Quantifying the Relationship Between Southern-end Supercells and Tornado Production

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Introduction

For decades, there has been a common practice among storm chasers of targeting the southernmost supercell (colloquially known as the "Tail-end Charlie) when there are multiple supercells aligned in a north-south manner (Fig. 1). This orientation is typically the result of a similarly configured surface boundary, such as a cold front or dryline (e.g. Bluestein and Parker, 1993). This practice is based off of the belief that the southernmost storm has the greatest likelihood of producing a tornado due to its relatively uncontaminated inflow and its tendency to remain isolated longer than cells farther north. Indeed, some studies also point to this storm as being favored for longevity and isolation from other storms (e.g. Bluestein and Weisman 2000) for typical northern-hemisphere shear profiles, factors which might favor the success of tornado production of this storm.

This work statistically evaluates the distribution of tornado-producing supercells in the U.S., when multiple (2 or more) supercells are linearly oriented along a north-south axis to determine whether or not the southernmost storms indeed are more prolific tornado producers, or produce stronger tornadoes, than other cells in the line.

Methodology

- Identified cases from the entire 2013 and 2016 calendar years and select cases from 2011 in which there were 2 or more supercells in a north-south oriented line with a distance < 75 km between the supercells for a total of 568 sample storms.
- Used SPC's severe-weather database coupled with WSR-88D radar data.
- Cases were required to have at least 1 mesocyclonic tornado report.
- For each tornado report, documented:
  1. Which supercell in the line produced the tornado, and the EF rating
  2. Whether it was the southernmost storm
  3. How many other storms produced tornadoes within a 20-min window of when the first tornado was produced
  4. The total number of supercells in the line.
- The number of supercells in the line was recounted for each tornado report unless there was < 20 min between consecutive reports to account for convective evolution.
- Produced contingency tables to evaluate (in)dependence between southern supercell tornado production/intensity and tornadoes/tornado intensity produced by other non-southern supercells (Table 1).
- Tornado intensity was calculated based on the destruction potential index (DPI = EF scale x path length (km) x path width (km)) (Thompson and Vescio, 1998).
- Supercell and tornado production numbers were tallied for all cases individually and collectively.
- From contingency tables, calculated expected values, Chi-squared statistics for both tornado production and tornado intensity.

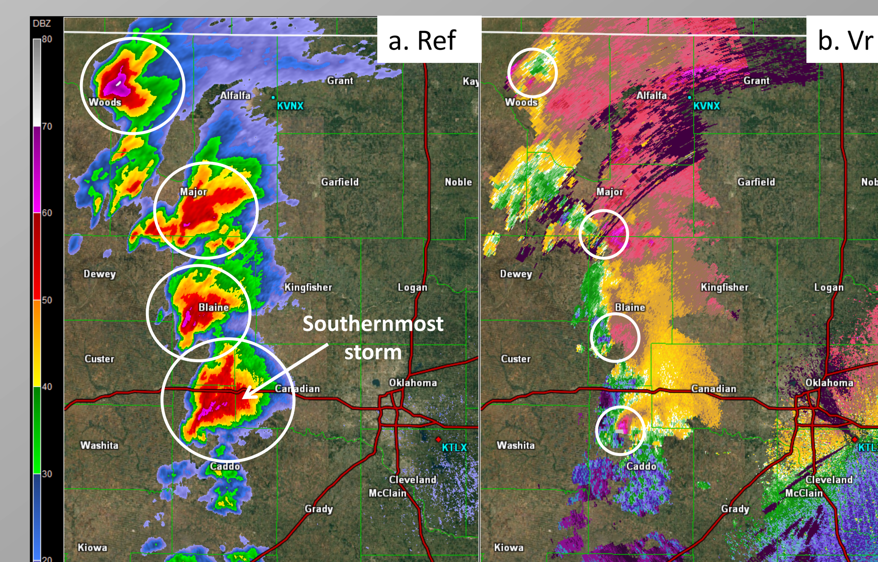

Fig. 1: KTLX Radar reflectivity (a) and radial velocity (b) example of a north-south line of supercells from 2032 UTC, 24 May 2011 in central OK. Circles denote individual supercells (a) and mesocyclones (b).

Fig. 2: Photograph of the EF5 tornado produced by the southern-end storm in Fig 1. © Jana Houser

Description of Event	Number of supercells that produced a tornado	Number of supercells that did not produce a tornado	Total
Number of southernmost supercells	Number of southern-most supercells that produced a tornado	Number of southernmost supercells that did not produce a tornado	Total number of southernmost supercells
Number of non-southernmost supercells	Number of non-southernmost supercells that produced a tornado	Number of non-southernmost supercells that did not produce a tornado	Total number of non-southernmost supercells
Total	Total number of tornadoes produced	Total number of supercells that did not produce a tornado	**Grand total of all supercells**

Table 1: Example contingency table to evaluate for statistical dependence between the relative location of the supercell and whether or not it produced a tornado.

All Events	Number of supercells that produced a tornado	Number of supercells that did not produce a tornado	Total
Number of southernmost supercells	<u>88</u>, *81.3*	<u>102</u>, *108.7*	190
Number of non-southernmost supercells	<u>155</u>, *161.7*	<u>223</u>, *216.3*	378
Total	243	325	**568**
	χ^2 = 1.25	***α ~0.26***	

Table 2: Contingency table for all observed (underlined values) and expected (italicized values) tornado and non-tornado events with respect to whether or not the supercell was the southernmost one. Statistical significance requires $\chi^2 \geq 3.84$.

DPI	0-50	50-100	100-150	150-200	200-250	250+	Total
Southern	<u>79</u>, *81.5*	<u>3</u>, *1.4*	<u>3</u>, *2.5*	<u>1</u>, *0.7*	<u>0</u>, *0.0*	<u>2</u>, *1.8*	88
Not Southern	<u>146</u>, *143.5*	<u>1</u>, *2.6*	<u>4</u>, *4.5*	<u>1</u>, *1.3*	<u>0</u>, *0.0*	<u>3</u>, *3.2*	155
Total	225	4	7	2	0	5	**243**
					χ^2 = 2.78	***α ~0.73***	

Table 3: Contingency table for observed (underlined values) and expected (italicized values) tornado DPI ratings for tornado events, classified by whether or not the tornado was produced by the southernmost supercell. Statistical significance requires $\chi^2 \geq 11.07$.

Results

Various groupings were tested to evaluate tornado production in the southernmost supercell including: number of supercells in the line (N=2, 3, 4+), month of occurrence, geographic location (Northern Plains, Southern Plains, South-central, Midwest), frontal boundary initiating storms. The distance between supercells and environmental parameters were also preliminarily examined for a single case.

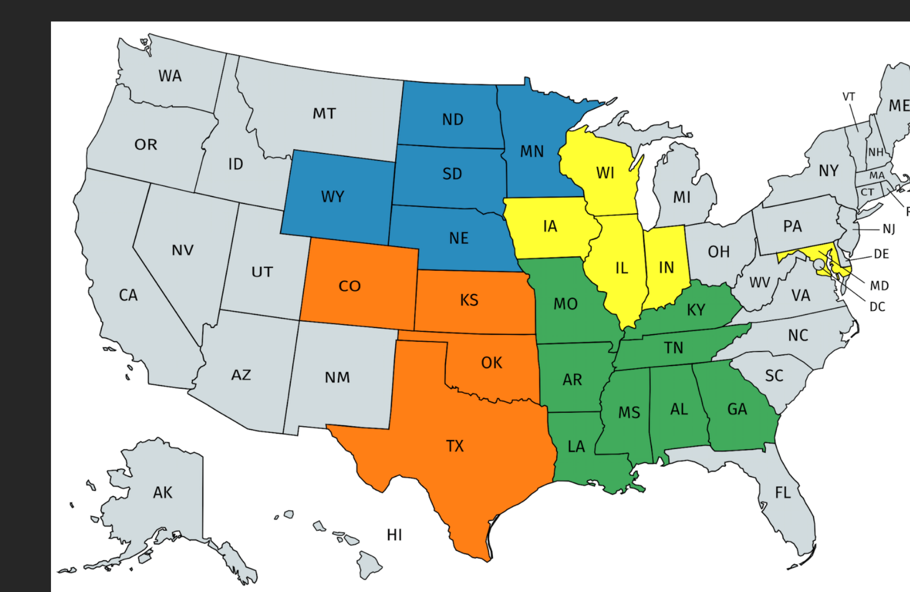

Fig. 3: Visualization of geographic regions. Midwest (yellow), Northern Plains (blue), Southern Plains (orange), and South-central (green).

Note: no tornadoes occurred with lines of supercells in OH, WV, and PA during the years examined.

Conclusions:

1. **When looking at all events combined, *<u>expected values of southernmost tornado production were slightly lower than observed</u>*, signaling a slight tendency for southernmost supercells to produce tornadoes more frequently than expected.**
2. **The tornado production among all the supercells within this study was NOT DEPENDENT statistically on the location of the supercell. (There was a 26% chance that the supercells producing a tornado were dependent on the location of the storm in the line). The southern-end storm was NOT statistically more likely to produce a tornado (Table 2).**
3. **No grouping had a statistically significant dependence between the supercell location and tornado production, although some groupings had a stronger dependence than others.**
4. **When examining the data broken down geographically, southernmost supercells produced tornadoes more frequently than expected in the Southern Plain and Midwest, but the result was not statistically significant.**
5. **The DPI intensity was NOT statistically dependent upon the supercell location (Table 3), so it cannot be said that southernmost supercells produce more intense tornadoes.**

References

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