Evolution of Shear Profiles Preceding Significantly Tornadic, Tornadic, and non-Tornadic QLCSs

Haniston P. Holloway[1], Isaiah J. Montgomery[1], & Todd A. Murphy[1]
[1]Atmospheric Science Program, University of Louisiana Monroe

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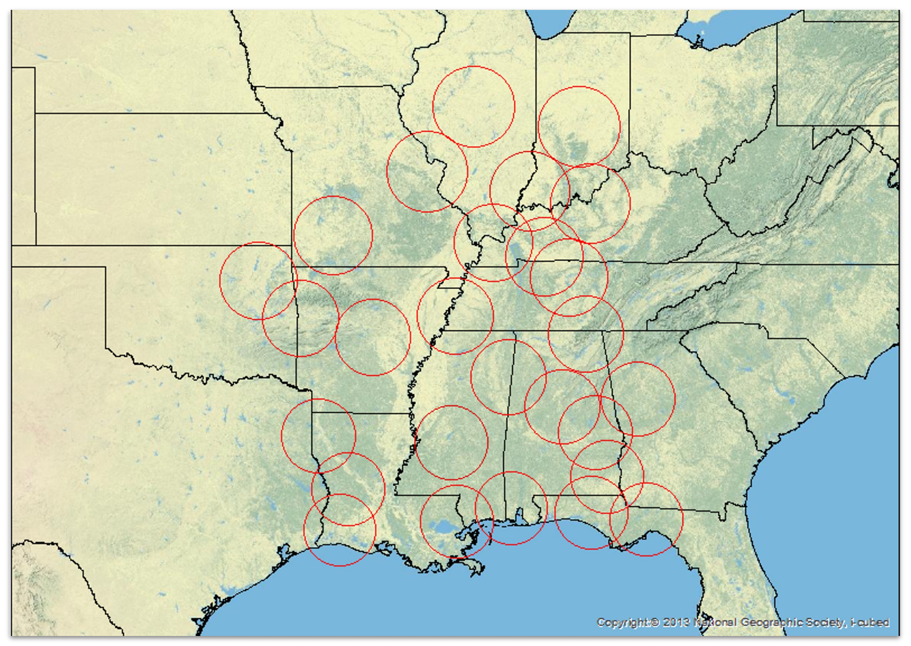
Methodology

In support of the NOAA PERiLS project, this research examines QLCSs (squall lines) across the Southeastern and Central US from 2005 - present within 100 km of NEXRAD sites, with the goal of stratifying QLCSs based on their tornado potential, and track changes in mean wind.



QLCSs were examined if tornado or wind damage reports were produced inside of the range rings shown above.

QLCS events were stratified into 3 subsets:
1. Highly Tornadic - QLCSs that produced 5 or more tornadoes, all within 100 km of a NEXRAD radar in the study area.
2. Weakly Tornadic - QLCSs that produced only a single tornado
3. Non Tornadic - QLCSs that produced greater than 10 severe wind reports but no tornadoes.

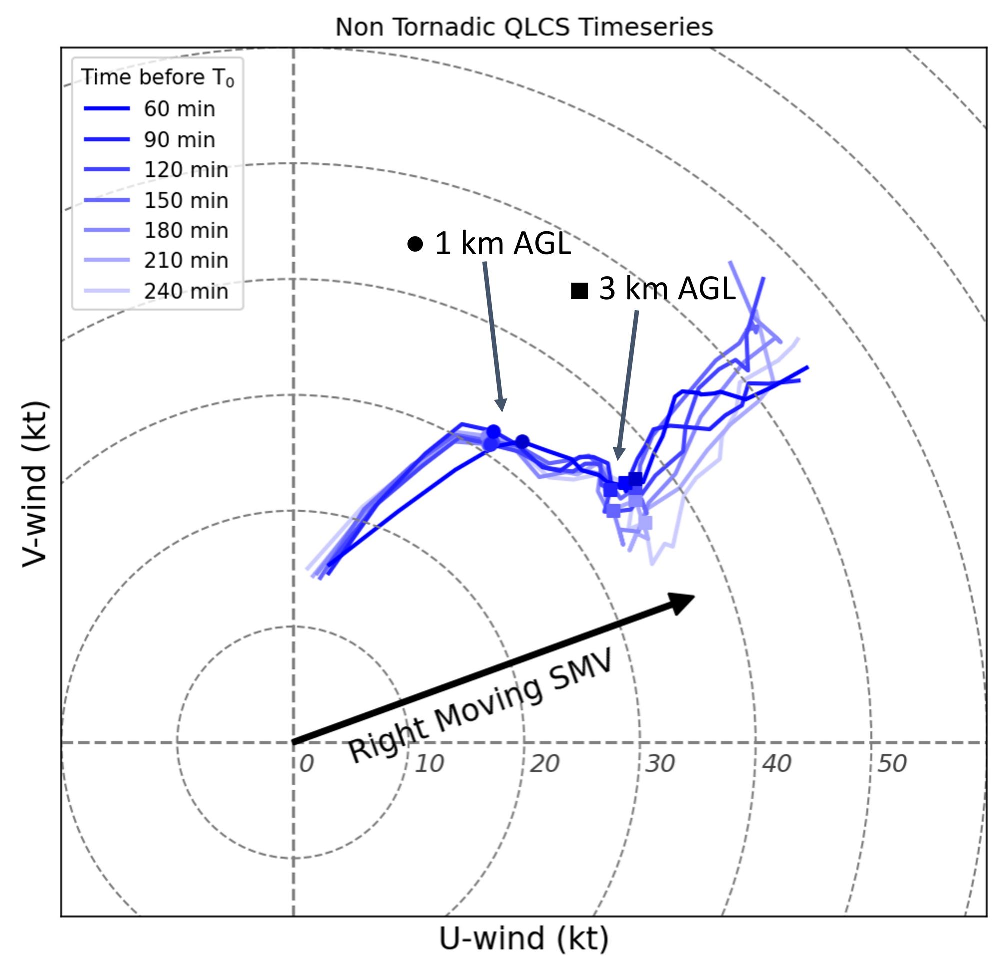
All storm reports are pulled from the Storm Prediction Center Database.

VAD profiles were analyzed and mean wind profiles for each of the 3 subsets were created. Using the mean wind profiles, temporal evolution of hodographs for each subset were analyzed. Wind profiles start 4 hours before the QLCS passes over the NEXRAD site (hereby referred to as T_0), and were averaged to the nearest 15 minute mark before T_0.

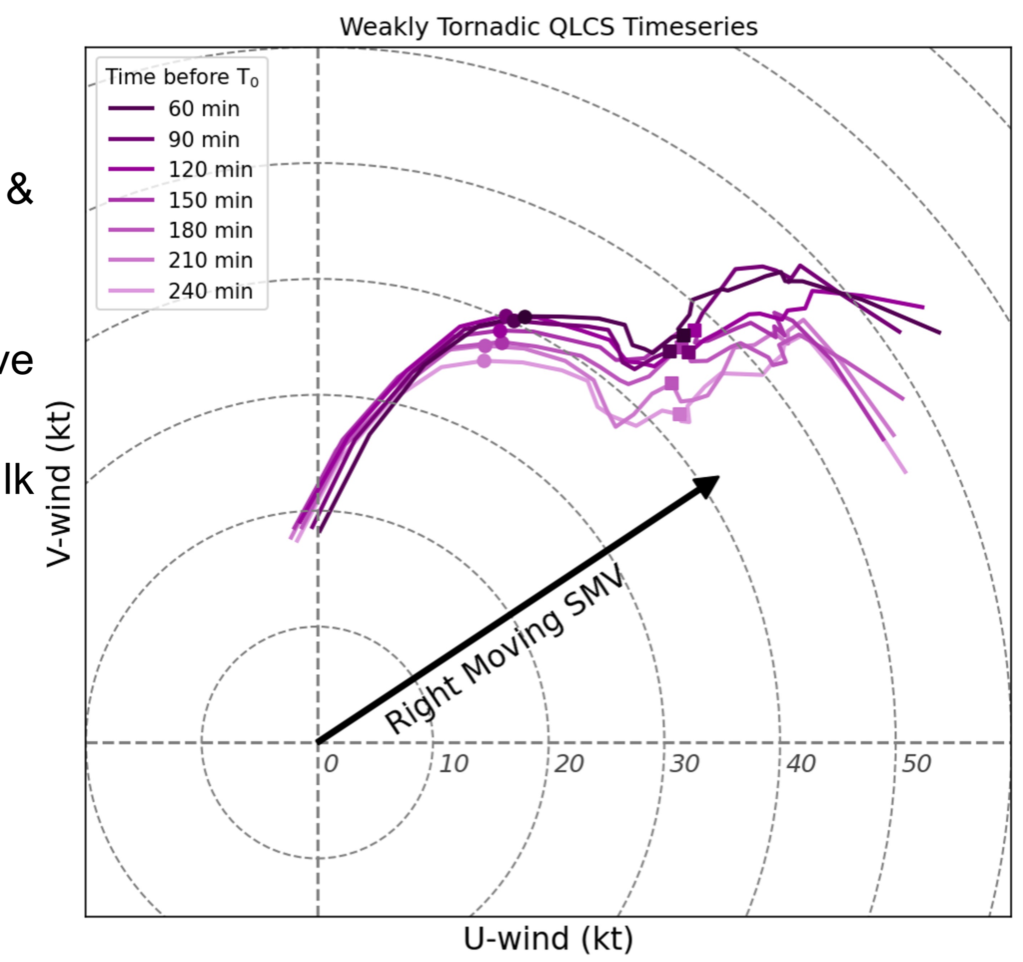
Using MetPy, kinematic parameters associated with tornadic environments were analyzed from the mean wind profiles, including their temporal evolution.

Once a QLCS ≤ 60 minutes away from a radar site, due to slant retrievals occurring at some distance from the NEXRAD, data quality issues begin. For the parameter plots a vertical dashed line represents the end point for the most accurate data.

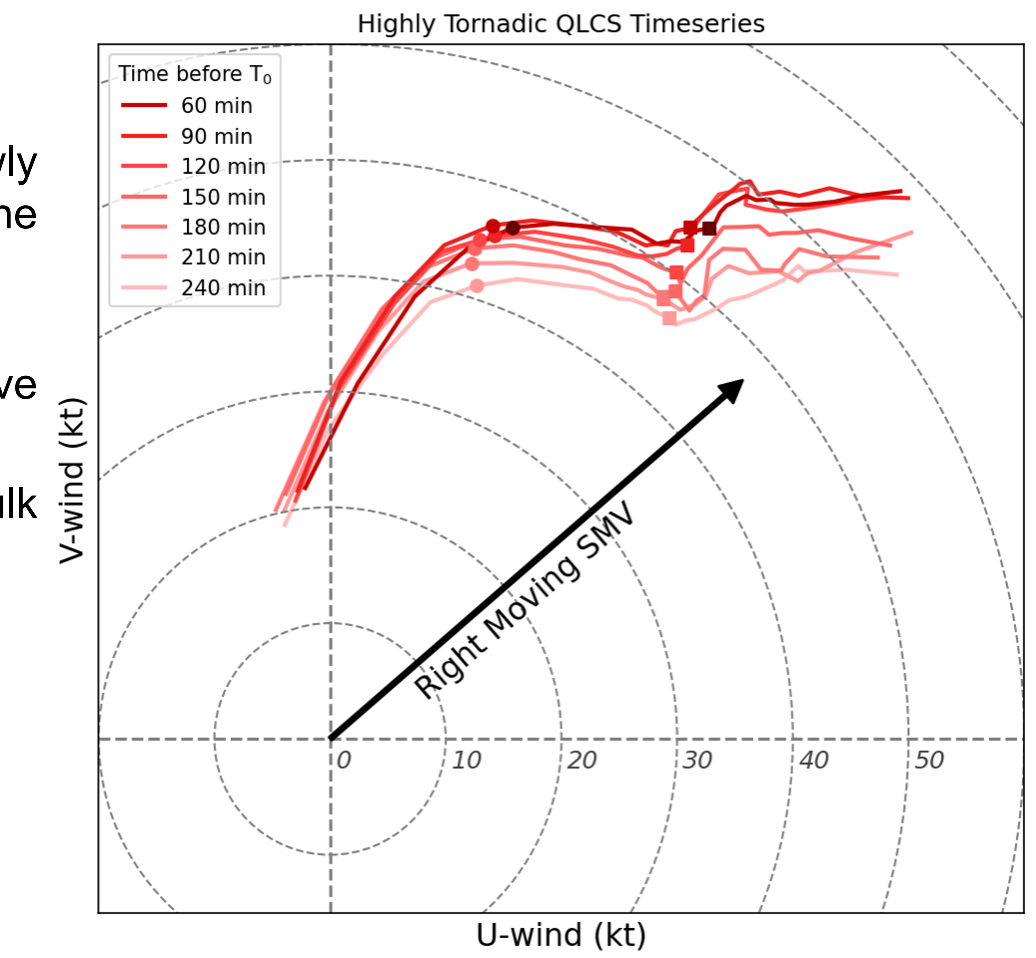
Hodographs



- 55 Cases
- Low shear & helicity
- Strong backing above 3 km
- 0-6 km Bulk Shear ~45 kt

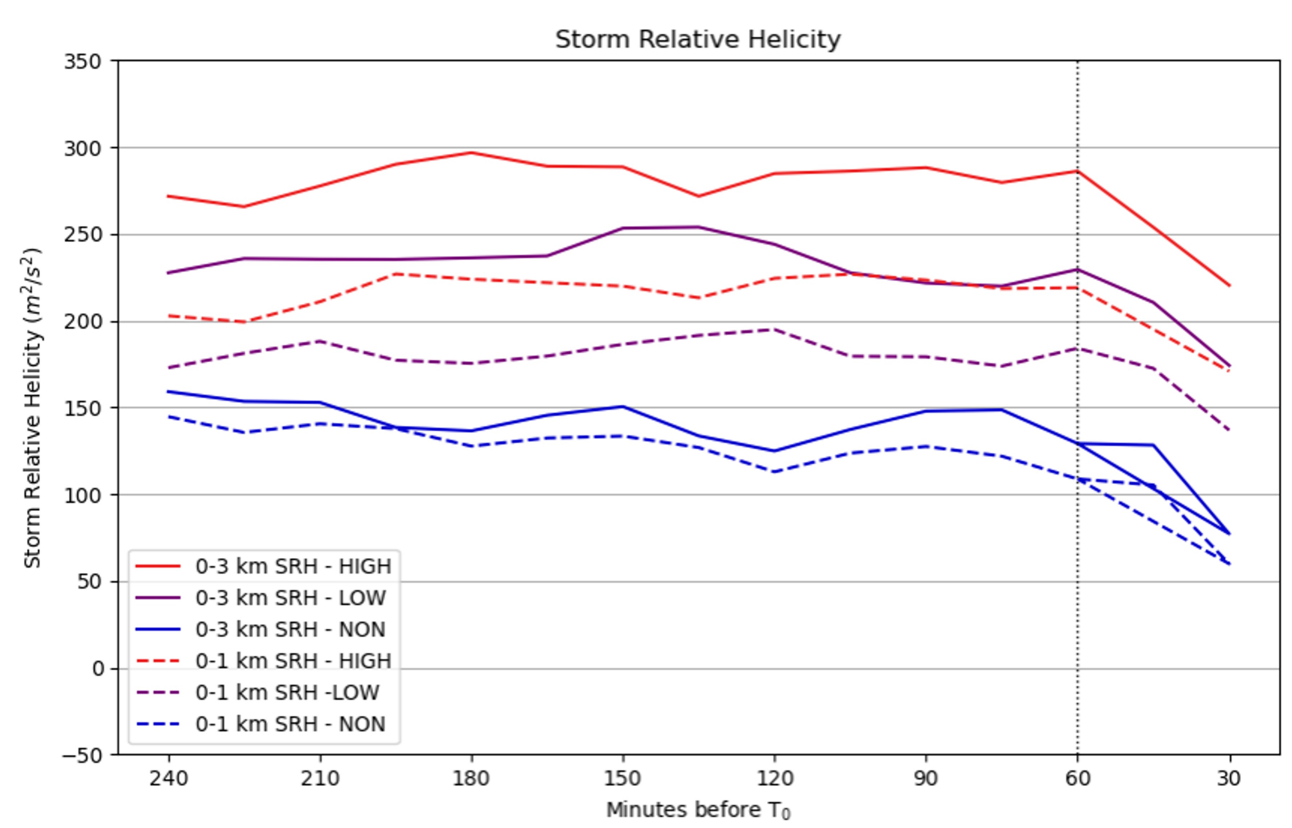


- 48 Cases
- Winds slowly ramp up as line approaches
- Moderate backing above 3 km
- 0-6 km Bulk Shear ~55 kt

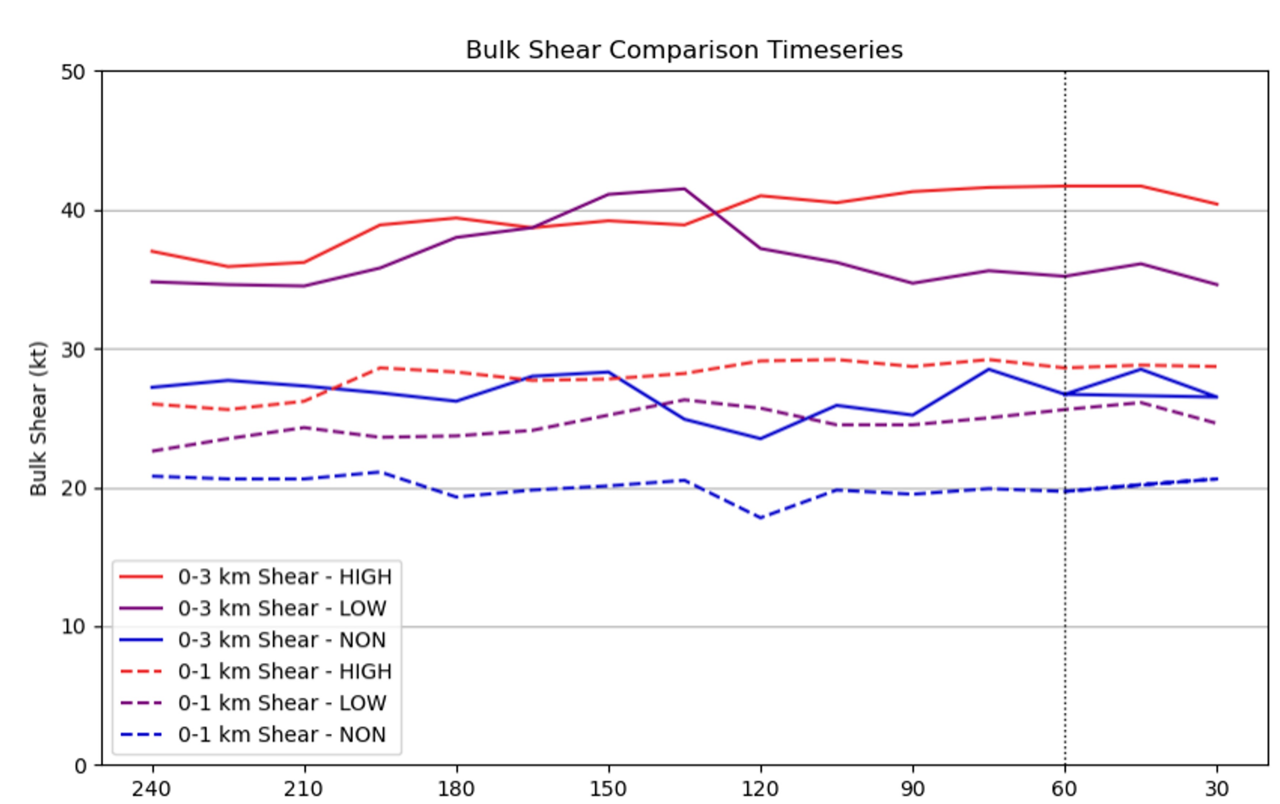


- 76 Cases
- Winds veer & strengthen significantly with time
- Very weak backing above 3 km
- 0-6 km Bulk Shear ~60 kt

Parameter Charts

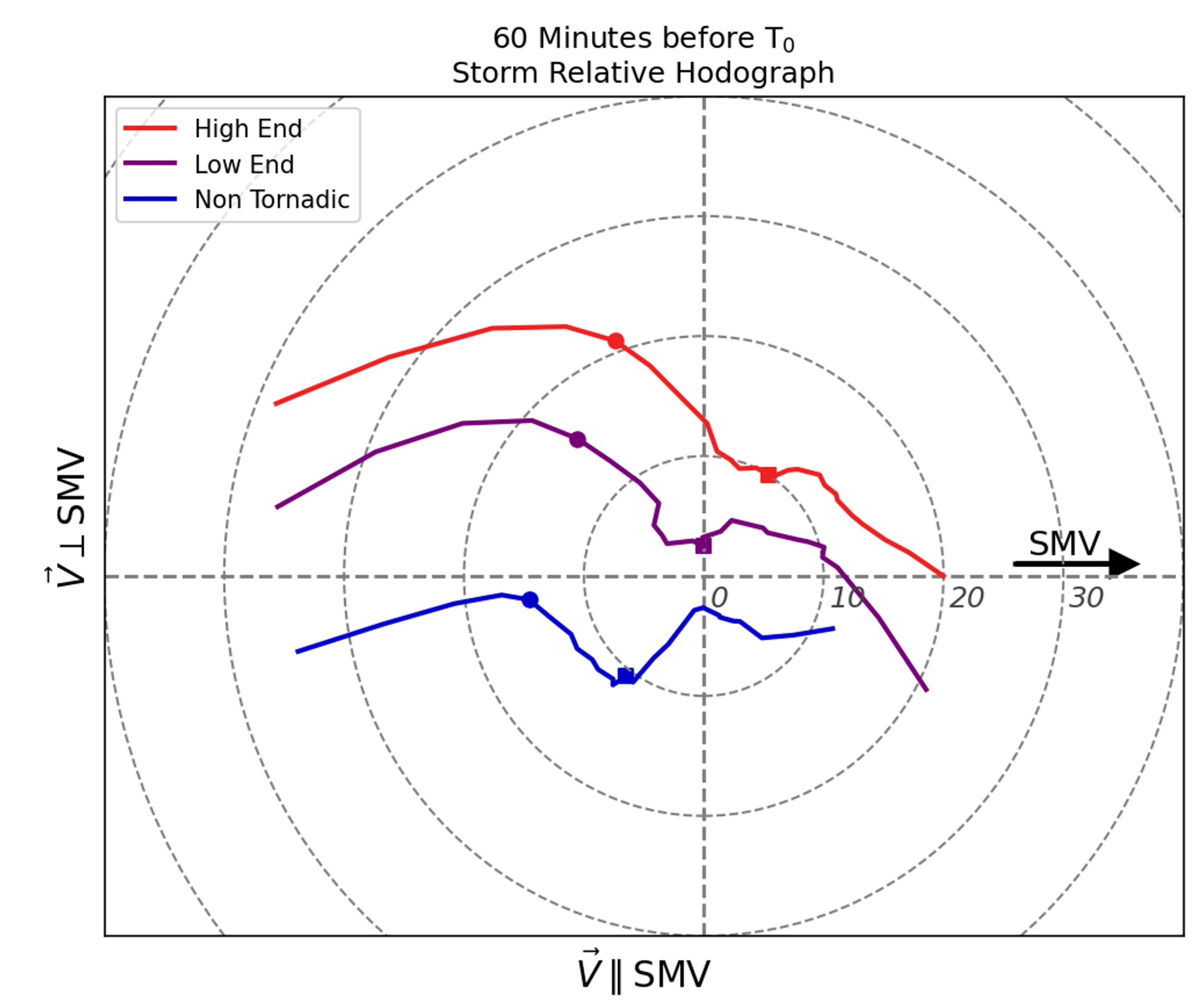


- Highly Tornadic QLCSs have the highest SRH values.
- Tornadic QLCSs have much higher SRH than non-tornadic QLCSs.
- The low-end tornadic QLCSs SRH does not increase with time.



- Highly tornadic QLCSs have strongest increase in shear.
- Low end tornadic QLCSs tend to see decreasing shear.
- 3 km shear > 30 kt is associated with a higher likelihood of tornadogenesis.

Storm-Relative Framework



- Storm relative hodographs where the SMV parallels the + x-axis.
  - Each SMV used is unique to the subset and time shown.
- High end tornadic QLCSs have the strongest SR inflow.
- For non tornadic QLCSs, the SR winds are blowing to the right of the storm motion.
  - This could lead to the ingestion of cooler, downdraft air into the updraft.

Conclusions

Using only NEXRAD data reveals differences between low end and high end tornadic QLCS environments. Higher end environments have stronger winds, as well as more veering in the low levels. As a result of this, shear and helicity are both higher.

Lower end environments are more likely to have backing aloft, which is likely responsible for low numbers of tornadoes when the environment is otherwise supportive. By altering the line motion, significant backing could be limiting the ingestion of streamwise vorticity into the updraft.

Additionally, significant kinematic differences exist between tornadic and non-tornadic environments.

On average, tornadic environments respond more aggressively than non-tornadic environments. Individual cases in the PERiLS field campaign confirm the rapid response in the environment.