Environmental Characteristics of Recent Tornadic Versus Non-Tornadic Events

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Outline

• Direct comparisons (7/26/12 vs. 8/14/12)
  – Four-panel radar imagery
    • Recent Dual-pol study (ZDR and KDP signatures)
  – Synoptic settings
  – Convective parameters

• Relevance to past studies of tornadic vs. non-tornadic supercell environments

• Conclusions
Radar Imagery
Reflectivity + Dual-Pol Variables

Z/ZDR/KDP/CC @ 0007z, 8/15

Z/ZDR/KDP/CC @ 1937z, 7/26

Strong Inflow / WER
Velocity Products

SRM/V/HC/SW @ 0007z, 8/15

- Rot Vel ~ 30 kt

SRM/V/HC/SW @ 1937z, 7/26

- Rot Vel ~ 37 kt
- Inbound maximum ~ 70 kt
Reflectivity + Dual-Pol Variables

Z/ZDR/KDP/CC @ 0020z, 8/15

Z/ZDR/KDP/CC @ 1951z, 7/26
Velocity Products

SRM/V/HC/SW @ 0020z, 8/15
Rot Vel ~ 33 kt

SRM/V/HC/SW @ 1951z, 7/26
Rot Vel ~ 30 kt
Inbound maximum ~ 65 kt
Potential Dual-Pol tornadic signatures

Modeling studies indicate that ZDR arcs on the southern edge of the forward flank precipitation shield, are associated with enhanced storm relative helicity.

Enhanced shear is also indicated by separation between maxima of ZDR (large drops) and KDP (maxima of liquid water).
Reflectivity + Dual-Pol Variables

Z/ZDR/KDP/CC @ 0024z, 8/15

ZDR Arc is still rather ill-defined

KDP max is still displaced west of ZDR Arc

Z/ZDR/KDP/CC @ 1956z, 7/26

ZDR Arc is still well defined

ZDR Arc is still well defined
Velocity Products

SRM/V/HC/SW @ 0024z, 8/15

Rot Vel ~ 30 kt

SRM/V/HC/SW @ 1956z, 7/26

Rot Vel ~ 30 kt

Vel Max ~ 60 kt
Radar Summary

• Overall, each sampled storm exhibited similar traits
  – Well defined inflow / weak echo regions
  – Vr maxima of 30-40 kt at a range of 30-40 nm
    • Moderate mesocyclones

• Newly proposed ZDR / KDP signatures showed promise in this particular comparison
  – More pronounced ZDR arc and KDP separation on 7/26, versus 8/14
Synoptic Setting
Upper-Level (300 mb) Analyses

August 14, 2012 @ 23z

July 26, 2012 @ 20z
Mid-Level (700-400 mb) Analyses

August 14, 2012 @ 23z

July 26, 2012 @ 20z
MSLP Analyses

August 15, 2012 @ 00z

July 26, 2012 @ 18z
Synoptic Summary

• Stronger upper-level jet dynamics on 7/26, versus 8/14
• Both events featured flat progressive short-waves, at the southern edge of the westerlies
• In both cases, convective lines raced well ahead of weak surface fronts/troughs
Convective Parameters
Mixed Layer CAPE

August 14, 2012 @ 23z

July 26, 2012 @ 19z
Deep-Layered Shear (0-6 km)

August 14, 2012 @ 23z

July 26, 2012 @ 19z
Low-Level SR Helicity (0-1 km)

August 14, 2012 @ 23z

July 26, 2012 @ 19z
LCL Heights

August 14, 2012 @ 23z

July 26, 2012 @ 19z
Convective Environment Summary

• With regards to stability (ML CAPE) and low-level moisture (LCL Heights), each case had a very similar back-drop.

• However, fairly large differences were noted in the shear profiles:
  – 40 to 50 kt of shear in the lowest 6 km on 7/26, versus only around 20 kt on 8/14.
  – SRH in the lowest km of about 150 m2/s2 on 7/26, versus less than 50 m2/s2 on 8/14.
Past Studies of Tornadic vs. Non-Tornadic Events
SPC Study (Thompson, et al., 2003)

Percentage of Missing Ingredients

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<th>SRH</th>
<th>SHR</th>
<th>CAPE</th>
<th>LCL</th>
<th>ND</th>
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Table 5: Percentage of missing significant tornado ingredients for each event class (sample size): ST (≥ F2 tornado, 36), T (F0-F1 tornado, 45), SH (≥ 2 inch hail, 142), H (1.75 inch hail, 25), SW (≥ 65 kt wind, 49), W (53-64 kt wind, 7). ND=non-discrete storms, M2 = missing two ingredients, and M3+ = missing ≥ three ingredients.

10th and 90th Percentile Threshold Values

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<th>90th</th>
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Table 1: Significant tornado threshold percentile values for the four sounding-derived ingredients, based on T03. SRH1 = 0-1 km SRH, and SHR6 = 0-6 km bulk shear.
SPC Study (Thompson, et al., 2003)

Percentage of Missing Ingredients

Historically, 0-1 km SRH and 0-6 km Shear have been the Most Reliable Indicators

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10th and 90th Percentile Threshold Values

* For these two cases (7/26/12 and 8/14/12), 0-1 km SRH and 0-6 km Shear were the Best Discriminators

For 0-6 km Shear:
* July 26 – 40 to 50 kt
* August 14 – 20 kt

For 0-1 km SRH:
* July 26 – 150 m2/s2
* August 14 - <50 m2/s2

Table 1: Significant tornado threshold percentile values for the four sounding-derived ingredients, based on T03. SRH1 = 0-1 km SRH, and SHR6 = 0-6 km bulk shear.
Study by Tim Humphries (Past Hollings Scholar)

- Environments of tornadic vs. non-tornadic cases in the WFO BGM CWA
  - Low-level shear parameters were the most reliable discriminators
  - CAPE and LCL heights were less so
0 – 6 km Bulk Shear

Knots (kt)

July 26

Aug. 14

Supercell

QLCS

Multicell

Median

Min

Max
The diagram illustrates the Joules/kilogram (J/kg) of CAPE (Convective Available Potential Energy) for different convective modes: Supercell, QLCS (Quasi-Low-Level Jet), and Multicell. The Supercell has the highest CAPE, followed by the Multicell and then the QLCS, which has the lowest CAPE among the three.
Supercell 0 – 1 km SRH

Meters $^2$/Seconds $^2$ (m$^2$/s$^2$)

- **Verified**
  - July 26
- **Null**
  - Aug. 14

Min, Median, Max markers are shown.
Overall Conclusions

• The two sampled storms in this study had a very similar radar presentation
  – Strong low-level shear and WER’s
  – Tornado warnings were issued for each based on WSR-88D signatures

• However, the results were vastly different
  – July 26 storm turned to be a long-lived supercell, with a number of associated tornadoes
  – August 14 storm had only sporadic wind damage, with no tornadoes
A Few Last Conclusions

• Some similarities, but also important differences noted with the synoptic setting/convective parameters
  – Jet dynamics better on 7/26, versus 8/14
  – ML CAPE (~1000) and LCL heights (< 1 km) nearly the same
  – Much stronger shear on 7/26 (0-6 km shear and 0-1 km SRH), versus 8/14

• Prior work on tornadic vs. non-tornadic settings did indeed show 0-6 km shear, and especially 0-1 km SRH to be good discriminators
The End

Questions ??