Impacts of Distance from the Nearest Radar, Time of Day, Resident Population, and Season on Severe Warning Performance

Part I: CONUS Analysis

Janice M. Maldonado-Jaime[1], Philip N. Schumacher[1] ,Alex P. Ferguson[2]

[1]*NOAA/NWS Weather Forecast Office, Sioux Falls, SD*

[2]*NOAA/NWS Weather Forecast Office, Amarillo, TX*

Introduction

- Severe thunderstorm and tornado warnings notify the public about imminent threats to life and property.
- NWS examines the warning performance by calculating the Probability of Detection (POD), False Alarm Ratio (FAR) and the Critical Success Index (CSI). [Brooks, 2004]
- Over the last few years, the national FAR and POD for *only* severe thunderstorms has been 0.48 and 0.78, respectively. [NOAA Performance Management]
  - The goal is a FAR closer to 0.00, and a POD closer to 1.00.
  - CSI maximizes when the FAR is low and the POD is high.
- Warning performance research are mainly focused on how tornado warning verification has evolved by time of year and time of day. [Barnes et al. 2007; Berchoof 2009; Brooks 2004; Brotzge and Erickson 2009; Brotzge et al 2011 & 2013; Keene, et al. 2008]
  - However, a similar study has not been performed for severe thunderstorm warnings, which constitute a large majority of warnings issued across the United States.
  - Over half of non-tornadic convective wind fatalities during 1986-2007 were unwarned. [Black and Ashley 2011]

Objectives

- Examine how severe thunderstorm warning performance varies by hour of the day, season, population density, and distance of the warning or event from the nearest radar across the CONUS.
  - Does the population density impact warning performance?
  - Does the distance from radar impact warning performance?
  - Does the performance vary by time of day and season?
  - Does the performance differ for hail vs wind?
- Identify future research and training to address any of these issues and decrease their impact on warning performance.

Methodology

Data Acquisition (2010-2018)

NWS Performance Management	Hail and wind reports and additional attribute information
Iowa Environmental Mesonet (Iowa State University)	Warning polygons, Impact Based Warnings (IBW) tags
2010 U.S. Decennial Census	Population data classified by deciles

Data Processing

Calculate distance of warnings and events to nearest radar (ArcGIS Program)

→ Classify warnings and events by severe hail or damaging wind. (R script)

→ Was the report in a warning? Y/N

Was the warning verified? Y/N

→ Categorize events:

Non-Significant
Hail < 2”, Wind < 65 kts
Significant
Hail ≥ 2”, Wind ≥ 65 kts

Data Analysis

Warning performance verification:

- Probability of Detection
- False Alarm Ratio
- Critical Success Index

Categories for verified and false alarms warnings:

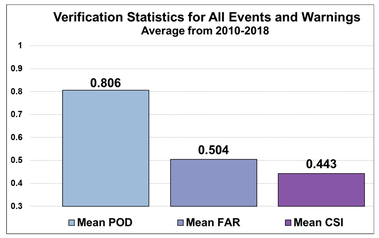
All: All warnings (with or without IBW Tags)
Both : Hail and Wind IBW Tag
Hail : Only Hail IBW Tag
Wind: Only Wind IBW Tag

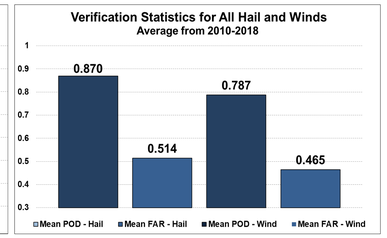
Results

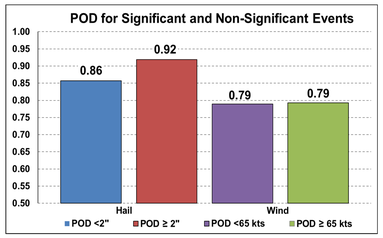
Total Warnings and Events
Average from 2010 - 2018

Total Number of Events	Hit Events	Missed Events
207,087	169,285	37,802

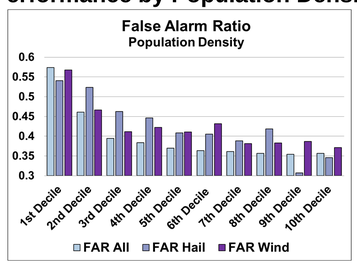
Total Number of Warnings	Verified Warnings	False Alarm Warnings
165,470	85,044	80,426

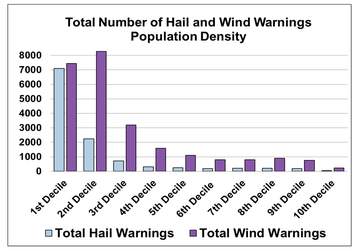


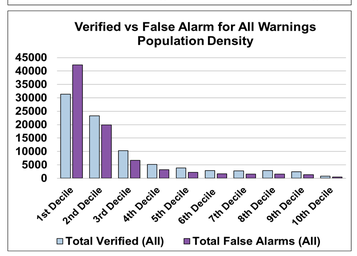




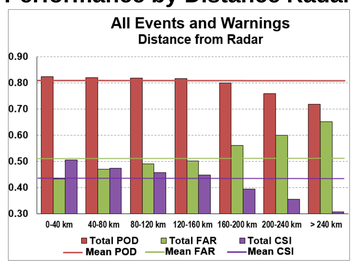
Performance by Population Density

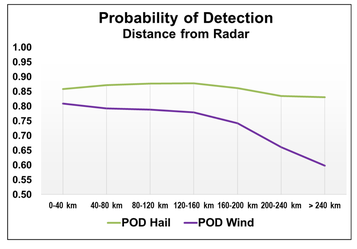


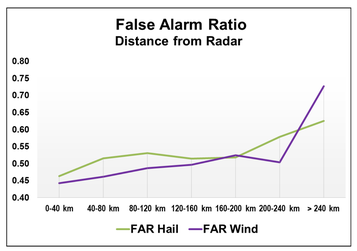




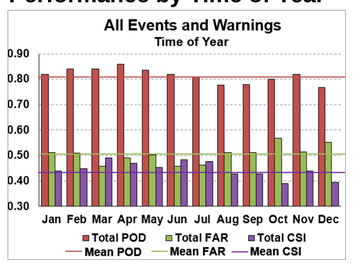
Performance by Distance Radar

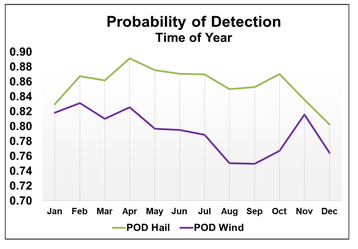


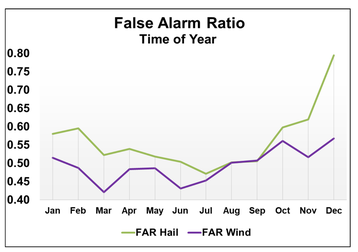




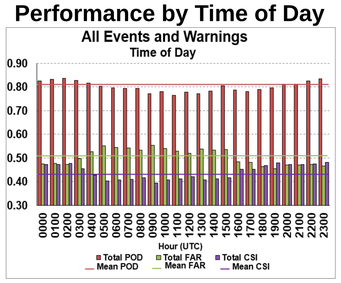
Performance by Time of Year

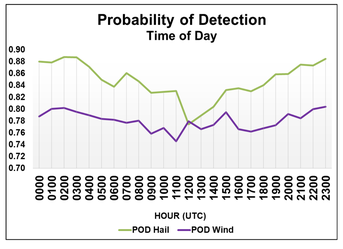


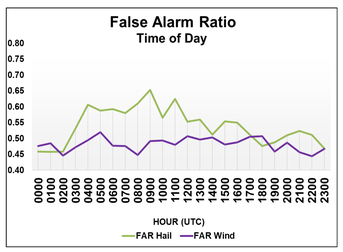




Performance by Time of Day







Discussion and Conclusions

- There were more severe thunderstorm warnings for damaging winds than severe hail from 2010 - 2018.
- Overall, the POD is higher for hail than wind but warnings for winds have a lower FAR than hail.

Does the population density matter?

- FAR increases with less population density.

Does the distance from radar matter?

- POD for Wind decreases with radar distance.
- Best performance for all events is in the first 40 km.

Does the performance vary by time of day and season?

- Warning performance is worse at night regardless of severe weather type (0500-0900 UTC).

Does the performance vary by time of day and season? *Cont'd*

- Total CSI increases from 1400 – 0200 UTC (Diurnal Trend).
- Performance is worse (high FAR) in winter and during the transition season (Spring, Fall).

Does the performance differ for hail vs wind?

- POD for hail events is better than wind events regardless of time of day.
- POD is better for significant hail (≥ 2”).
- There is no difference in POD between significant vs non-significant wind events.

Limitations and Future Work

- Storm data limitations which could impact results include:
  - Sparsely populated areas.
  - More difficulty getting severe reports after 10 PM LT.
- Determine if there are statistically significant differences in results.
- Determine if there are signals in the environmental and radar data to improve warning performance for severe winds.
- Verify high end events (hail/wind) directly against IBW tags for size/magnitude.