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A Search for the Most Destructive Tornado Outbreak in the Modern Record (1950-2018).

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Introduction:

This study has focused on the analysis and comparison of the two greatest outbreaks of tornado activity in the modern U.S. record (1950-2018). The most productive 24 hour period of tornado activity for each was selected: 3 April 1974 and 27 April 2011 from 12 am CST to 11:59 pm CST. The 3 April 1974 outbreak totaled 119 tornadoes ranging from (E)F1- (E)F5, 88 of which were significant. The 27 April 2011 outbreak totaled 137 tornadoes ranging from (E)F1- (E)F5, 59 of which were significant. These events far exceed the criteria for a *tornado outbreak*, defined as 6-10 tornadoes in a 24 hour period with intensity \geq (E)F1, and including at least one significant tornado (of intensity \geq (E)F2). The objective of this study was to determine appropriate physical quantities of severity for the two superoutbreaks in order to analyze and compare the extremeness of the events. These identifying quantities are path width, path length, intensity, and the *Total Destructive Index* (TDI).

Analysis and Results:

3 April 1974						
(E)F Scale	Number of Tornadoes (Total = 119)	Mean Path Width (m)	Max Path Width (m)	Path Length (km)	TDI* 10^{10} Max Area (m^4/s^2)	TDI $*10^{10}$ Total Area (m^4/s^2)
1	31	119	151	13.4	0.014	1.53
2	31	171	200	23.9	0.061	6.18
3	29	226	400	29.1	0.362	14.92
4	22	420	590	57.6	1.166	81.03
5	6	394	850	115.7	2.900	182.28

Table 1. The mean path width for all five intensity scales averaged 226 meters, max path width averaged 438 meters, path length averaged 47.9 kilometers, TDI of max area averaged $0.9 \cdot 10^{10} m^4/s^2$, and TDI of total area averaged $57.2 \cdot 10^{10} m^4/s^2$.

27 April 2011						
(E)F Scale	Number of Tornadoes (Total = 137)	Mean Path Width (m)	Max Path Width (m)	Path Length (km)	TDI* 10^{10} Max Area (m^4/s^2)	TDI* 10^{10} Total Area (m^4/s^2)
1	78	123	155	10.7	0.023	1.59
2	34	544	574	12.2	0.497	10.02
3	16	650	823	73.7	1.536	108.48
4	5	862	1031	117.0	3.563	337.78
5	4	856	1312	162.2	6.887	555.72

Table 2. The mean path width for all five intensity scales averaged 607 meters, max path width averaged 779 meters, path length averaged 75.2 kilometers, TDI of max area averaged $2.5 \cdot 10^{10} m^4/s^2$, and TDI of total area averaged $202.7 \cdot 10^{10} m^4/s^2$.

Outbreak Criteria and Destructive Index:

The definition of an outbreak in this study is based on similar concepts presented by Fuhrmann et al. (2014), and Agee et al. (2014). Fuhrmann et al. (2014) study was based on ranking tornado outbreaks in the modern tornado record. The most severe according to his study were 1974 and 2011. Then Agee et al. (2014) study calculated the annual cumulative total kinetic energy for the modern tornado record. Their findings also identified the years 1974 and 2011 as the most extreme events. In the current study calculations were made for the total destructive index defined in equations 1 and 2 listed below.

$$TDI_{Max\ area} = (V_{med} \cdot PW_{max})^2 \quad (1) \quad TDI_{Total\ area} = V_{med}^2 \cdot PW_{mean} \cdot PL \quad (2)$$

In the above equations the total destructive index is calculated for all tornadoes in both outbreaks, and results are presented and plotted in the respective tables and figures provided. But in these equations the TDI_max is calculated for a square area of each tornado determined by maximum path width and the median speed in the (E)F scale.

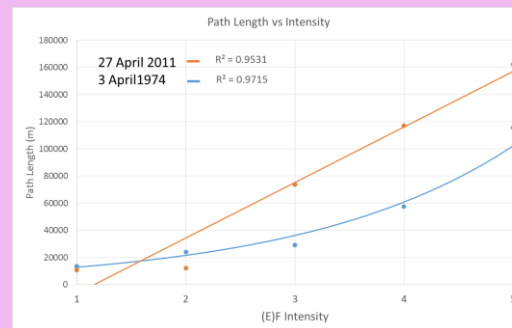


Figure 1. Plots of path length versus the Enhanced Fujita intensity scale for each of the outbreaks. Best line fits explain most of the variance for each. Path lengths are much longer for the 27 April 2011 event, especially for the strong and violent tornadoes.

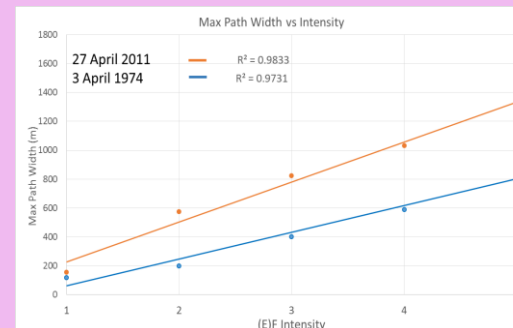


Figure 2. Plots of maximum path width versus the Enhanced Fujita intensity scale for each of the outbreaks. Best line fits explain most of the variance for each. Maximum path widths are much wider for the 27 April 2011 event, especially for the strong and violent tornadoes.

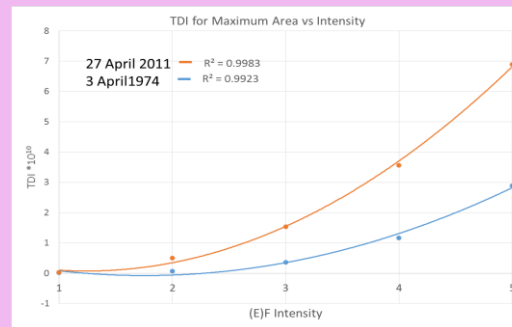


Figure 3. Plots of TDI of maximum area versus the Enhanced Fujita intensity scale for each of the outbreaks. The TDI for maximum area is much larger for the 27 April 2011 event, especially for the strong and violent tornadoes where it is 2-3 times larger. The polynomial fits for the two outbreaks are presented with high degrees of variance explained for TDI for the maximum area vs intensity scale. The 27 April 2011 outbreak is over 2 times more destructive than the 3 April 1974 outbreak.

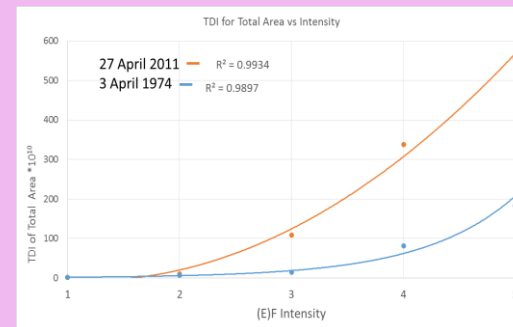


Figure 4. Plots of TDI for total area versus the Enhanced Fujita intensity scale for each of the outbreaks. The TDI of total area is much larger for the 27 April 2011 event, especially for the strong and violent tornadoes where it is 2-3 times larger. The polynomial fits for the two outbreaks are presented with high degrees of variance explained for TDI for the total area vs intensity scale. The 27 April 2011 outbreak is over 2 times more destructive than the 3 April 1974 outbreak.

Summary and Conclusion:

Based on these results of this study the 27 April 2011 outbreak is determined to be the most destructive tornado outbreak in the modern tornado record. The quantities calculated showed the 27 April 2011 was over 1.8 times wider, 1.5 times longer and 3.5 times more destructive power as the 3 April 1974 outbreak. Simply put the 27 April 2011 outbreak was wider, longer and stronger than the 3 April 1974 outbreak. Therefore, the 27 April 2011 tornado outbreak has the most destructive power of the tornado outbreaks in the modern tornado record.

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Tornado data at the Storm Prediction Center, <https://www.spc.noaa.gov/wcm/>