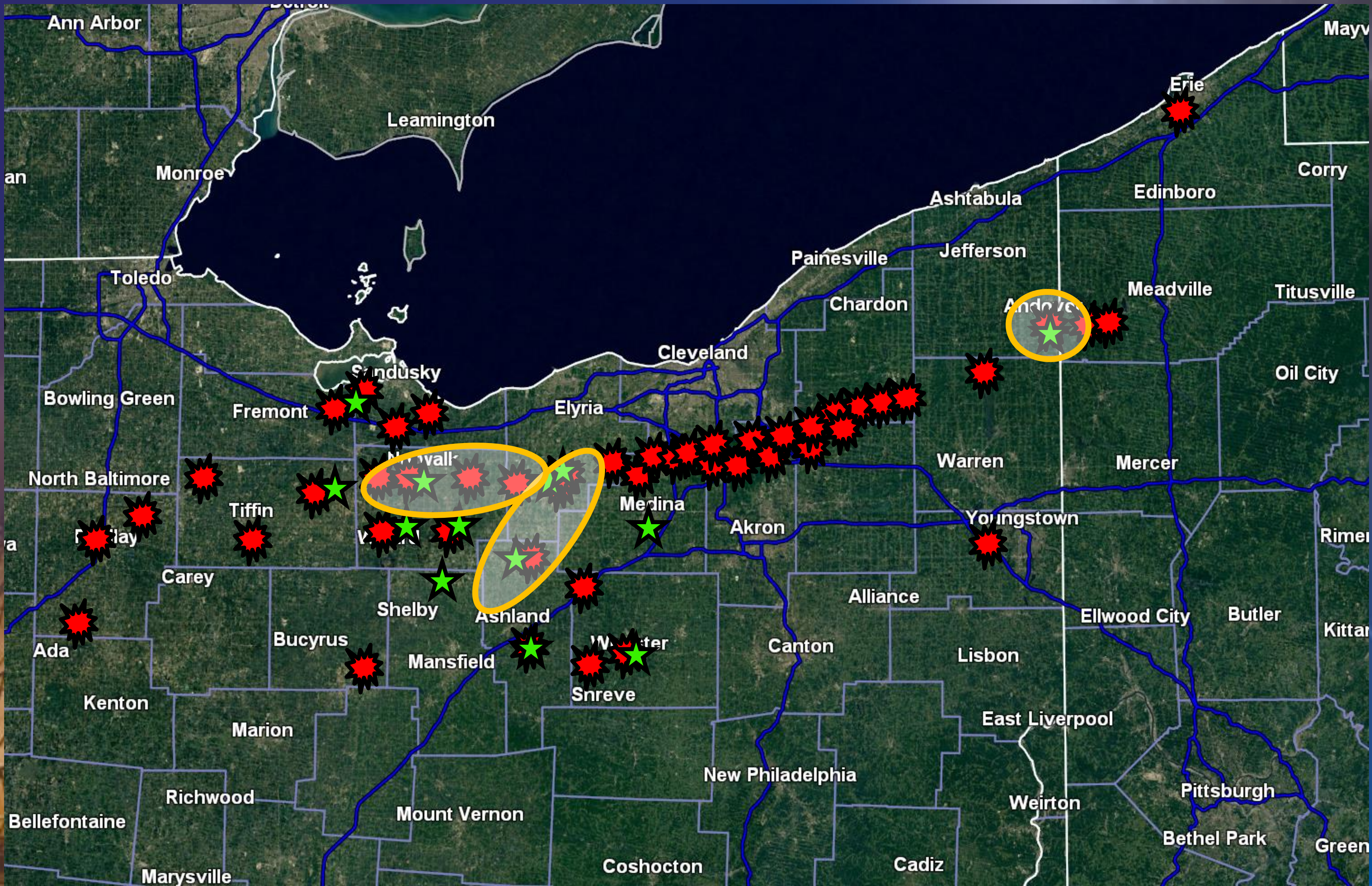
Map of CC Minimum Locations (Potential TDSs)



NWS Cleveland Survey Teams – Day 1



NWS Cleveland Survey Teams – Day 2



Damage Photos- Tornado or Not?

Damage Photos- Tornado or Not?

Damage Photos- Tornado or Not?

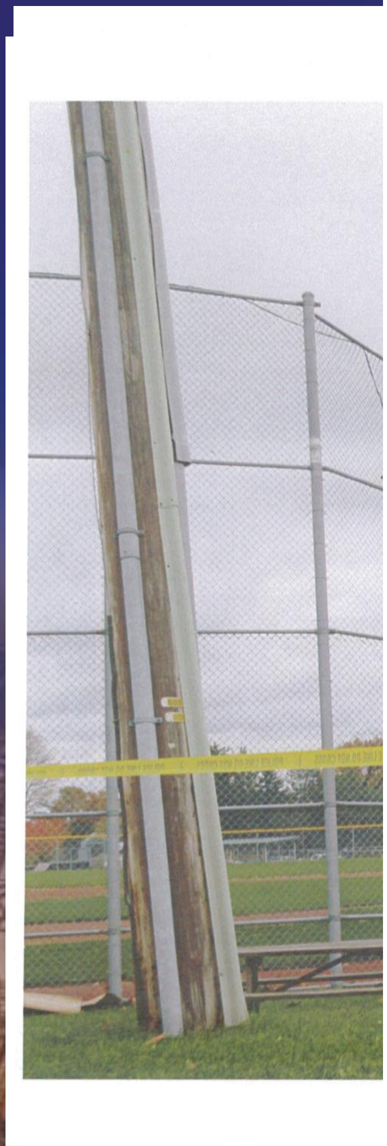
Damage Photos- Tornado or Not?

Damage Photos- Tornado or Not?

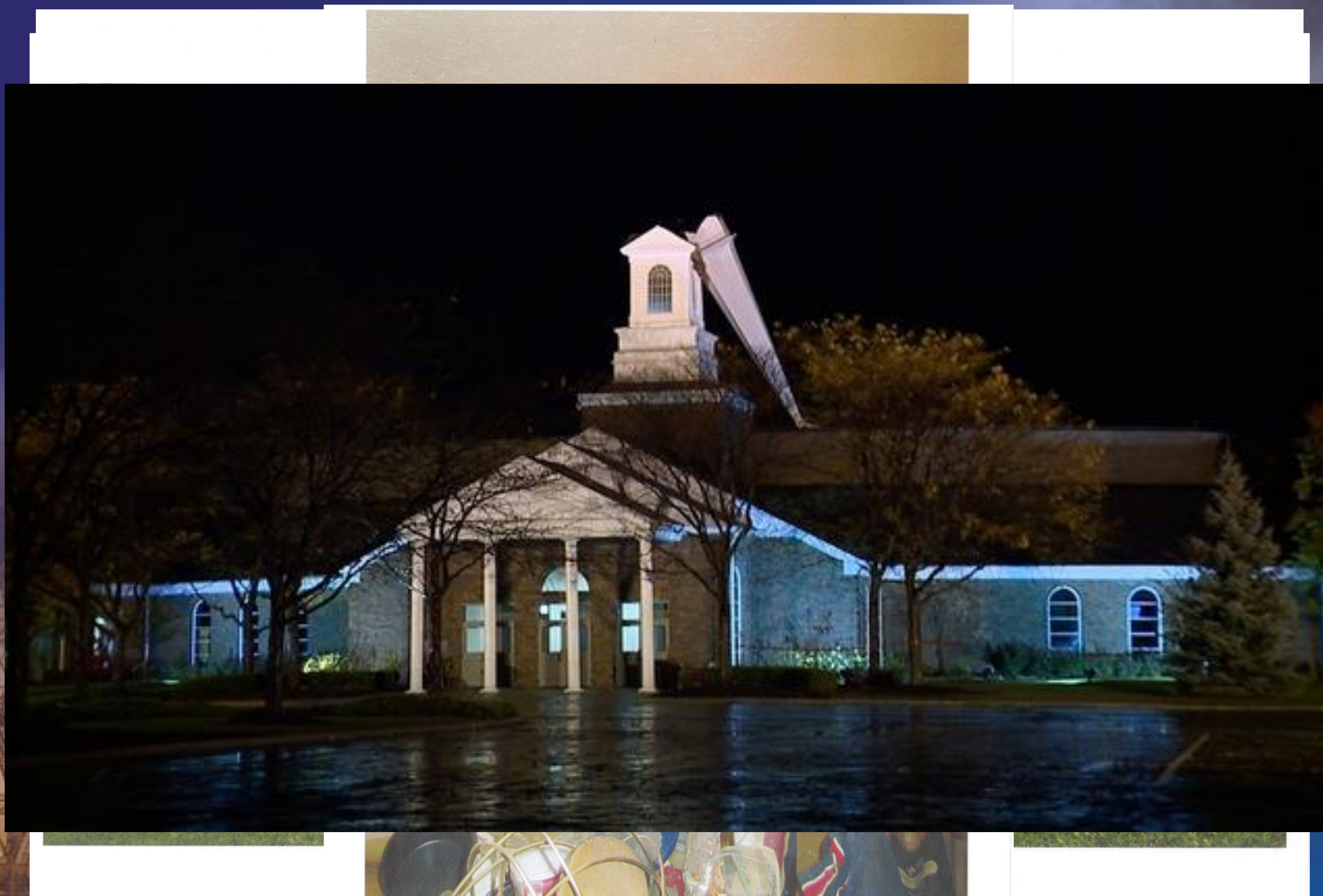
Suburban Cleveland Damage

Suburban Cleveland Damage

Suburban Cleveland Damage

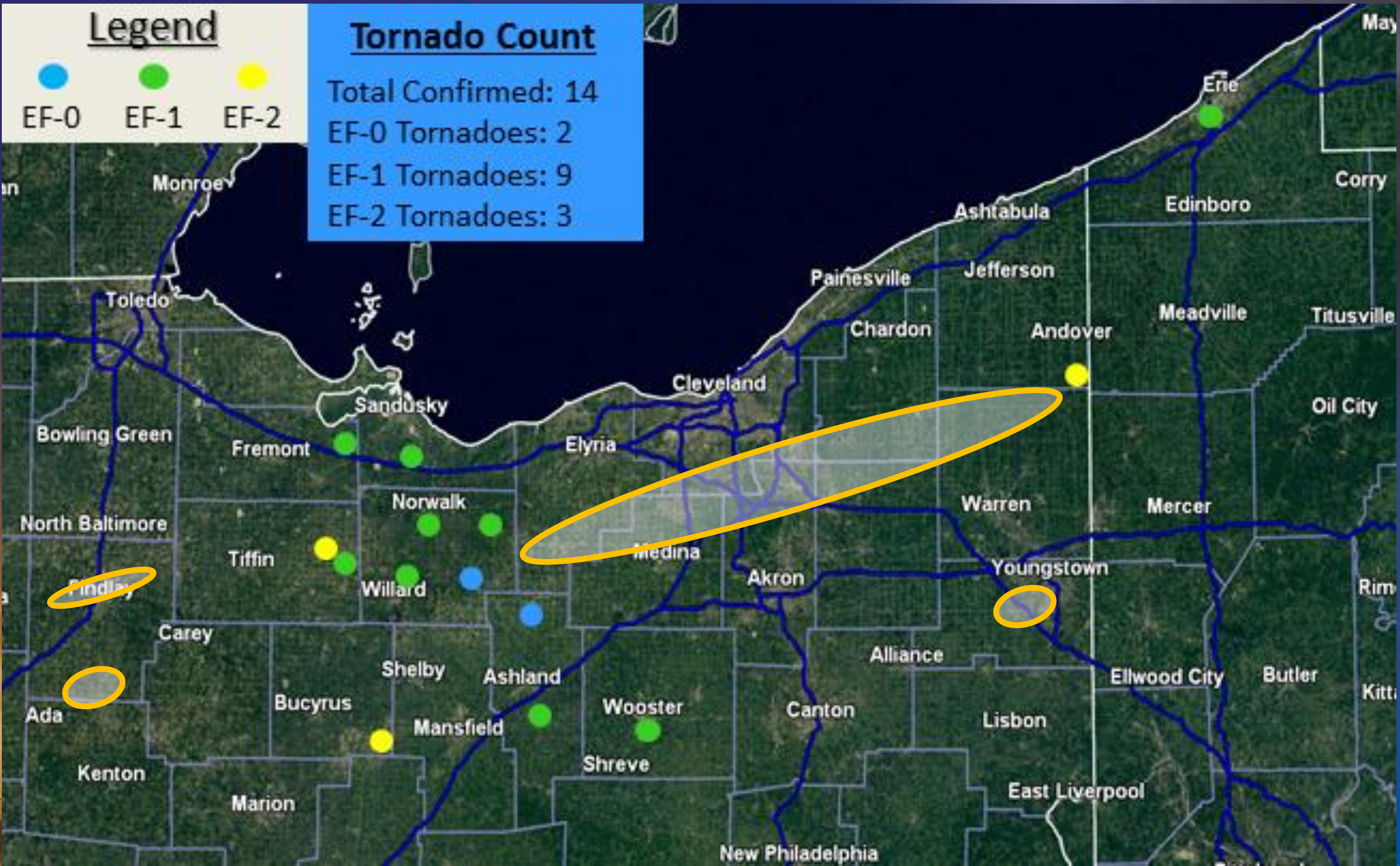


Suburban Cleveland Damage

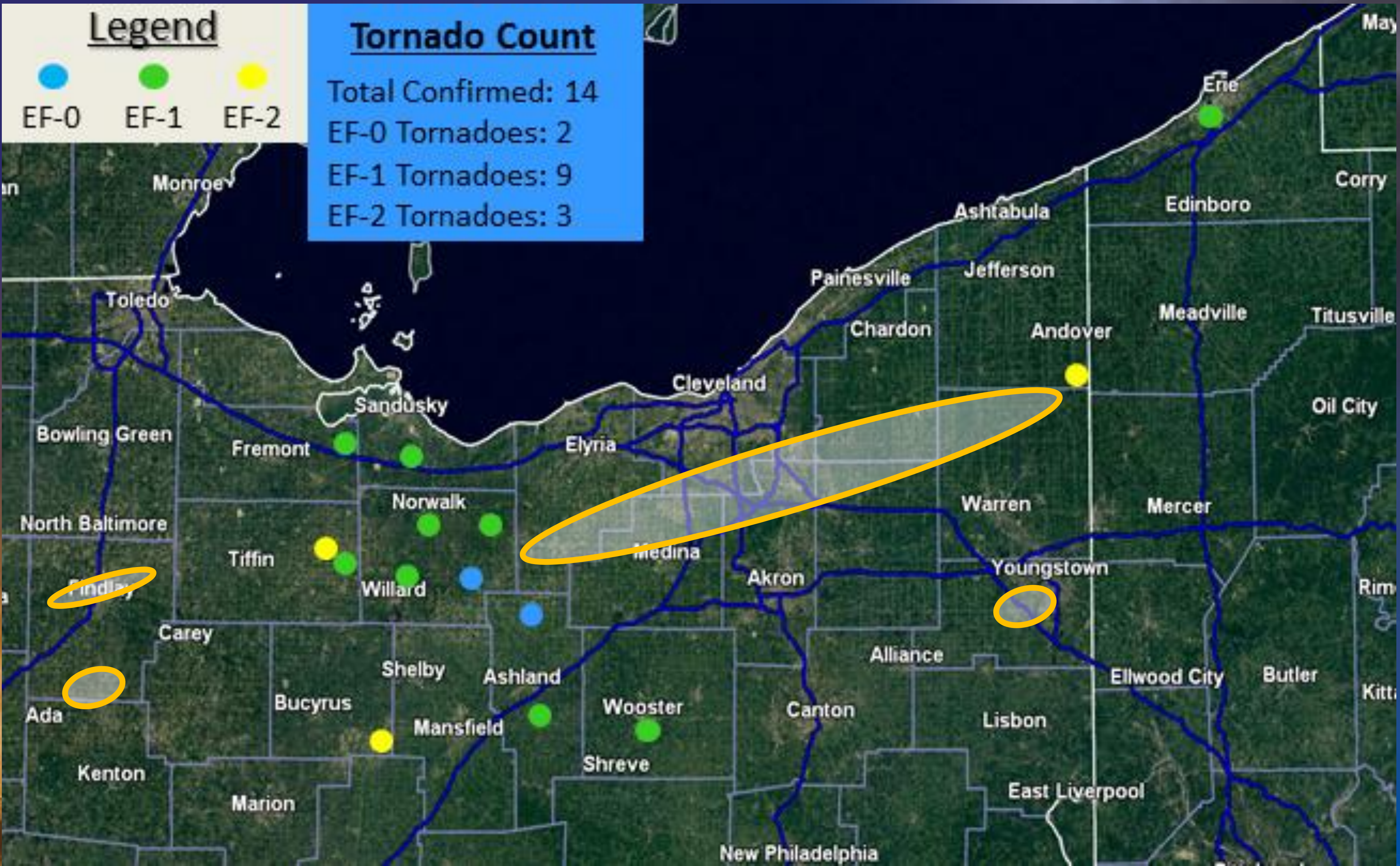


Suburban Cleveland Damage

Damage Survey Results



Damage Survey Results



Food for Thought…

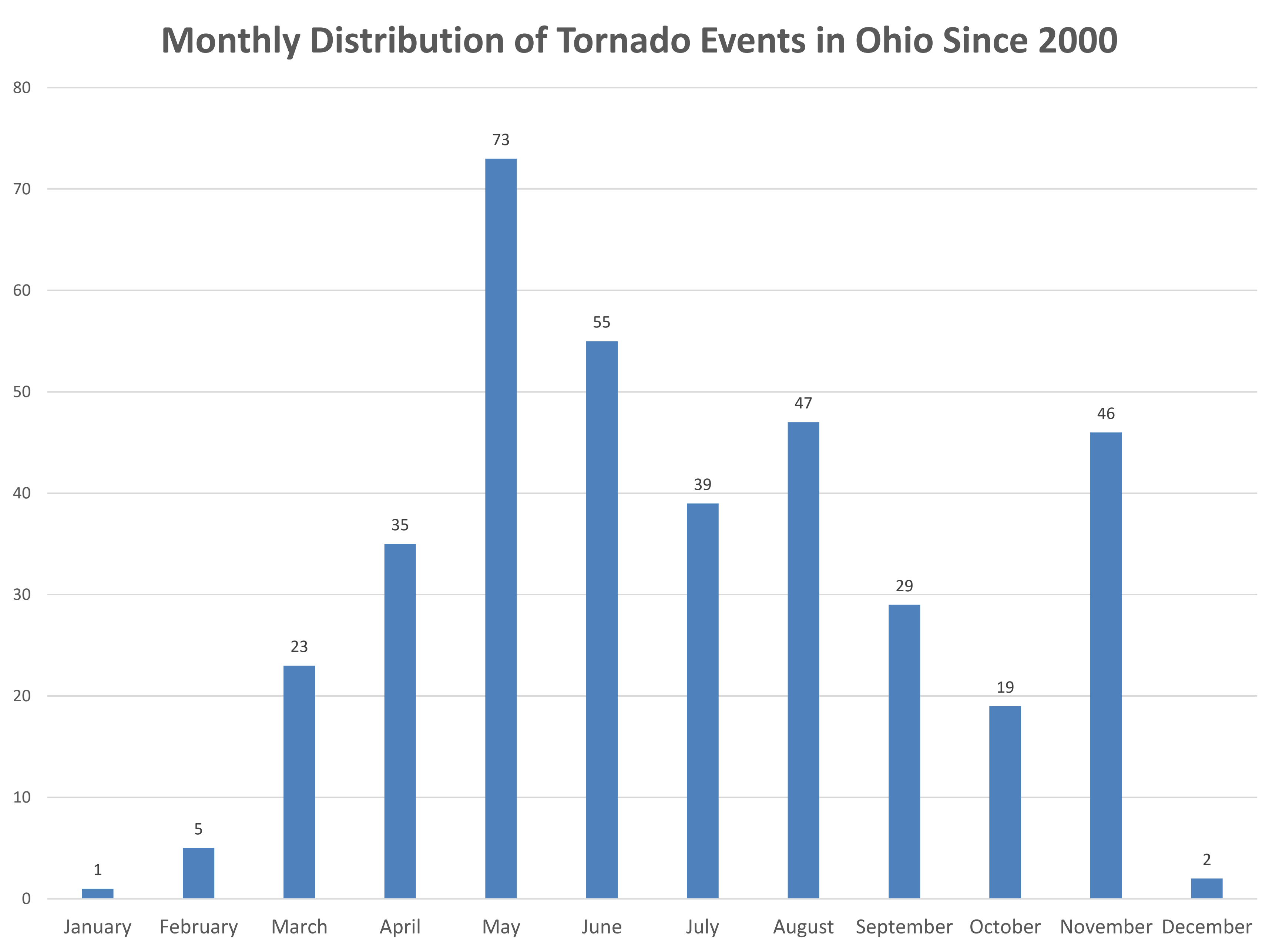
- How do you “triage” severe weather reports for surveying during a QLCS event?
  - Area impacted?
  - Media interests?
  - Tornadic Evidence?
  - EMA Confidence?
  - Radar signatures?
  - Other?
- In QLCS events, are tornadoes the priority to survey? What if straight-line wind damage is “worse?”
- Can you confirm tornadoes vs. straight-line wind damage without performing an in-person survey? (Are partners like EMA or radar products enough? EFU?)

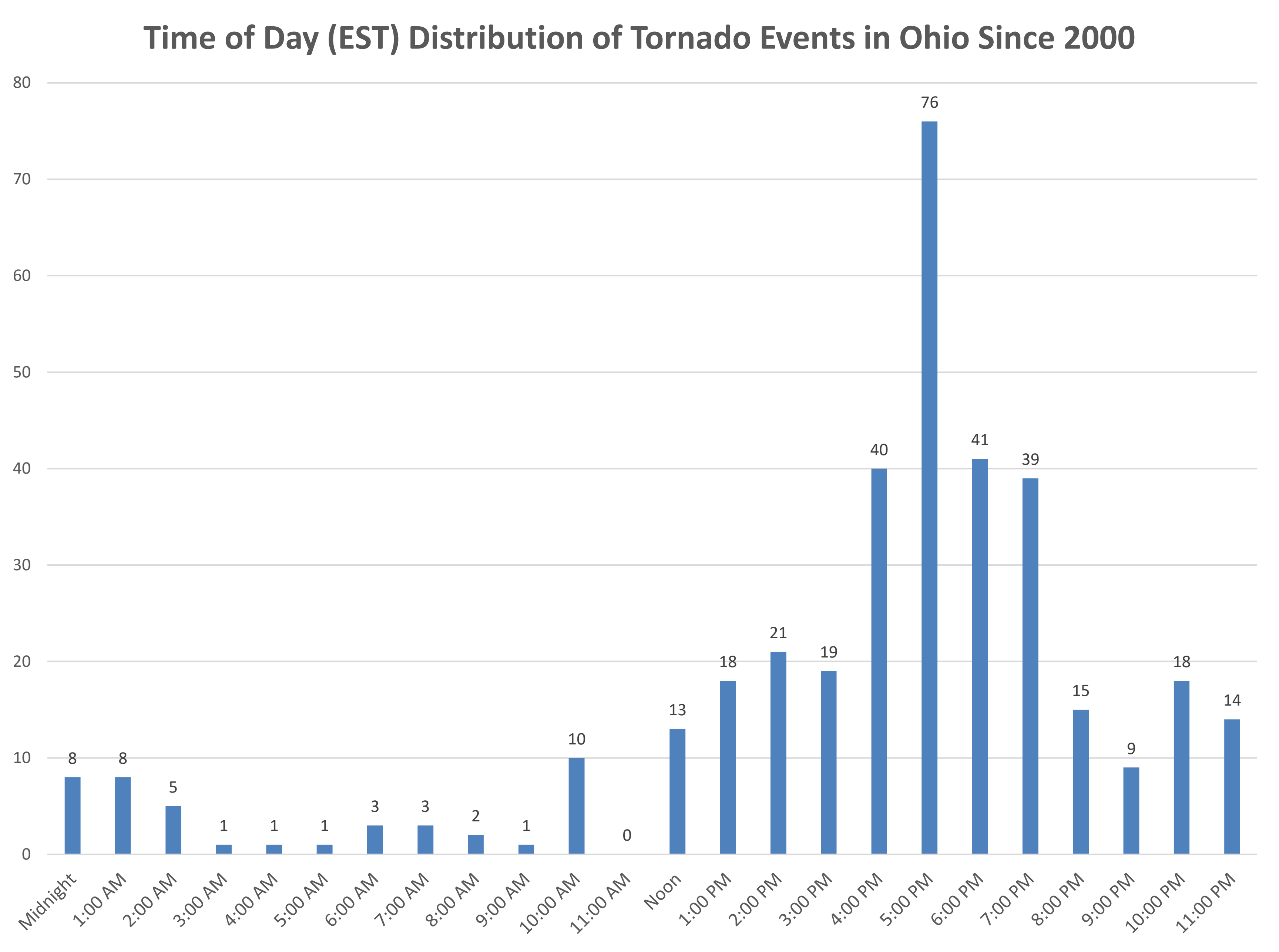
This Event Featured 16 Tornadoes in Ohio… Where Does it Belong in Ohio Severe Weather Lore?

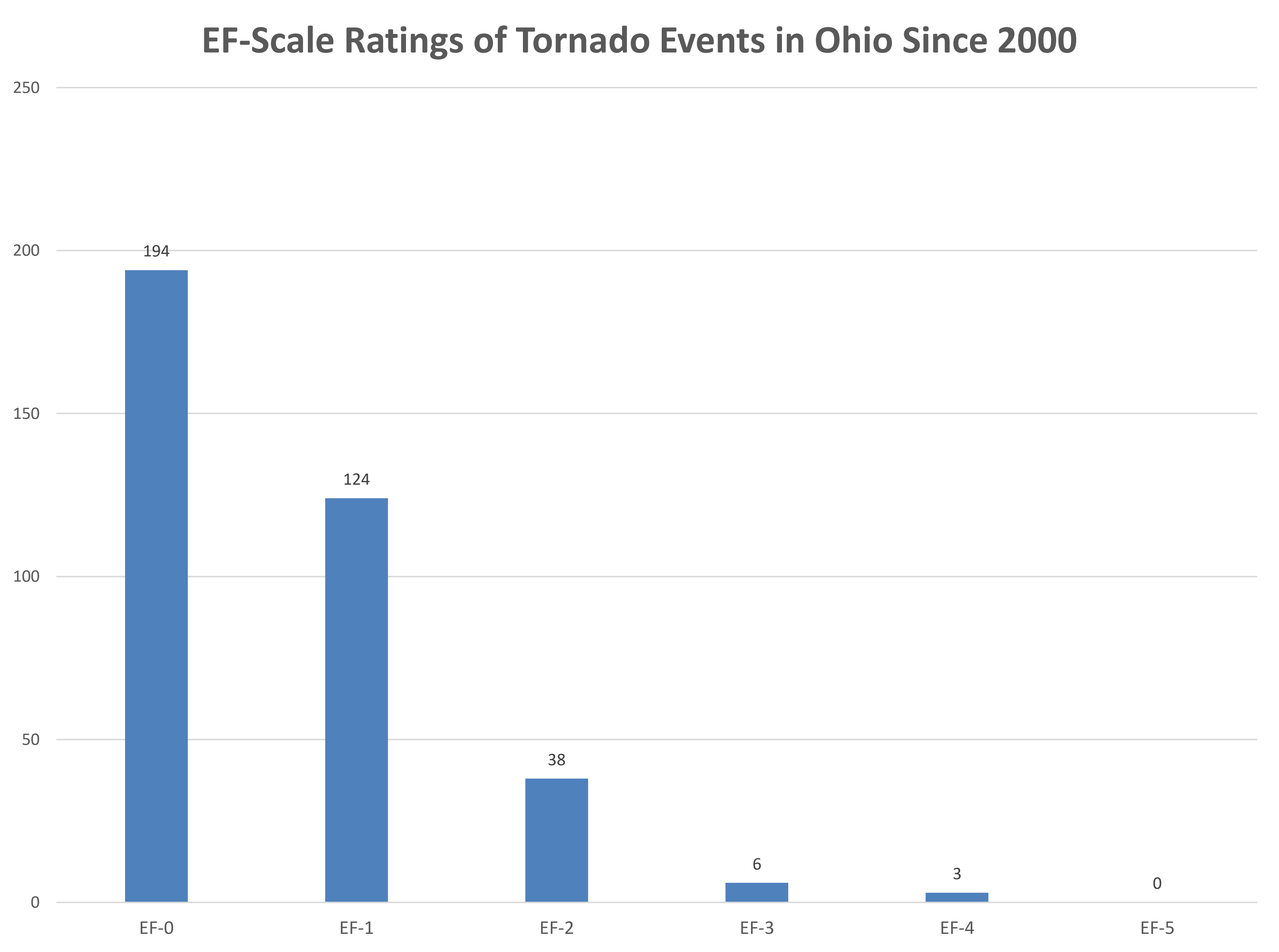
Ohio Tornado Climatology

- Ohio has had 374 tornadoes since 2000
  - Average of about 19-20 per year

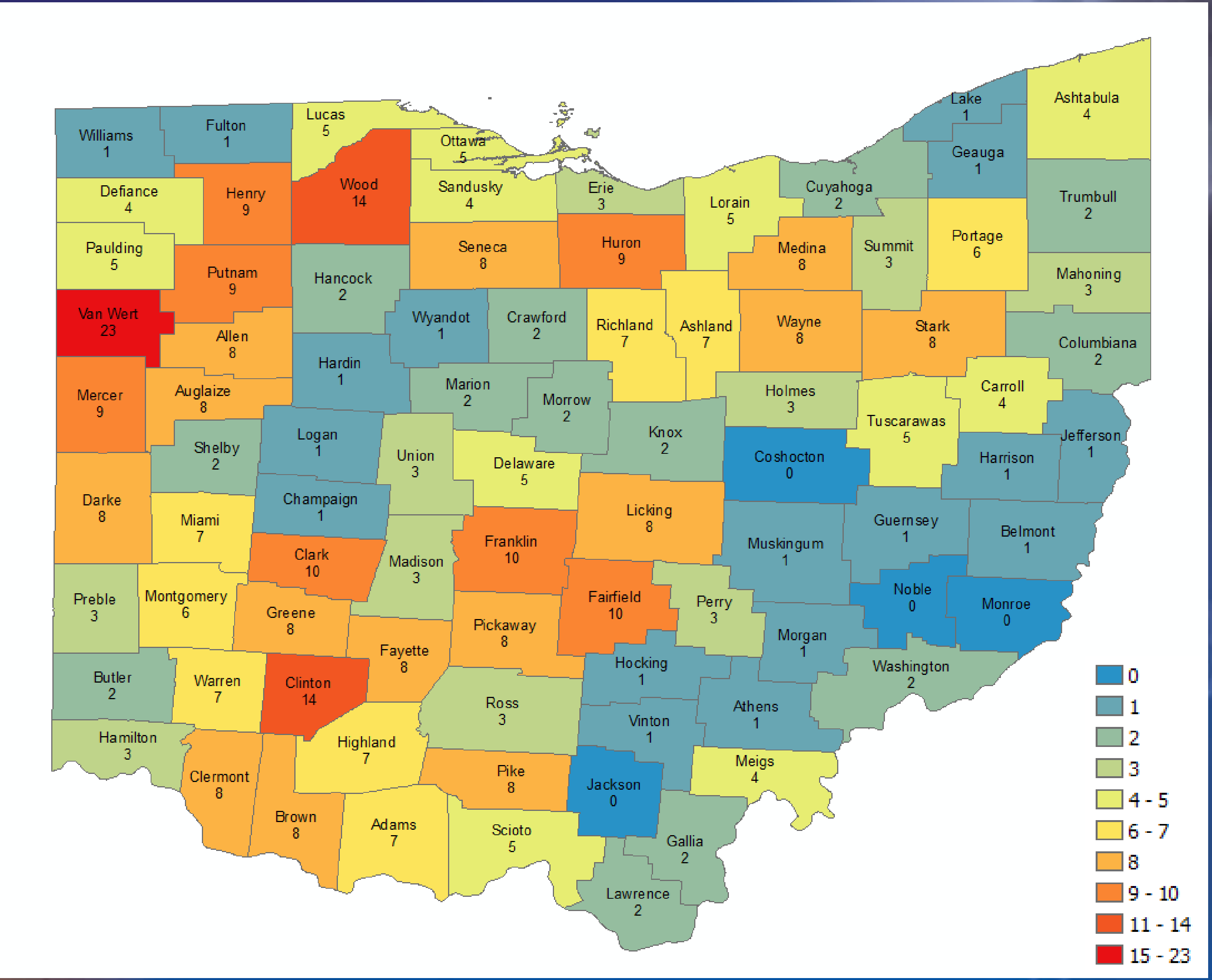
NWS Office/County Warning Area	Number of Tornadoes
NWS Wilmington	183
NWS Cleveland	113
NWS Northern Indiana	48
NWS Charleston	15
NWS Pittsburgh	13
Multi-NWS Office Events	2


Monthly Distribution of Tornado Events in Ohio Since 2000
80
70
60
50
40
30
20
10
0
1
5
23
35
73
55
39
47
29
19
46
2
January
February
March
April
May
June
July
August
September
October
November
December


Time of Day (EST) Distribution of Tornado Events in Ohio Since 2000
80
70
60
50
40
30
20
10
0
8
8
5
1
1
1
3
3
2
1
10
0
13
18
21
19
40
76
41
39
15
9
18
14
Midnight
1:00 AM
2:00 AM
3:00 AM
4:00 AM
5:00 AM
6:00 AM
7:00 AM
8:00 AM
9:00 AM
10:00 AM
11:00 AM
Noon
1:00 PM
2:00 PM
3:00 PM
4:00 PM
5:00 PM
6:00 PM
7:00 PM
8:00 PM
9:00 PM
10:00 PM
11:00 PM


EF-Scale Ratings of Tornado Events in Ohio Since 2000
250
200
150
100
50
0
194
124
38
6
3
0
EF-0
EF-1
EF-2
EF-3
EF-4
EF-5

Spatial Distribution of Tornadoes Since 2000



November 5th Event Breakdown

- 16 Confirmed Tornadoes in Ohio:
  - 5- EF-2s
  - 9- EF-1s
  - 2- EF-0s

- Ohio Tornadoes by CWA:
  - 13- Cleveland
  - 3- Wilmington

November 10, 2002 Statistics

- The “Veteran’s Day Tornado Outbreak”
- 18 Confirmed Tornadoes in Ohio:
  - 1- F4 (Four Fatalities)
  - 2- F3s (One Fatality)
  - 5- F2s
  - 8- F1s
  - 2- F0s
- Cyclic supercells spawned several long track tornadoes
  - Van Wert Tornado- Over 50 Miles Long!

Other Ohio Outbreaks Since 2000

- June 5, 2010- 5 Tornadoes in NW Ohio- EF-4 in Millbury (Wood County)- Five Fatalities (Supercell)
- March 2, 2012- 7 Tornadoes in SW Ohio- EF-3 in Moscow (Clermont County)- Four Fatalities (Supercell)
- August 24, 2016- 11 Tornadoes in NW Ohio- A pair of EF-2 Tornadoes in IWX area- No Fatalities (Supercell)
- March 1, 2017- 7 Tornadoes in southern Ohio- All EF-1s and EF-0s- No Fatalities (QLCS)
- May 24, 2017- 6 Tornadoes in SW Ohio- All EF-1s and EF-0s- No Fatalities (Supercell)

Final Thoughts…

- November 5, 2017 will pale in comparison to other Ohio Tornado Outbreaks…
  - No high impact tornadoes/fatalities
  - However, span of areas impacted is larger than most since 2000 due to wind damage
  - How "memorable" are events with EF-1s and EF-0s?
- Fall shouldn't be considered a "secondary season" for severe weather in Ohio!
  - November is just as active as August and more active than March and April with tornadoes since 2000

That’s All!

Questions?

Cory Mottice – Cory.Mottice@noaa.gov
Meteorologist – NWS Glasgow