# A SPATIOTEMPORAL ASSESSMENT OF TORNADO WARNINGS WITHIN STORM PREDICTION CENTER CONVECTIVE OUTLOOKS USING GEOGRAPHIC INFORMATION SYSTEMS

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## Overview & Objective

### TWO PRODUCTS ISSUED ON DIFFERENT SCALES:

1) **National Weather Service (NWS) Tornado Warning**
   - Short-fuse, polygon-based (since 2007) alert for a forecaster-defined threat area
2) **NWS Storm Prediction Center (SPC) Day 1 Outlook**
   - Daily guidance on locations of forecasted high-risk weather across the continential United States

### STUDY OBJECTIVE:

**Using Geographic Information Systems (GIS), spatial characteristics from these forecaster-defined warnings can be used to develop associations between warnings and other factors.**
**This study provides an empirical analysis of Tornado Warning area, storm motion, and warning performance within different SPC Day 1 Outlook tornado probabilities.**

## Data & Methods

**Study Timeframe:** 12z 01 January 2008 - 12z 01 January 2010

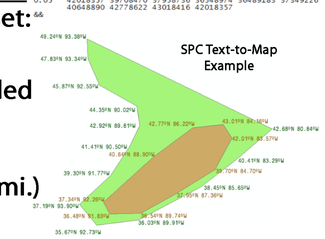
**Totals:** 7923 Tornado Warnings 3228 Tornado Events
3645 SPC Tornado Probability Forecasts

### *THREE SPATIAL LAYERS FOR ANALYSIS*

### 1) SPC TORNADO PROBABILITIES

**Five SPC probability groups in the dataset:**
- 2%, 5%, 10%, 15%, 30%

**Two additional classification groups added for warnings that fall outside all risks:**
- Within 250 mi. from risk (≤ 250 mi.)
- Greater than 250 mi. from risk (> 250 mi.)

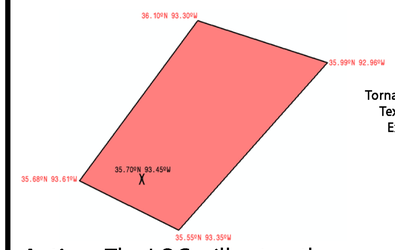



### 2) TORNADO WARNINGS

**Classified as a point based on the TIME...MOT...LOC inputs in the warning**

**SCENARIO 1**
LOC Inside Warning Polygon

```
LAT...LON 3599 9296 3555 9335 3568 9361 3610 9330
TIME...MOT...LOC 2147Z 217DEG 45KT 3570 9345
```

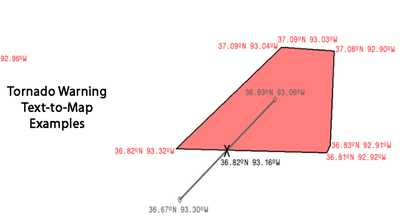



**Action:** The LOC will act as the warning location point

Tornado Warning Text-to-Map Examples

**SCENARIO 2**
LOC Outside Warning Polygon

```
LAT...LON 3709 9304 3709 9303 3708 9290 3683 9291
          3681 9292 3682 9332
TIME...MOT...LOC 2122Z 227DEG 56KT 3667 9330
```




**Action:** A line will be drawn between the LOC and the polygon centroid The intersection will be the warning location point

### 3) TORNADO EVENTS

**Classified as a point based off the latitude/longitude location of first tornado touchdown**

## Polygon Area by Tornado Risk

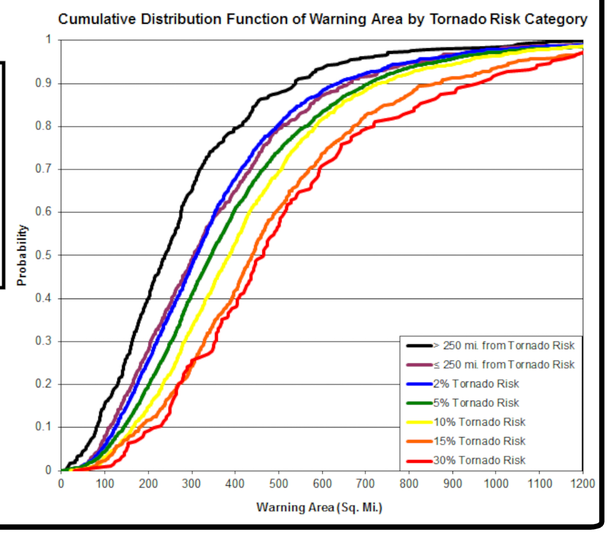
Warnings classified within higher tornado risk categories cover a larger area.

Permutation testing showed statistical significance between areas at the 99% confidence interval for 19 of the 21 comparison groups. The two pairs of comparison groups which did not meet this requirement were:

1) **15% vs. 30%** - Significantly different at the 85% confidence interval
   **FACTOR:** Insufficient sampling of warnings within 30% risk (~2.5% of study)
2) **≤ 250 mi. & 2%** - Exceeded population mean 83% of time
   **FACTOR:** 64% of warnings classified in the ≤ 250 mi. group were < 50 mi. from the 2% risk category

**Mean Warning Area By Tornado Risk Category**

| Category | Warning Frequency | Mean Area (Sq. Mi.) |
|---|---|---|
| > 250 mi. | 418 | 279.62 |
| ≤ 250 mi. | 578 | 359.66 |
| 2% | 1705 | 357.19 |
| 5% | 3048 | 399.96 |
| 10% | 1242 | 430.86 |
| 15% | 740 | 494.09 |
| 30% | 192 | 530.80 |




## Storm Motion by Tornado Risk

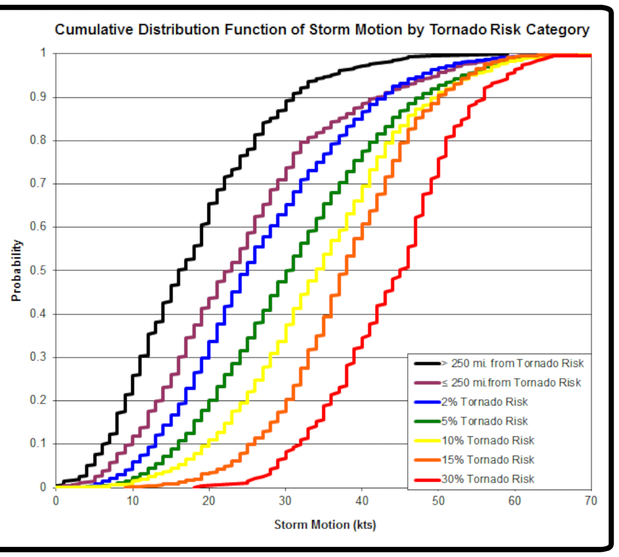
Warnings classified within higher tornado risk categories had faster storm motions.

Permutation testing showed statistical significance between speeds in different categories at the 99% confidence interval for all 21 possible comparison groups.

Faster motions can be a contributing factor in the size of Tornado Warnings. Longer warning polygons would be necessary as a faster moving storm would cover a greater area in a shorter time.

**Mean Storm Motion by Tornado Risk Category**

| Category | Warning Frequency | Mean Storm Motion (kts) |
|---|---|---|
| > 250 mi. | 418 | 17.85 |
| ≤ 250 mi. | 578 | 24.26 |
| 2% | 1705 | 26.67 |
| 5% | 3048 | 31.33 |
| 10% | 1242 | 34.54 |
| 15% | 740 | 37.96 |
| 30% | 192 | 44.18 |




## Performance by Tornado Risk

Three performance metrics were calculated:
- Probability of Detection (POD)
- False Alarm Ratio (FAR)
- Critical Success Index (CSI)

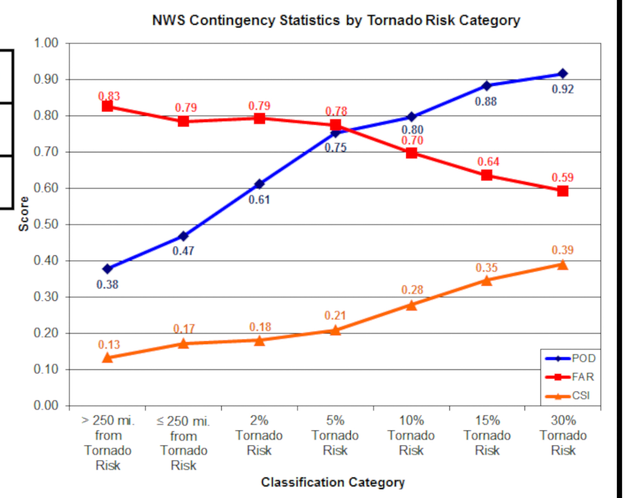
All three metrics showed an overall improvement in performance for warnings classified within higher tornado risk categories.

OVERALL IMPROVEMENT:
**POD:** + 0.539
**FAR:** - 0.234
**CSI:** +0.257

**2x2 Contingency Table**

| FORECAST \ OBSERVED | YES | NO |
|---|---|---|
| YES | A | B |
| NO | C | D |

$$POD = \frac{A}{A+C}$$

$$FAR = \frac{B}{A+B}$$

$$CSI = \frac{A}{A+B+C}$$