An Analysis of Doppler Radar Coverage and its Effect on Tornado Warning Lead Time in Southeastern Ohio

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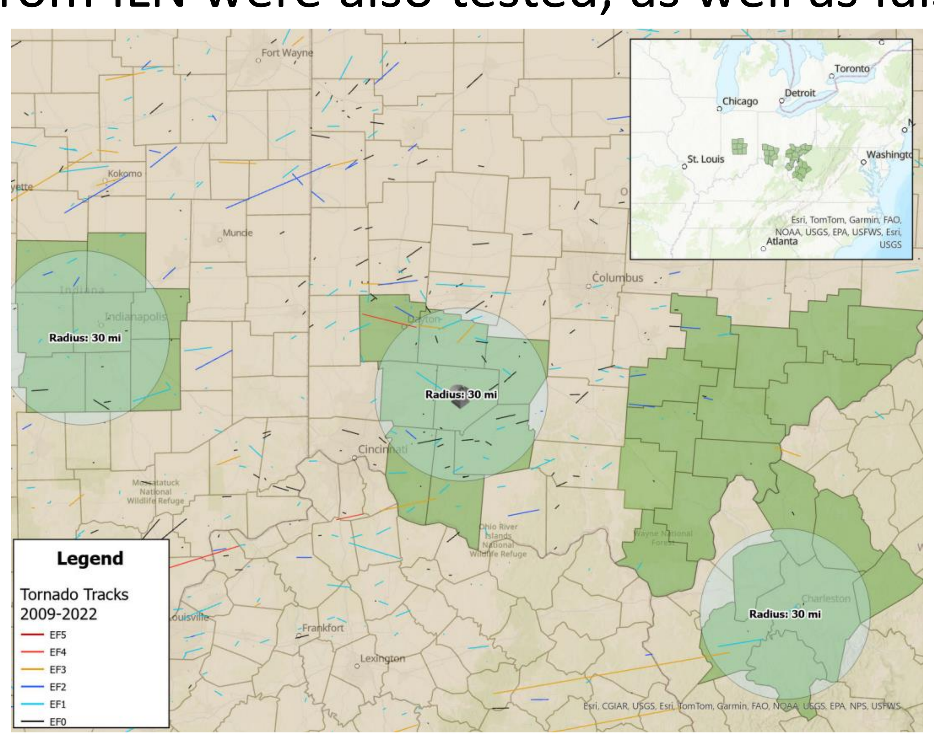
BACKGROUND/MOTIVATION

The nearest National Weather Service Doppler Radars to Southeastern Ohio are ILN in Wilmington, Ohio, 90 miles from Athens County, and RLX in Charleston, West Virginia, 70 miles from Athens County. The lowest angle of Doppler Radar beam emission (0.5˚) results in heights 6-9 kilofeet (kft) above the surface. An assumption could be made that higher beam elevation would result in worse detection of tornadoes, a relatively low-level process, and result in less adequate warnings. The purpose of this study is to compare rates of detection and the resulting warning and lead time products from Southeastern Ohio to other NWS offices in varying degrees of distance to better understand the correlation between proximity to radar and tornado discernment.

METHODOLOGY

Counties of Southeastern Ohio alongside counties of Ohio, West Virginia, and Indiana within 30 miles of their NWS office were chosen, including data from 2009-2022. An additional radius of 30-100 miles from ILN were also tested, as well as false-warning verification.



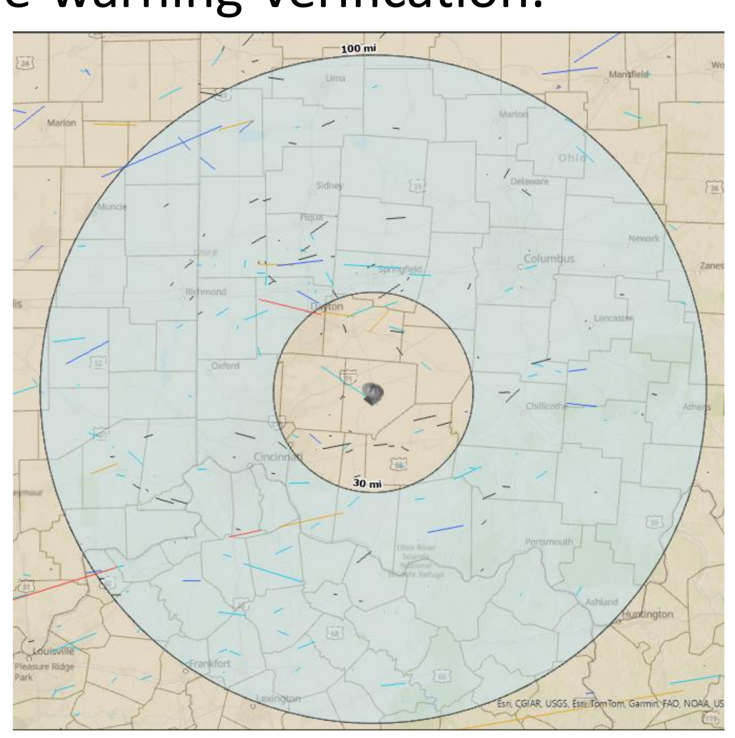
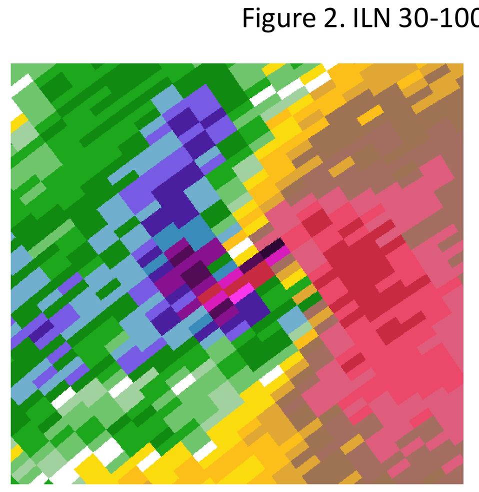
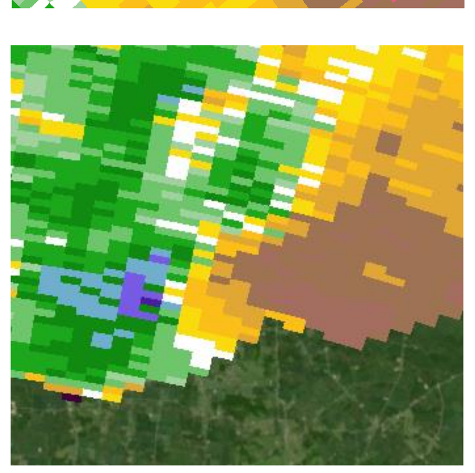


Figure 1. County maps for the four areas of investigation: ILN, RLX, IND, and Southeastern Ohio. Counties surveyed are in green, with the locations of each station provided.

Figure 2. ILN 30-100-mile analysis. Reports are done not county based, rather by distance from radar.





Each test would correspond the tornado report[3] to NEXRAD data, which was used to perform a series of checks of warning verification, lead time for warning (if applicable,) and tornado information[2] (i.e. Δv, storm mode, WFO, pixel difference, beam height.) Said information was used to diagnose whether the radar could "observe" the tornado[1]:

- $\Delta v \geq$ 30 kts
- Pixel difference ≥ 4 px

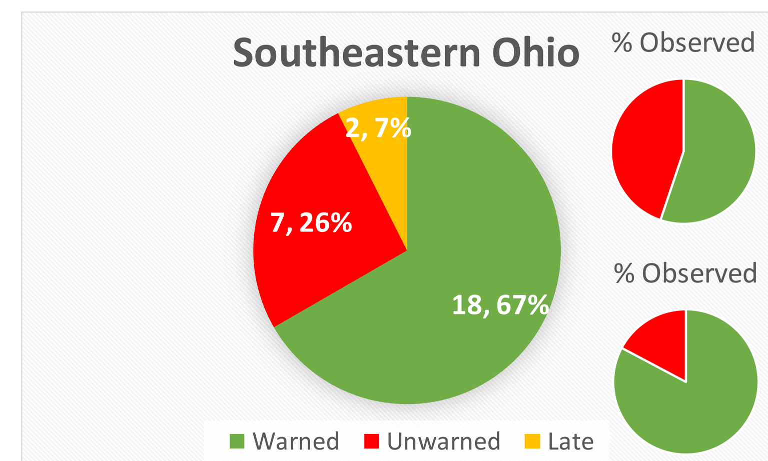
Radar beam obstruction and "cone of silence" proximity must also be considered.

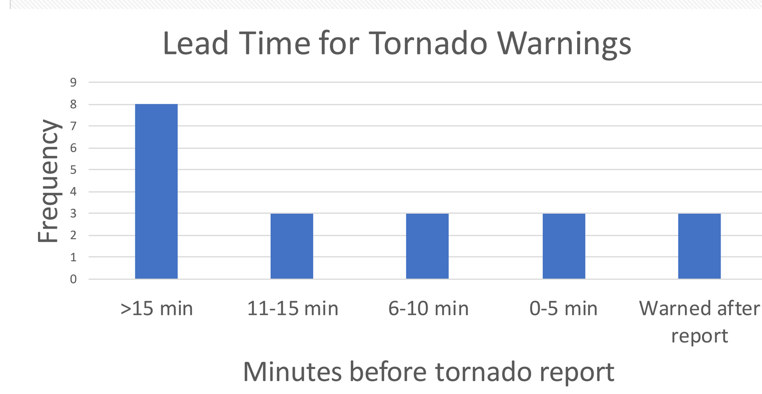
Figure 3. An "observable" tornado. Note the velocity folding and minimal pixel difference.

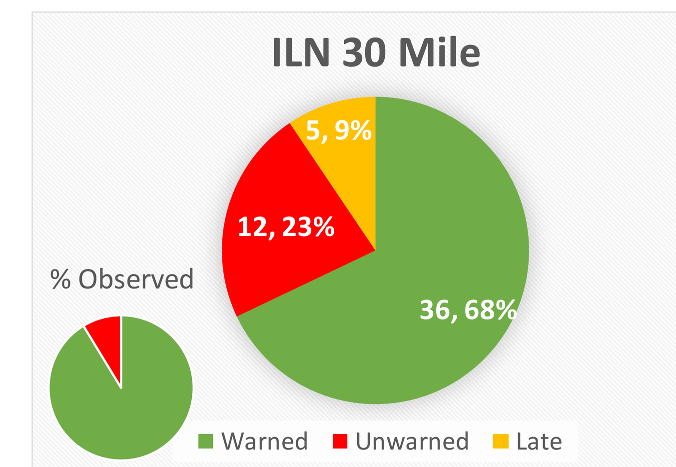
Figure 4. An "non-observable" tornado. Despite mesocyclone evidence, couplet is not tight enough to be distinguished tornadic.

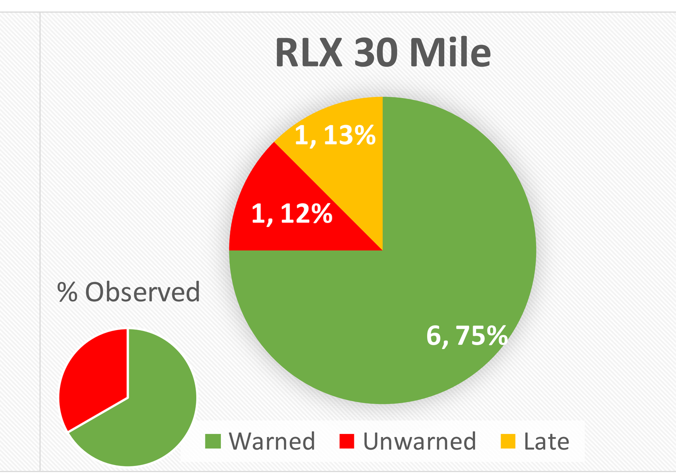
DATA/RESULTS

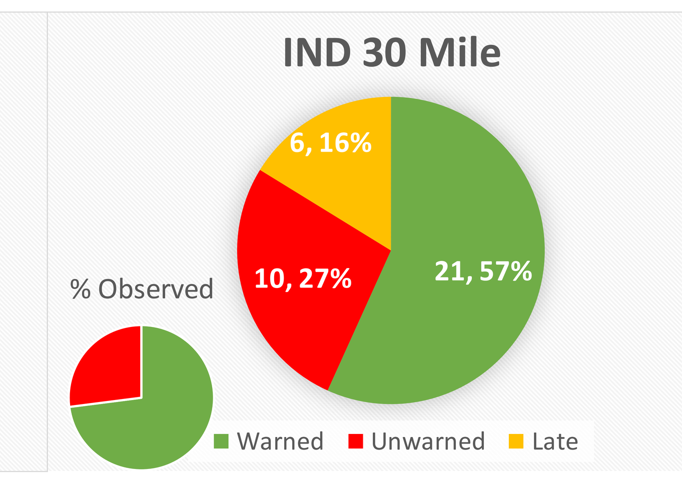
Below are the results for each station test. The pie charts represent the percentages of warned tornadoes, tornadoes warned after its reported start, and unwarned tornadoes. Inside the chart is a comparison of tornadoes deemed "observable" vs "unobservable" via the radar scan provided at the time of the report. The distribution of given lead time is also shown below.

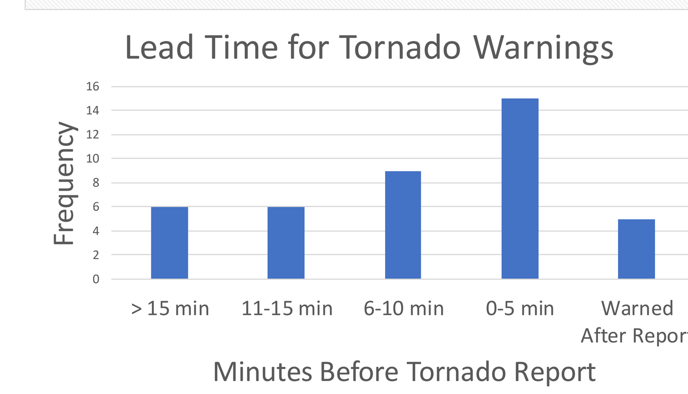


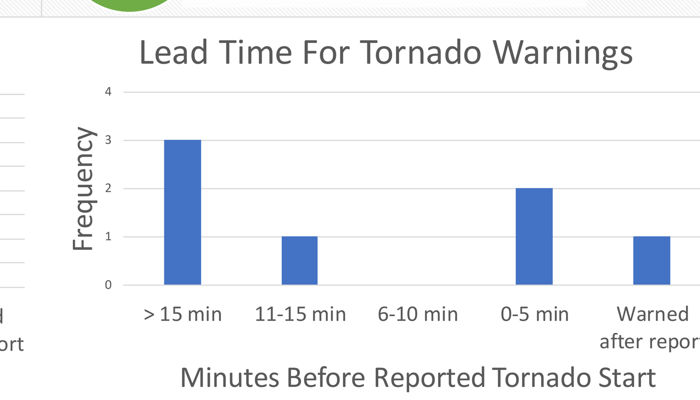


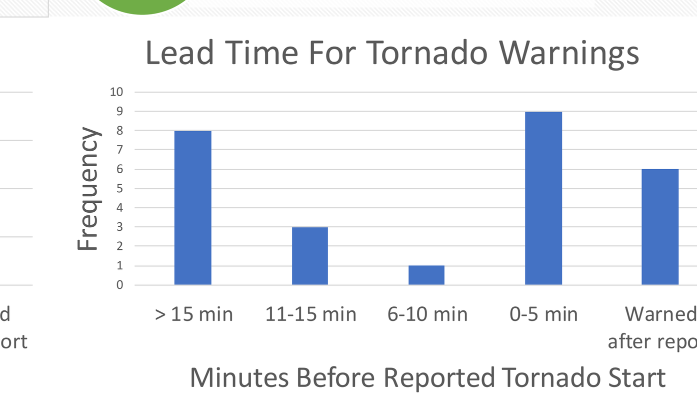


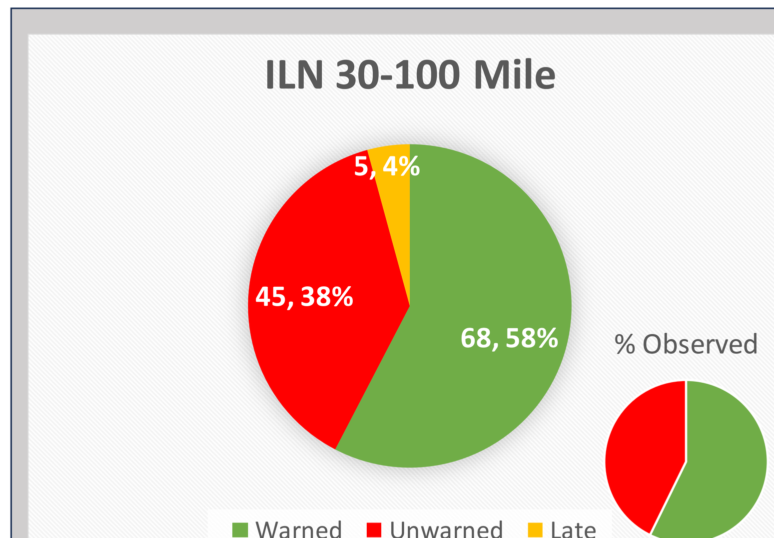


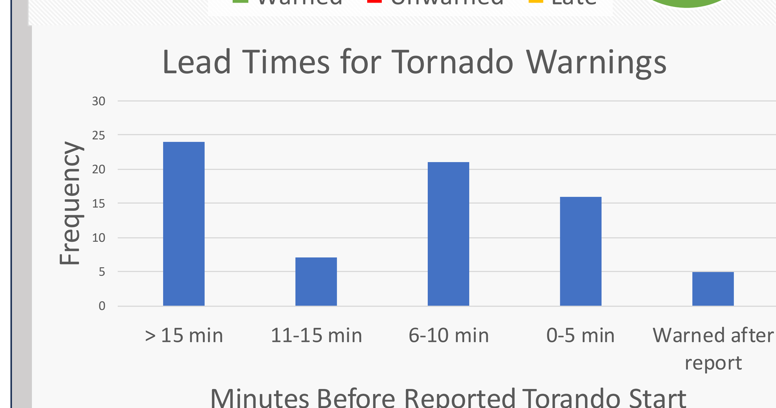






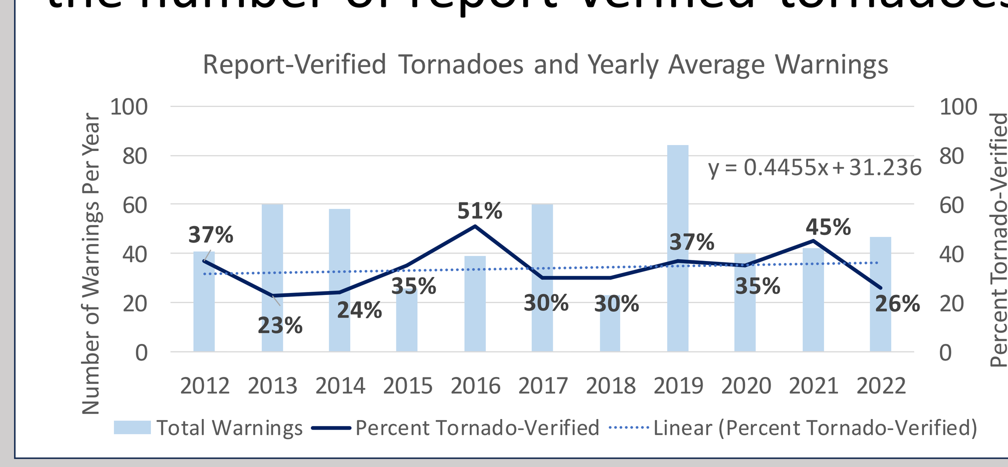






Data collected from ILN's 30–100-mile radius test yielded results that could be a direct comparison to the parameters of distance and geographic conditions that Southeastern Ohio possesses. A warning failure rate of 38% and an observation failure rate of 43% are reasonable for such distance, and indeed do the radar scans appear a poor representation of surface phenomena. However, comparing these results to that of the results of Southeastern Ohio, greater success (26% failure rate) in said region's warning verification and observations defies the preset set by ILN's 30-100-mile and the ≤30-mile station results.

The total rate of tornado warnings with and without an associated tornado was 33/67%, respectively. The data contained 520 tornado warnings from 2012-2022 in ILN associated counties[4]. No correlation was found between yearly warnings and the number of report-verified tornadoes.



CONCLUSIONS

The claim that distance from radar results in worse detection and warning of tornadoes remains subjectively proven. Excluding data from Southeastern Ohio, there remains correlation with better detection/warning rates within 30 miles of a station than that of 30-100 miles. However, including Southeastern Ohio in this sample creates disparity due to similar detection/warning rates to that of ≤30 miles. A few influencing factors include:

- Weight of reports via days of tornado outbreaks
- Influence of multiple WFOs in detection/warning
- Abnormality of tornado presence within Southeastern Ohio (low sample size)

Further detailing tornado warning issuing processes within this region is necessary to fully correlate how this region behaves comparatively to the trend of its neighboring stations.

SOURCES

[1] Evan S. Bentley, Richard L. Thompson, Barry R. Bowers, Justin G. Gibbs, Steven E. Nelson "An Analysis of 2016–18 Tornadoes and National Weather Service Tornado Warnings across the Contiguous United States" *NOAA Publications* 36 (2021) 1911-1913

[2] Rodger A. Brown and Vincent T. Wood "A Guide for Interpreting Doppler Velocity Patterns: Northern Hemisphere Edition" *NOAA Publications* 2 (2007) 44-45

[3] Ncei. (n.d.). *Storm events database*. National Centers for Environmental Information. https://www.ncdc.noaa.gov/stormevents/

[4] Akrherz@iastate.edu, D. H. (n.d.). *IEM :: NWS warning search by point or county/zone*. Iowa Environmental Mesonet. https://mesonet.agron.iastate.edu/vtec/search.php