# Contrasting the Environments of Simultaneous and Violent Tornadoes in Supercells

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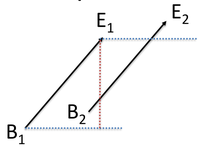
## 1: Introduction and Motivation

- Are environments supporting simultaneous and violent tornadoes different, or are simultaneous tornadoes mainly the result of somewhat random intra-storm processes?
- Simultaneous tornadoes are currently not forecast in routine severe weather outlooks.

## 2: Methodology

- Using the Storm Prediction Center tornado database (1995-2022), we identified pairs of simultaneous tornadoes using a latitude and longitude threshold (Fig. 1).
- The tornado paths must have overlapped in either latitude or longitude (or both) and tracked within 0.2° latitude or longitude of each other.

Example SW to NE Path




Longitude: $B_{1,Long} \leq B_{2,Long} \leq E_{1,Long}$

Latitude: $B_{1,Lat} \leq B_{2,Lat} \leq E_{1,lat}$

Figure 1: Example of two tornadoes categorized as simultaneous tornadoes. B refers to the beginning points and E refers to the ending points.

- Determine storm mode for each tornado pair to confirm that the tornadoes were produced by supercells and not any other storm mode.
- For all pairs, confirm that each tornado is greater than F/EF-1 strength. After applying all constraints, 61 pairs of tornadoes were identified.
- Analyze observed proximity soundings to assess the environment around each supercell. After determining proximity soundings, 28 pairs remained because some pairs did not have proximity soundings.
- Select violent supercell tornadoes with observed proximity soundings that approximately match the seasonal and geographic distribution of the simultaneous tornado pairs (Figs. 2 and 3).

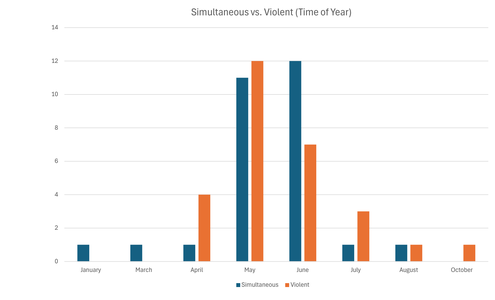



Figure 2: The month when all simultaneous and violent tornadoes analyzed occurred.

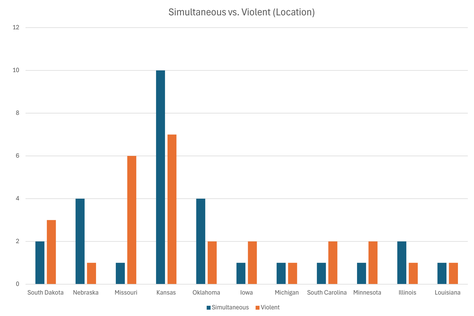



Figure 3: The state where all simultaneous and violent tornadoes analyzed occurred.

- Parameters and proximity soundings were then calculated using Python (Fig. 4).
- Parameters calculated include surface-based and mixed-layer CAPE and CIN, LCL height, precipitable water, 0-500 m, 0-1 km, 0-3 km, and 0-6 km bulk shear, bulk shear direction, 0-1 km and 0-3 km storm-relative helicity (SRH), supercell composite parameter (SCP), significant tornado parameter (STP), and critical angle.
- Parameters were then averaged and compared between the two groups of tornadoes using statistical significance.

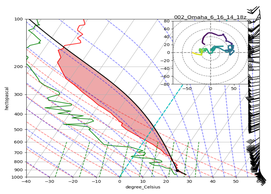



Figure 4: Observed sounding from 1800 UTC 16 June 2014 at Omaha, Nebraska.



Figure 5: Photo of simultaneous tornadoes near Pilger, Nebraska, on 16 June 2014.

## 3: Results

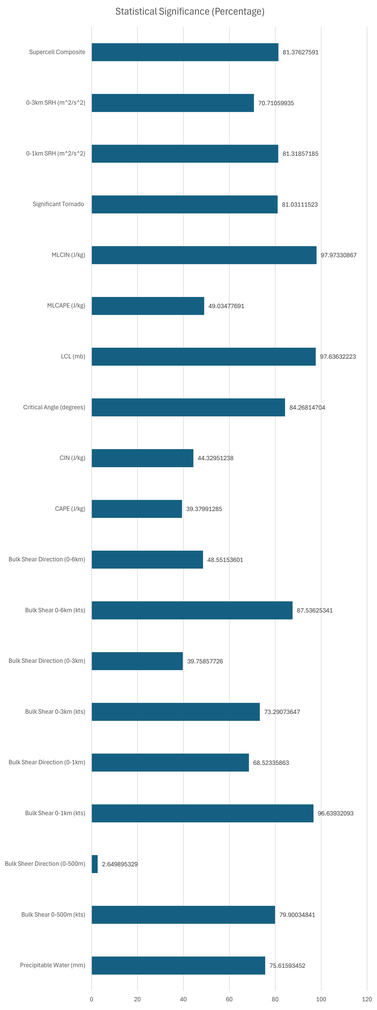



Figure 6: Statistical significance from the two-tailed p-test for each of the parameters calculated.

- We calculated statistical significance using a two-tailed p-test. Statistical significance varied greatly between parameters (Fig. 6).
- The parameters that exhibit the greatest statistical significance are LCL height, MLCIN, and 0-1 km bulk shear (Figs. 7, 8, and 9).

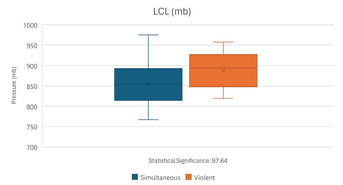



Figure 7: Box and whisker plot depicting LCL height.

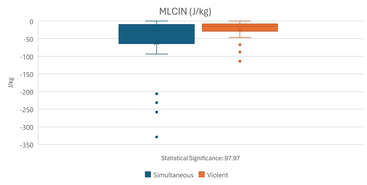



Figure 8: Box and whisker plot depicting mixed-layer CIN.

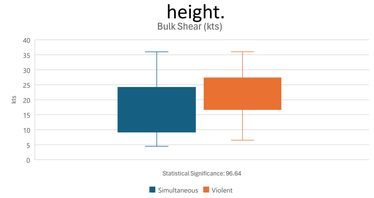



Figure 9: Box and whisker plot depicting 0-1 km bulk shear.

- The parameters that exhibit the least statistical significance are SBCAPE, MLCAPE, and SBCIN (Figs. 10, 11, and 12).

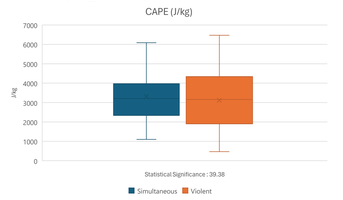



Figure 10: Box and whisker plot depicting surface-based CAPE.

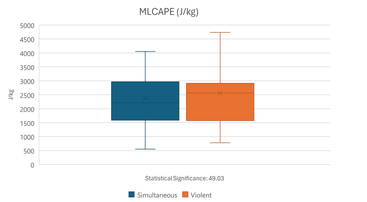



Figure 11: Box and whisker plot depicting mixed-layer CAPE.

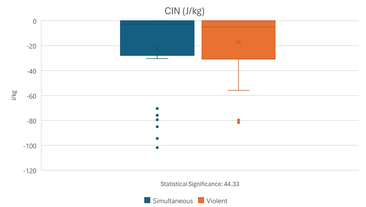



Figure 12: Box and whisker plot depicting surface-based CIN.

- For parameters that exhibit statistical significance > 90%, violent tornadoes occurred in more favorable environments than simultaneous tornadoes, consistent with many previous studies contrasting environments of F/EF-4+ tornadoes and weaker tornadoes.
- Not surprisingly, most thermodynamic variables exhibit poor statistical significance as does the direction of the bulk wind shear vector.

## 4: Conclusions

- There is little distinction in most forecast parameters between environments of violent and simultaneous tornadoes.
- The occurrence of simultaneous tornadoes is likely owing to quasi-random intra-storm processes.
- Future work includes analyzing model soundings and contrasting environments of tornadoes of the same intensity distribution.