Impacts of Distance from the Nearest Radar, Time of Day, Resident Population, and Season on Severe Warning Performance, Part II: Regional Analysis

Alex P. Ferguson[1], Janice M. Maldonado-Jaime[2], Philip N. Schumacher[2] ([1] NWS Amarillo, [2] NWS Sioux Falls)

1. Introduction

- Severe Thunderstorm Warnings (SVRs) are a prominent NWS product
  - They activate the Emergency Alert System!
  - Local TV viewers see crawlers, inset maps
  - SVRs may increase the actual and perceived false alarm rate
- Over half of non-tornadic convective wind fatalities during 1986-2007 were unwarned (Black and Ashley 2011)
- Most studies on warning performance focus on Tornado Warnings

- **Goal: study SVR performance across different regions of the Continental United States (CONUS), examining how performance varies by phenomena and non-meteorological factors**
  - Hail vs. damaging wind
  - Distance from the nearest radar
  - Time of day and time of year
  - Population density within the SVR

- Study period: 2010-2018
  - SVR hail criteria changed from dime (19.05mm) to quarter (25.4mm)
- Previous work (Davis and LaDue 2004)
  - Done within a county-based framework
  - Performance did not vary based on population density, distance from radar. Time of day had some relation to performance.

2. Methods

- Data Acquisition
  - SVR polygons: Iowa Environmental Mesonet
  - Events, additional SVR attributes: NWS Performance Management
  - Population: 2010 US Decennial Census (block level count)
  - Land Cover: 2011 National Land Cover Dataset (NLCD) (30m res.)
- Data Processing
  - Calculate distance from SVR/event to nearest radar (ArcGIS)
    - Measured using the centroid of SVR, starting point of event
  - Estimate population density within each SVR (ArcGIS) (Figure 1)
    1. Reduce 2010 census blocks by removing areas not classified as 'Developed' in 2011 NLCD
    2. Clip reduced census blocks using SVR polygon
    3. Estimate population density – if a SVR intersects 30% of a reduced census block with 10 people in it and 50% of a reduced census block with 20 people in it, 13 people are estimated to reside within the SVR. Density calculated using total area of SVR.
  - Classify SVRs and events (R)
    - Used sp, rgdal packages to determine if starting point of a severe event was within a SVR occurring at that time. If so, event is counted as 'warned' and SVR is counted as 'verified'
    - Counted events as warned if they occurred within a Tornado Warning

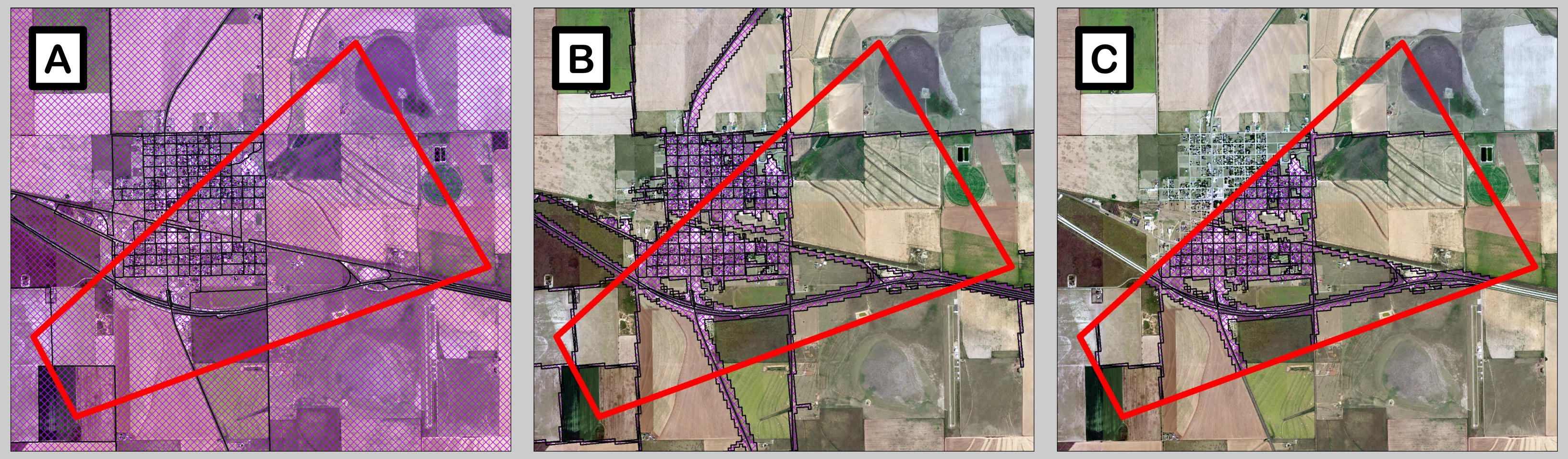

Figure 1: 2010 US Census Blocks (panel A, purple hatching) are reduced to areas identified as 'Developed' in 2011 NLCD (panel B). Reduced census blocks are then clipped (panel C) by warning polygons (red outline). Aerial imagery from 2010.

- Bin SVR verification status, event detection status by attributes:
  - Hour of day (UTC)
  - Climatological season
  - Distance from nearest radar in 40km increments
  - Region (Fig. 2; Table 1)
  - Events binned for the 4 above attributes separately for hail, wind
  - For warnings, population density by deciles
    - **Deciles defined using distribution of counties across CONUS**

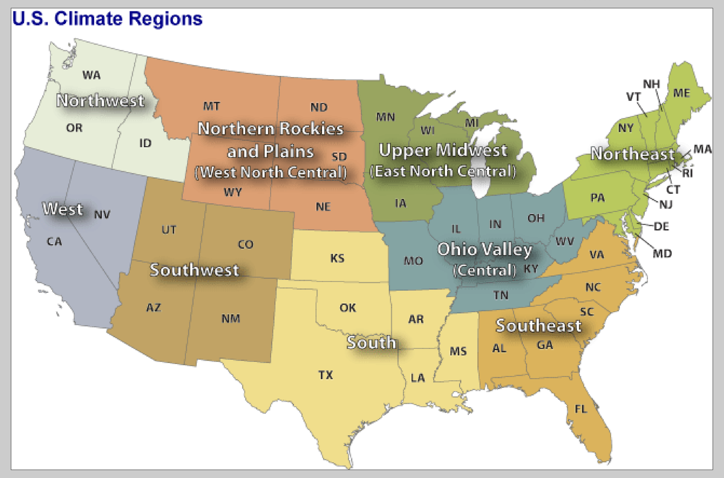

Fig. 2: CONUS climate regions

Climate Region	Abbreviation
Northwest	NW
West	W
Northern Rockies and Plains	NRP
Southwest	SW
South	S
Upper Midwest	UM
Ohio Valley	OV
Southeast	SE
Northeast	NE

Table 1: Climate region abbreviations used

3. Results

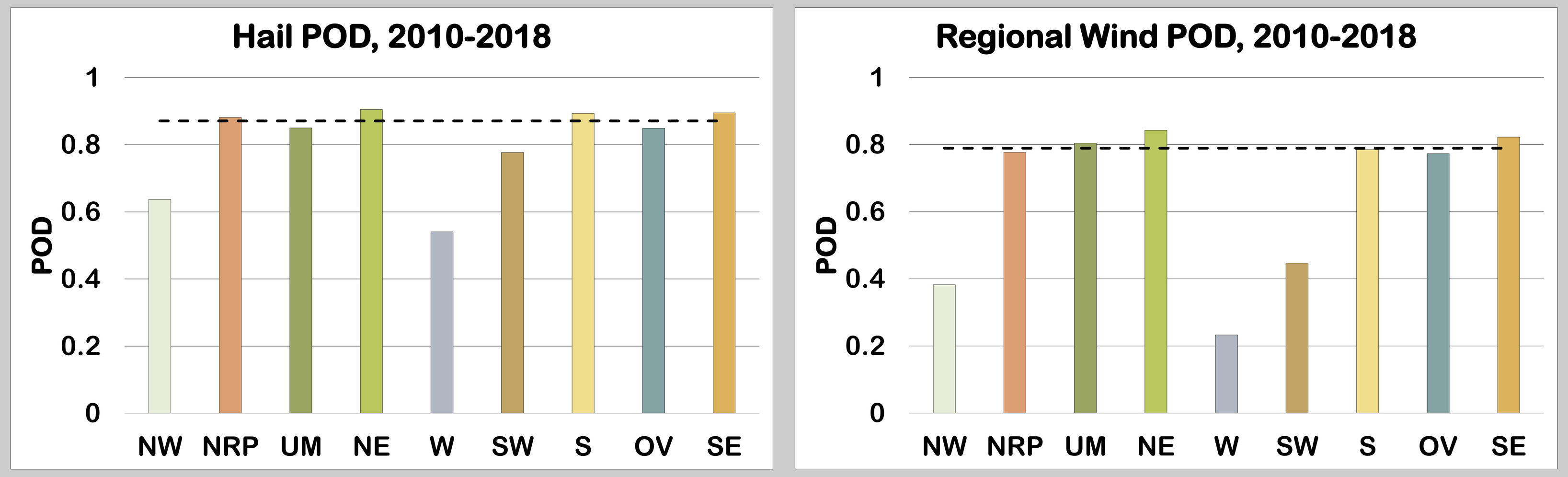

Fig. 3 and 4: Probability of detection (POD) by region for hail (left) and damaging wind (right). Dashed line is CONUS POD.

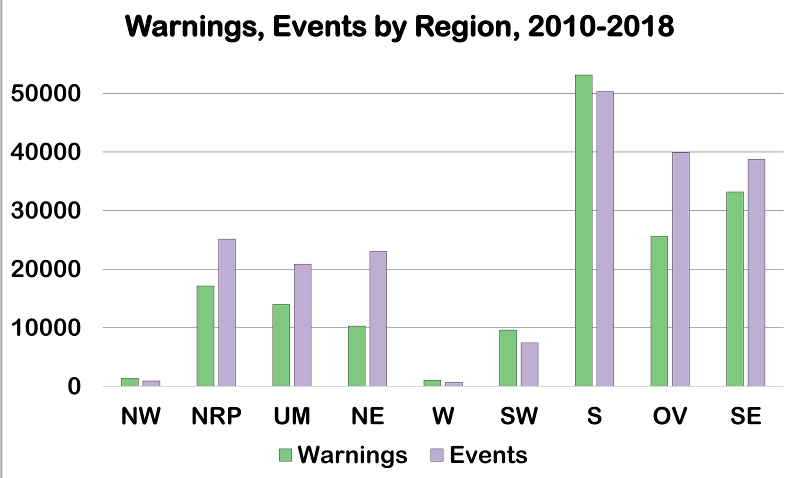

Fig. 5: Number of SVRs, events by Region.

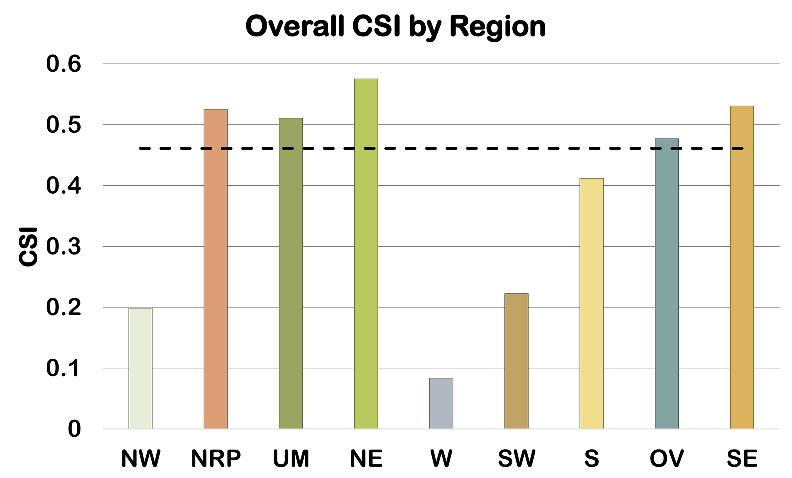

Fig. 6: Overall CSI by region. Dashed line is CONUS CSI.

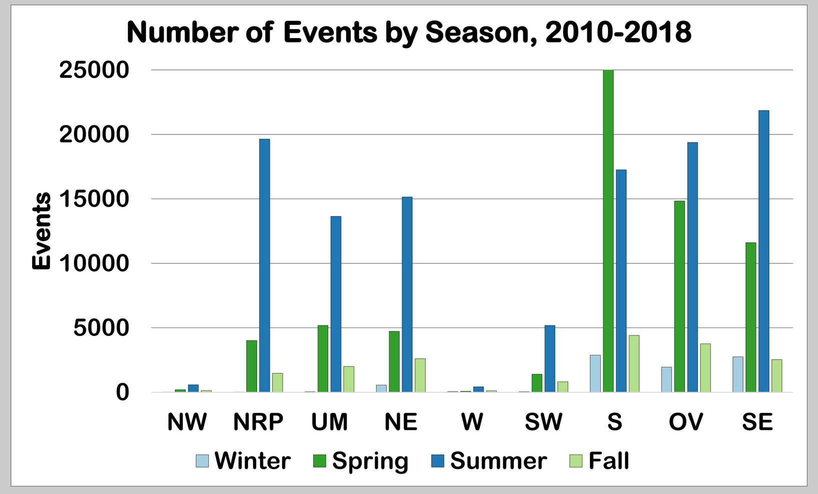

Fig. 7: Regional number of events by year.

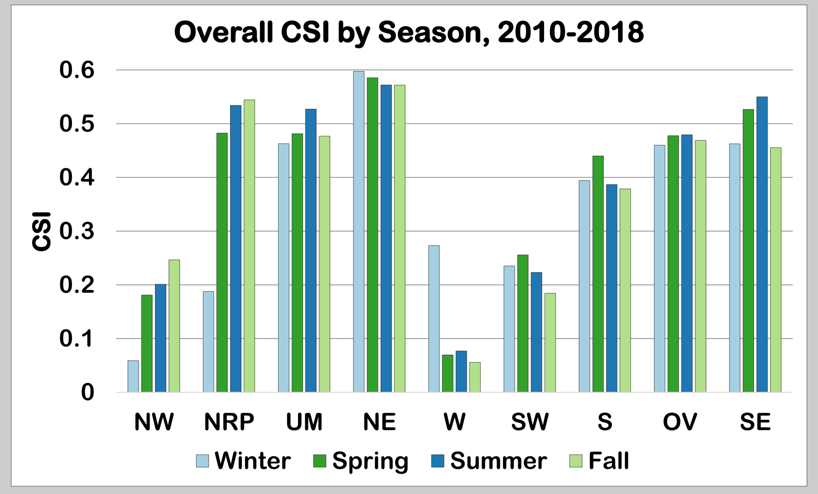

Fig. 8: Regional CSI by season.

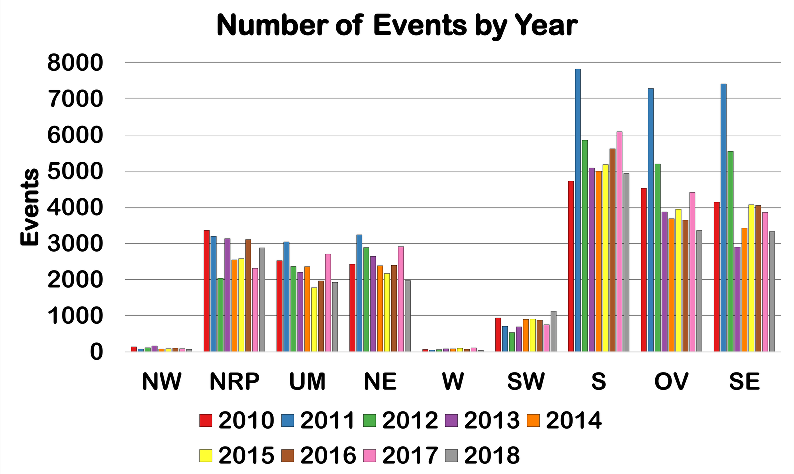

Fig. 9: Regional sum of SVRs and events by year.

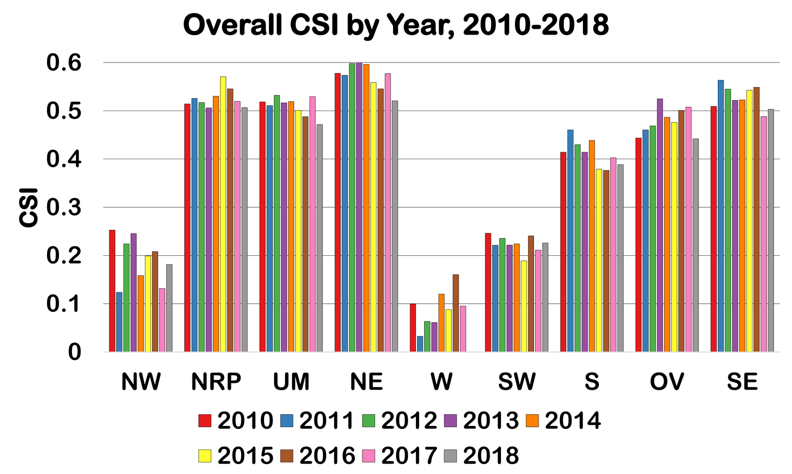

Fig. 10: Regional CSI by year.

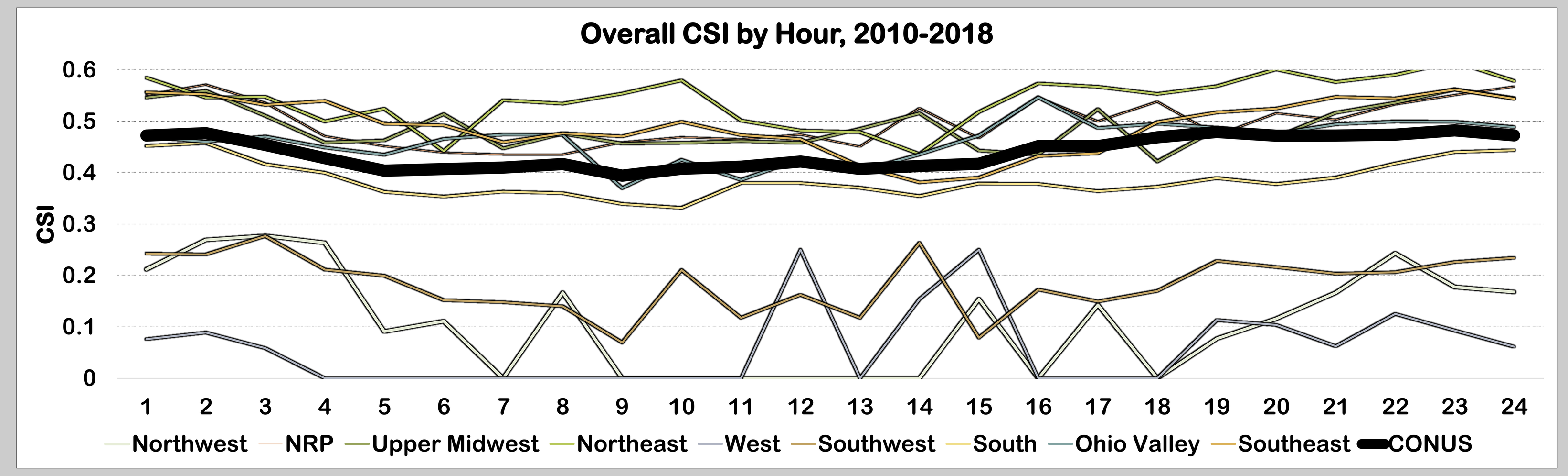

Fig. 11: Regional CSI by hour (UTC).

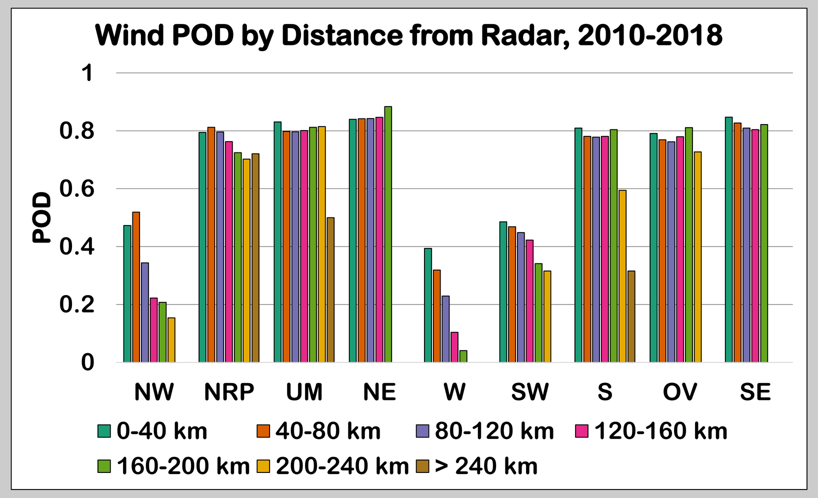

Fig. 12: Regional wind POD by distance from radar.

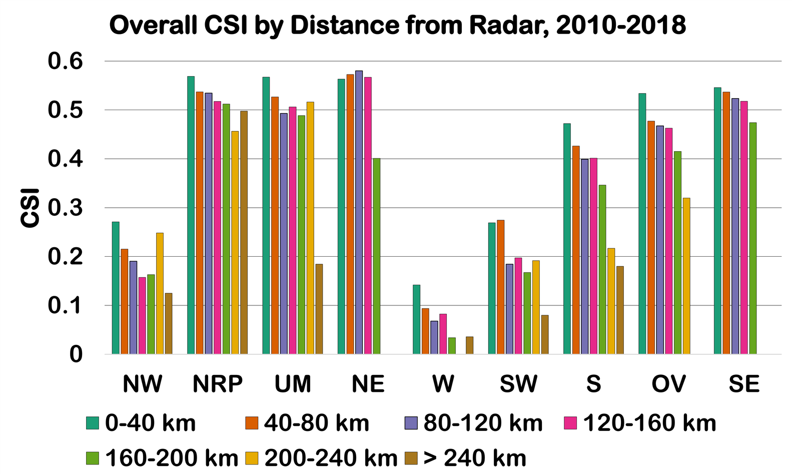

Fig. 13: Regional CSI by distance from nearest radar.

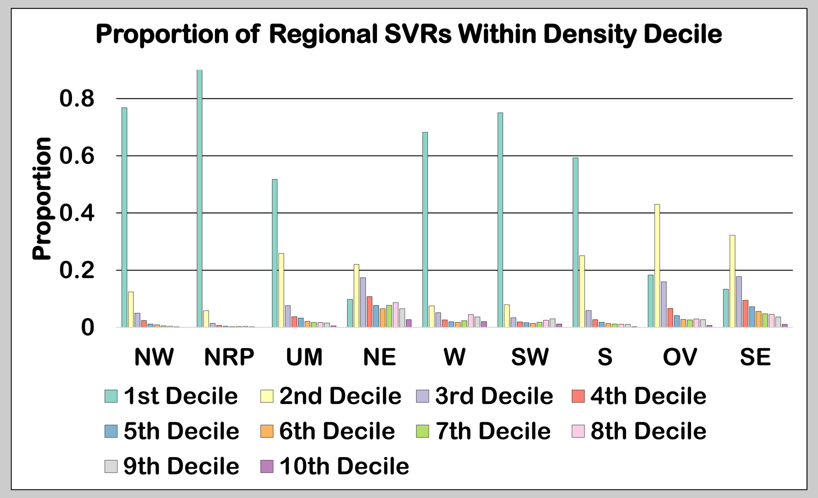

Fig. 14: Proportion of SVRs within each density decile.

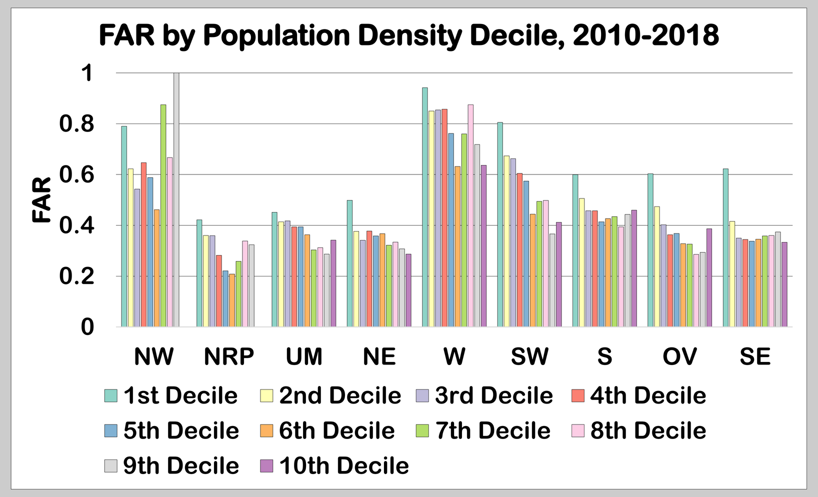

Fig. 15: Regional FAR by population density decile.

4. Discussion and Conclusions

- Wind lagged behind hail POD overall, within every region (Fig. 3 and 4).
- CSI tended to fall as distance from nearest radar increased (Fig. 13), largely due to poor detection of wind events at distance (Fig. 12).
- CSI exhibited a diurnal trend, regardless of region (Fig. 11).
- CSI markedly lower across the western CONUS (Fig. 6), with FAR higher even for SVRs with high resident populations (Fig. 15).
  - Less experience (Fig. 5), more beam blockage issues
- Higher CSI (Fig. 6) tended to occur in regions that experienced more severe weather (Fig. 5) and/or issued proportionally more SVRs in higher population areas (Fig. 13), but this was not always the case
  - NRP performance high compared to amount of severe weather and proportion of SVRs that had low population density (Fig. 13).
  - Ohio Valley performance only slightly better than CONUS despite many events and fewer low population warnings.
- Higher FAR in high population SVRs within several regions (Fig. 15).
  - Population bias for SVR issuance?

- **Recommendations**
  - **NWS training efforts should focus on identifying environments conducive for damaging winds and on exploiting alternative data sources (lightning, GOES-16/17) at long ranges from nearest radar.**
  - **For SVRs issued at night and/or in low population areas, do not overreact if a storm is not yielding any real-time reports.**
- Limitations
  - All reporting biases of Storm Data are present!
  - Beam blockages not accounted for