Evaluation of Dual-Polarization Radar Signatures in Pulse-Type Severe Thunderstorm Wind Events

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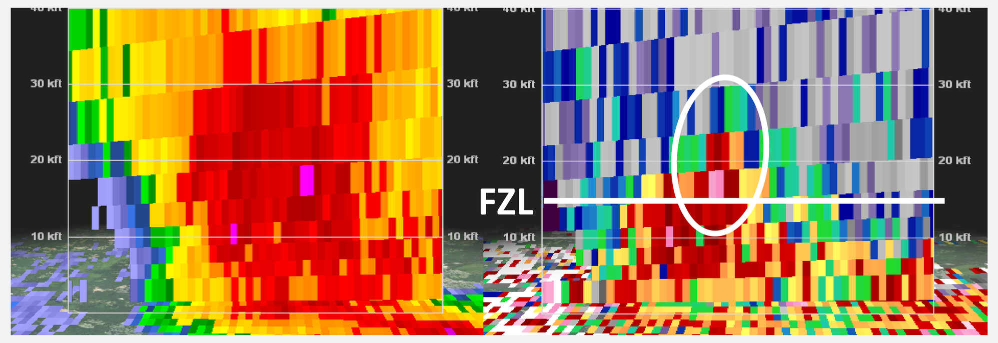
Background

Objective: Investigate usefulness of dual-pol differential reflectivity moment in identifying pulse-type severe thunderstorms in the Southeast, and ascertain how these findings can be applied to NWS warning operations.

Differential Reflectivity (Z_{DR}) Column

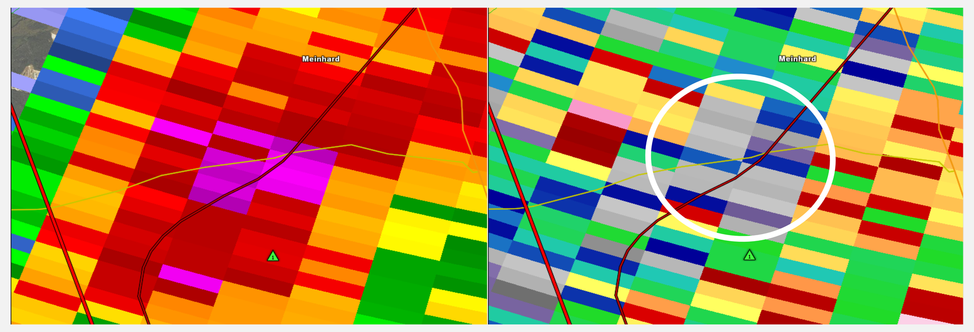
- High Z_{DR} values (supercooled liquid/mixed phase hydrometeors) lofted above the freezing level by updraft



Vertical cross-section of reflectivity (left) and Z_{DR} (right). Z_{DR} column circled.

Z_{DR} Hole

- Low Z_{DR} values (hail/melting hail) well below the freezing level indicating descending air

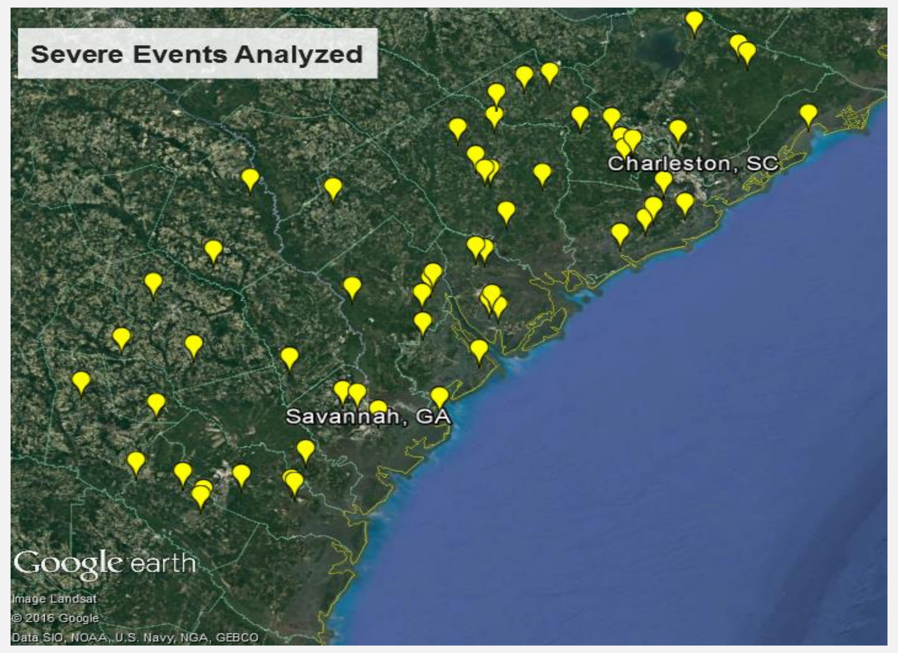


Plan view of reflectivity (left) and Z_{DR} (right). Scan height is about 5 kft below freezing level. Example of Z_{DR} hole circled.

Majority of prior research involved simulations or observations from supercells over the Great Plains, creating need for empirical examination of **pulse storms** in the **Southeast**.

Methodology

- Analyzed 58 pulse-type storms that produced severe (58+ mph) winds or wind damage in WFO Charleston, SC CWA:



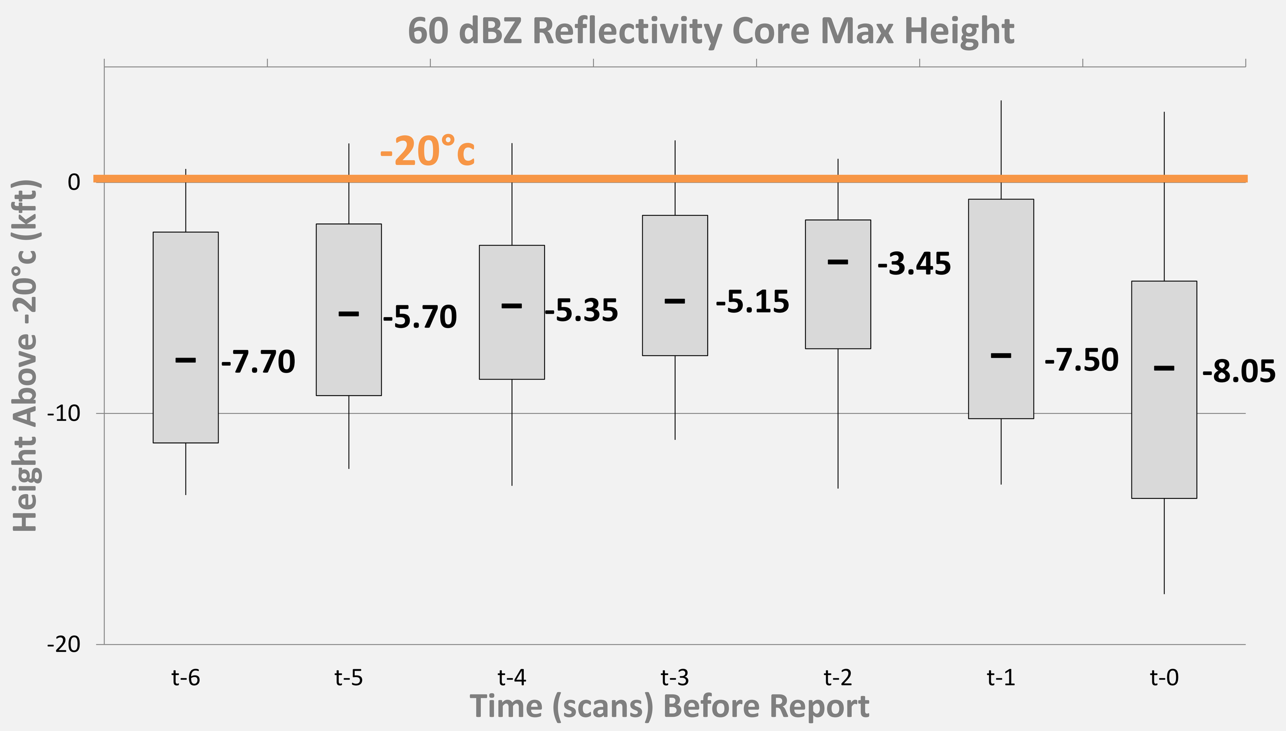
- Each elevation of 7 radar scans (~30 minutes) prior to report time were analyzed for **reflectivity core, Z_{DR} column, Z_{DR} hole, maximum Z_{DR} value above freezing level, storm top divergence, and mid-altitude radial convergence (MARC).**

Reflectivity Core

- The height of the reflectivity (50, 55, and 60 dBZ) core consistently increased up to 10 to 15 minutes before report time, then decreased rapidly within 10 minutes of report.
- The "pulsing" of the storm was most detectable in the 60 dBZ height field, which typically peaked 10-15 minutes before report
- Percent of storms where -20°C level was reached by reflectivity value:

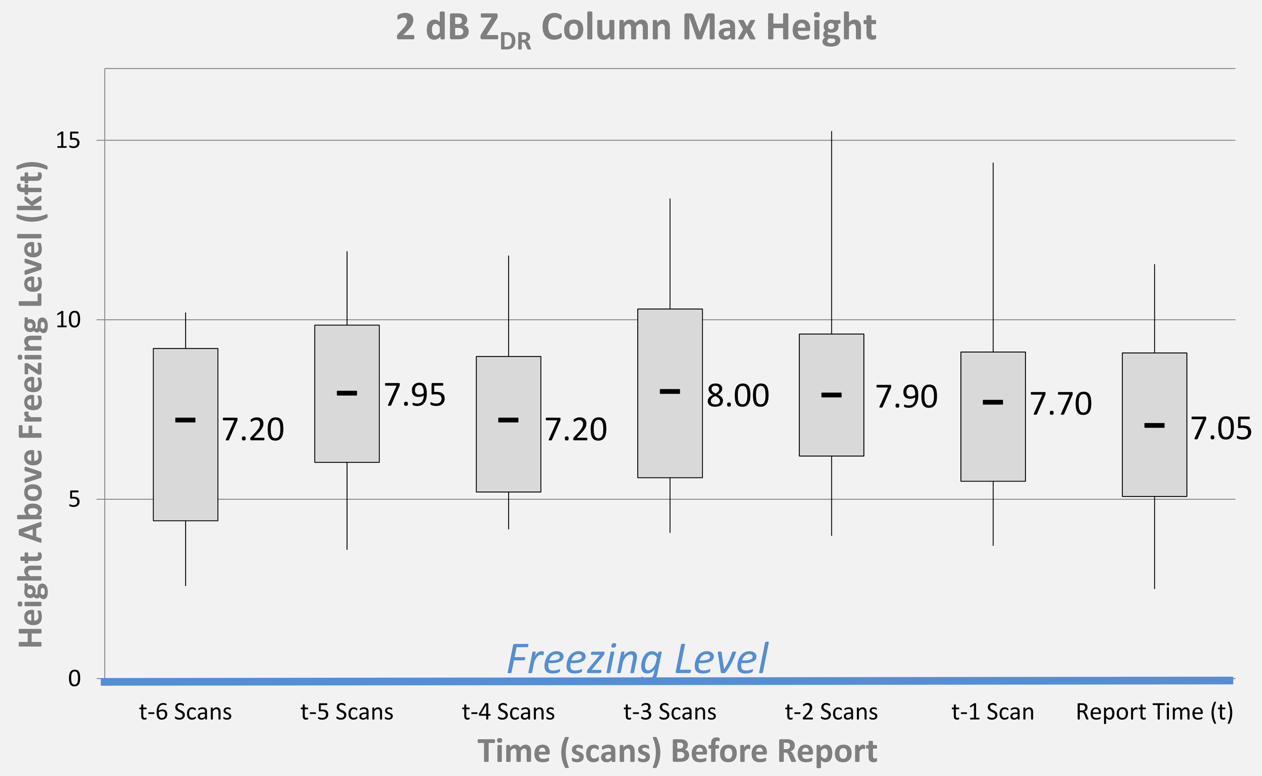
50 dBZ: 76%	55 dBZ: 66%	60 dBZ: 48%

- 65 dBZ did not show any significant signatures, with 40% of storms not even achieving 65 dBZ

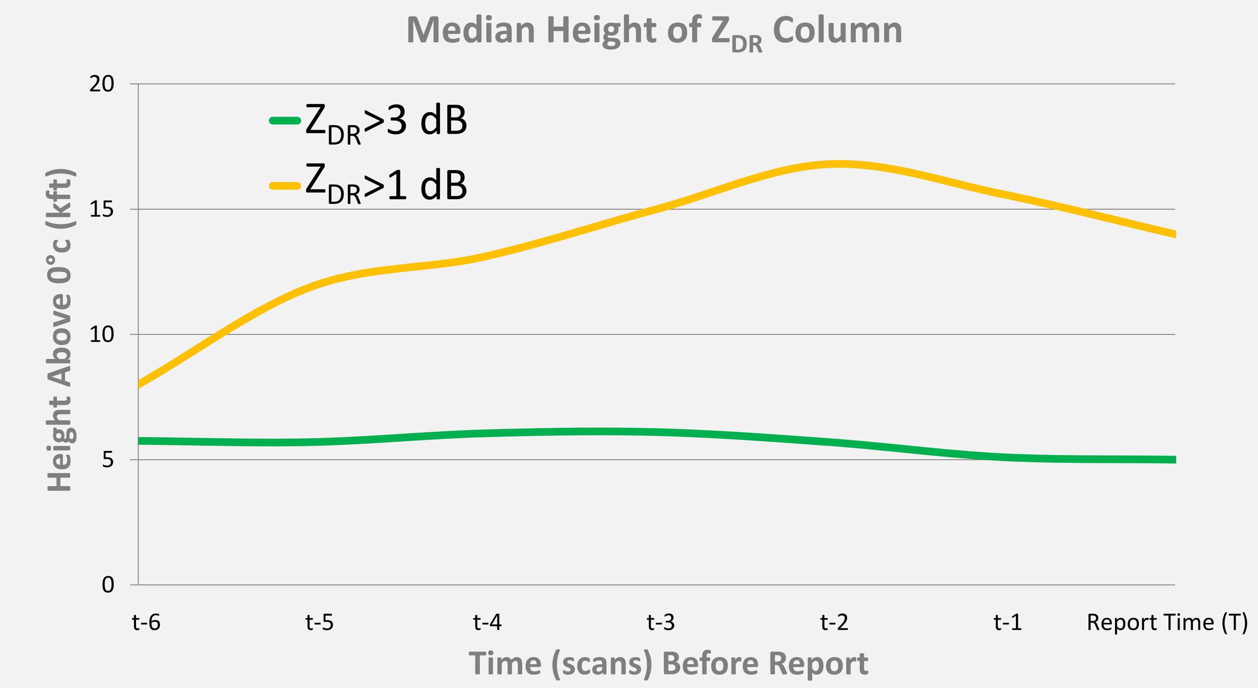


Z_{DR} Column

- Strong, consistent relationship between height of Z_{DR} column (1 and 2 dB) and maximum height of reflectivity core, but not Z_{DR} column height based on 3 dB.
- Z_{DR} column based on the maximum height of 2 dB showed the most consistent signal and, like reflectivity, increased through 10 to 15 minutes before report time before decreasing through report time



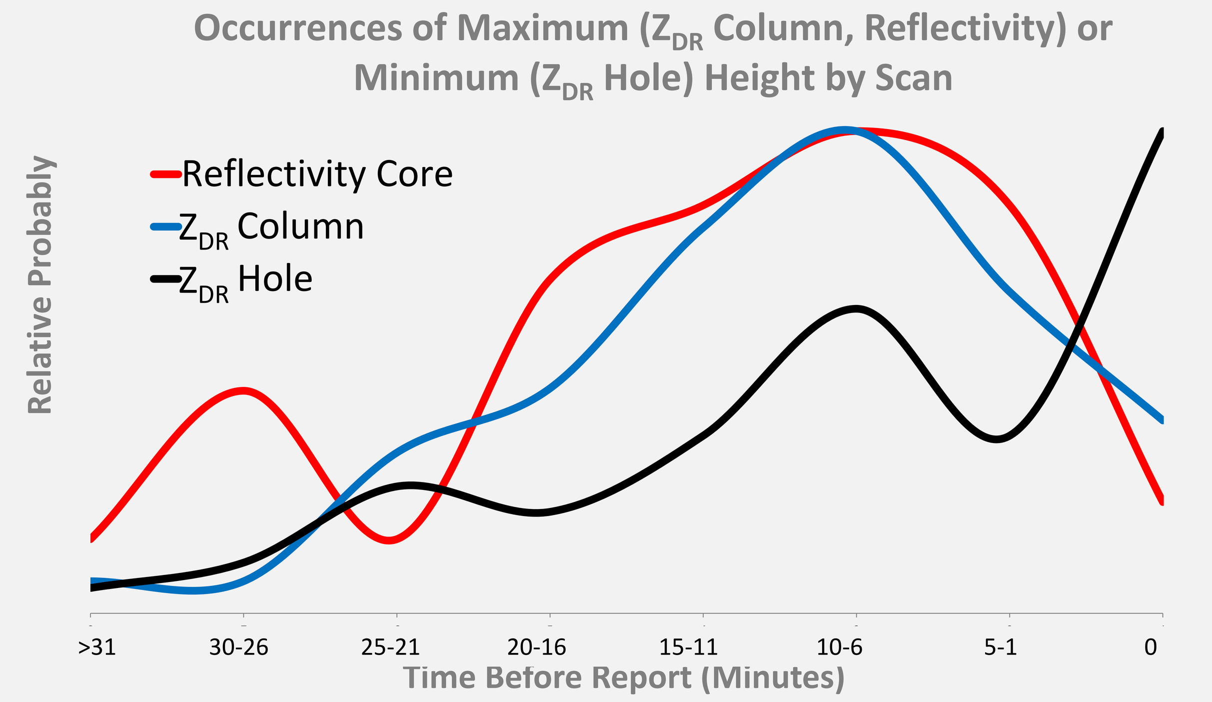
- The Z_{DR} column vertical gradient (difference between 1 and 3 dB height) increased through 10-15 minutes before report time, indicating that "pulsing" of the storm results in significant size sorting.



- There was no consistency in terms of which peaked first: Z_{DR} column or reflectivity core. However, for stronger storms, the two were more likely to peak simultaneously.

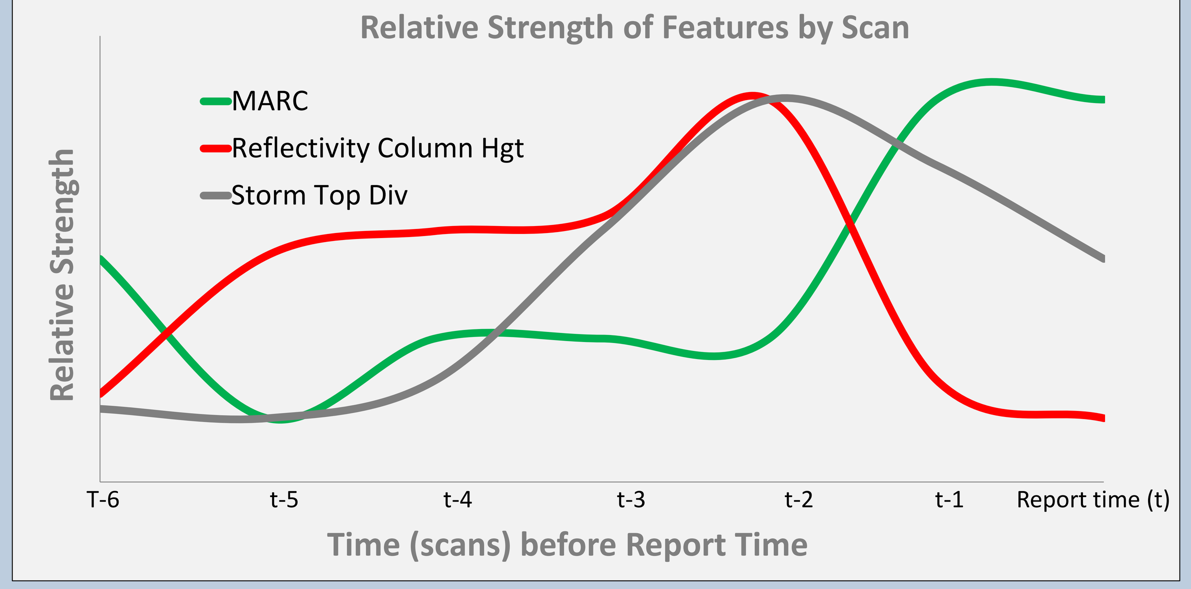
Z_{DR} Hole

- Z_{DR} values of -1 dB were found to be the best indicator of the Z_{DR} hole, as 0 dB was too noisy and -2 dB occurred too infrequently.
- The Z_{DR} hole showed a consistent deepening leading up to the time of the report, with most storms displaying their deepest Z_{DR} hole within 9 minutes of the report time.
- The maximum Z_{DR} column and reflectivity core heights were most often observed 2 scans (~10 minutes) or before report time, whereas the deepest Z_{DR} hole depth most often occurred at the time of the report.



Maximum Z_{DR} and Velocity

- Max Z_{DR} value above the freezing level was well correlated with the height of the reflectivity core and Z_{DR} column, as well as the trend of the height of the reflectivity core.
- Storm top divergence often peaked 10-15 minutes before the report, similar to reflectivity core and Z_{DR} column. MARC signatures were much less common, and surprisingly strongest within minutes of the report time



Conclusions and Future Work

1. The **Z_{DR} column** displayed a well defined signature in pulse thunderstorms, which may be useful for warning decision making. Examining this feature in null (non-severe) events will allow for a threshold value to assist in warning decision making.
2. The **Z_{DR} hole** is evident in pulse thunderstorms as well, though its usefulness in warning operations is likely limited by its more gradual trend, limiting lead time.
3. The **Max Z_{DR}** above the freezing level is related to the height of the storm as well as the trend of the reflectivity, which could be very useful for increasing warning lead time and accuracy. This feature should also be examined for null events to establish a threshold value.
4. Reflectivity core height and storm top divergence, two legacy features currently heavily relied on during pulse warning operations, are further validated based on their easily identifiable patterns. MARC remains a relatively unreliable feature for pulse convection.

Acknowledgements

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