Developing a Tornado Debris Signature Algorithm

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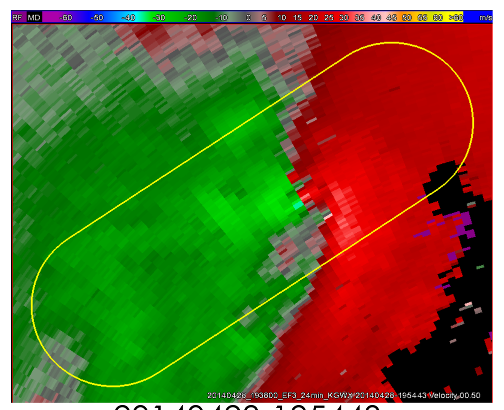
Defining a Tornado Debris Signature (TDS)

Tornadic debris contains a diverse range of shapes, sizes, and orientations of meteorological and non-meteorological scatters. When debris are lofted into the beam of a polarimetric radar, a tornadic derbis signature (TDS) is formed.

Importance and Impacts

A TDS observation can provide a warning forecaster with confirmation of a damaging tornado, especially in events where ground truth may not be available such as when the tornado is rain-wrapped or occurring at nighttime.

Characteristics of a TDS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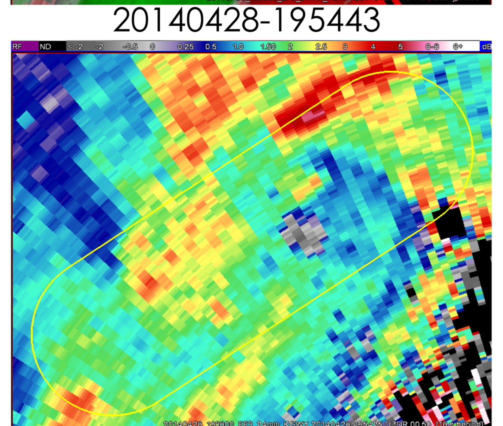
Presence of velocity couplet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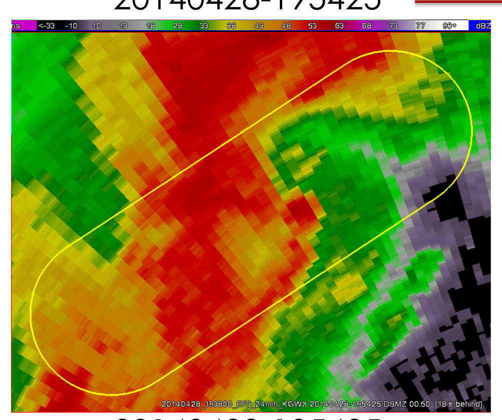
Decrease in differential reflectivity (Z_{DR}) to around zero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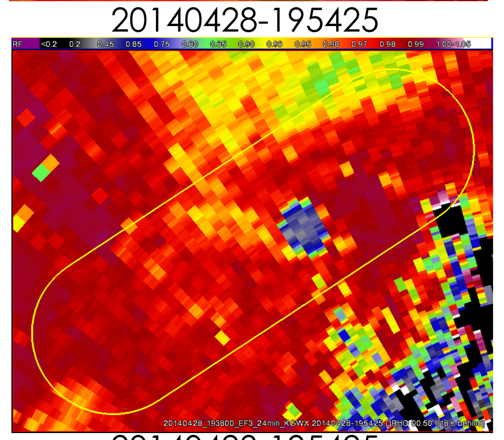
Increase in horizontal reflectivity (Z_H)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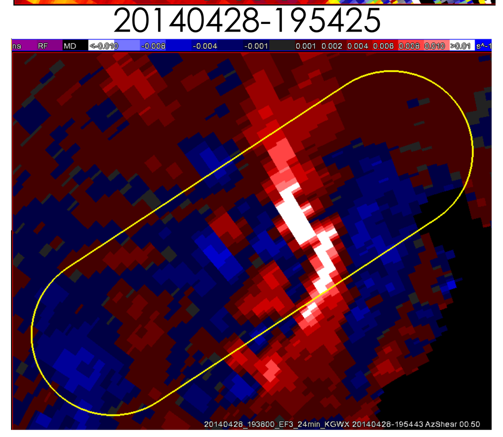
Decrease in co-polar cross correlation coefficient (ρ_{HV})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Higher values of azimuthal shear as a proxy for vertical vorticity

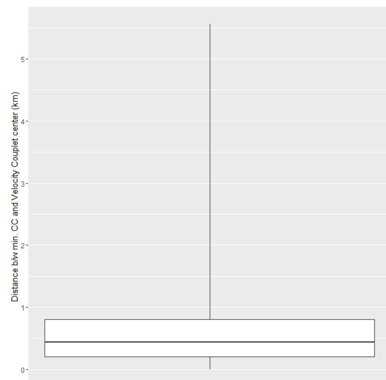
Challenges of a Standalone Algorithm

The offset of the time between the polarimetric moments and azimuthal shear. Polarimetric moments are collected before velocity data on separate revolutions of the radar.

Note* The difference in timestamps due to the split cuts of lower tilts

Manual vs. Automated Tracking

Previous research has shown that manual versus automated identification resulted in different parameter distributions, and low-level elevation scans on the WSR-88D separate the surveillance and Doppler scans, which can lead to disparate locations of polarimetric signature and Doppler velocity couplet.



Note* The whiskers on this boxplot denote the full range of the data. (0th to the 100th percentile)

Methodology

"Definite/Maybe/Loose" Classifications

Definite TDS

- Velocity couplet
- Minimum in ρ_{HV} values
- Reflectivity greater than 40 dBZ

Maybe TDS

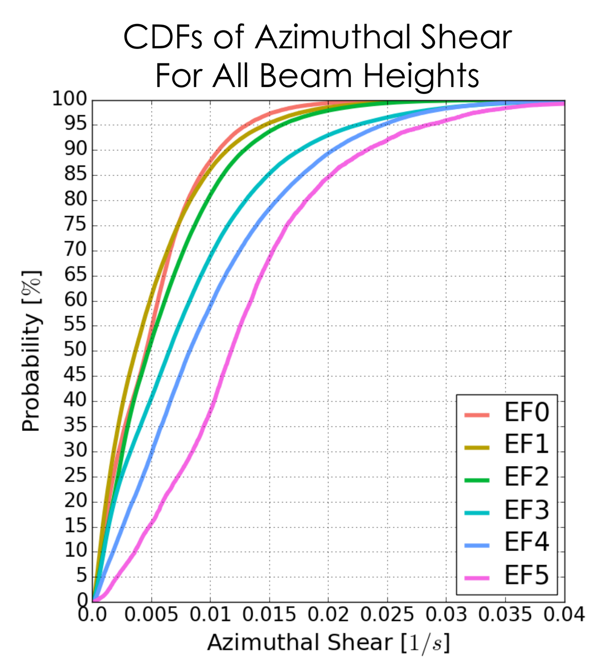
- One of the above specifications for a "Definite TDS" is missing (e.g. minimum in ρ_{HV} values with velocity couplet)

Loose TDS

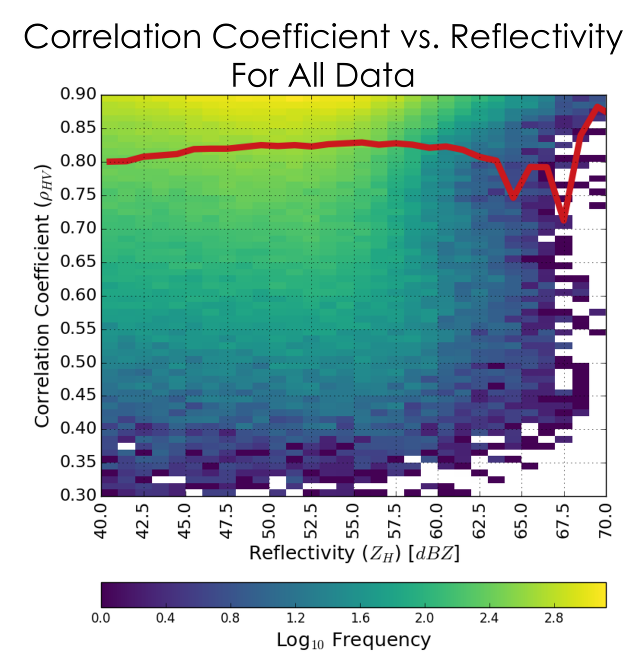
- Visual recognition of a TDS using only one of the above specifications (e.g. minimum ρ_{HV} only)

Note* This methodology is more important for upper tilts since they may show a weaker echo region of the storm of low precipitation values that could artificially inflate a TDS height

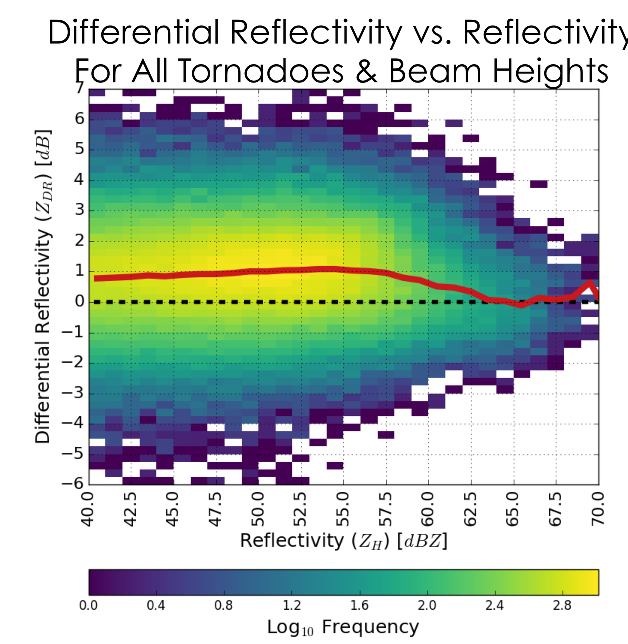
Preliminary Data Comparisons



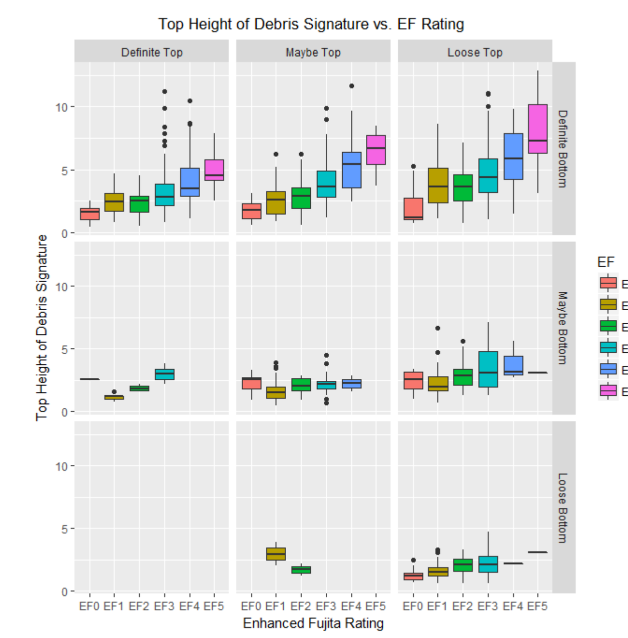
- Positive correlation between tornado intensity & azimuthal shear
- 50% of EF0 events had < 0.005 s^{-1} shear



- Median ρ_{HV} around 0.8 at most Z_H bins due to lack of confident TDS signal at higher elevations

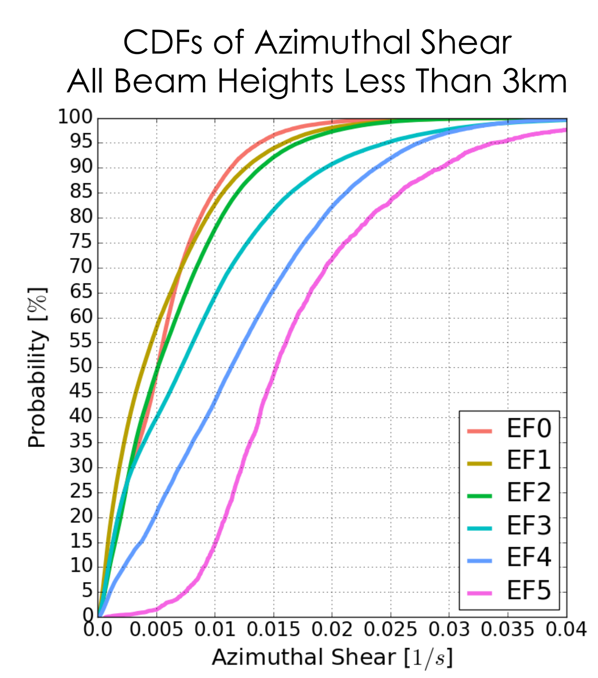


- Median Z_{DR} remains around 1 dB at Z_H < 60 dBZ

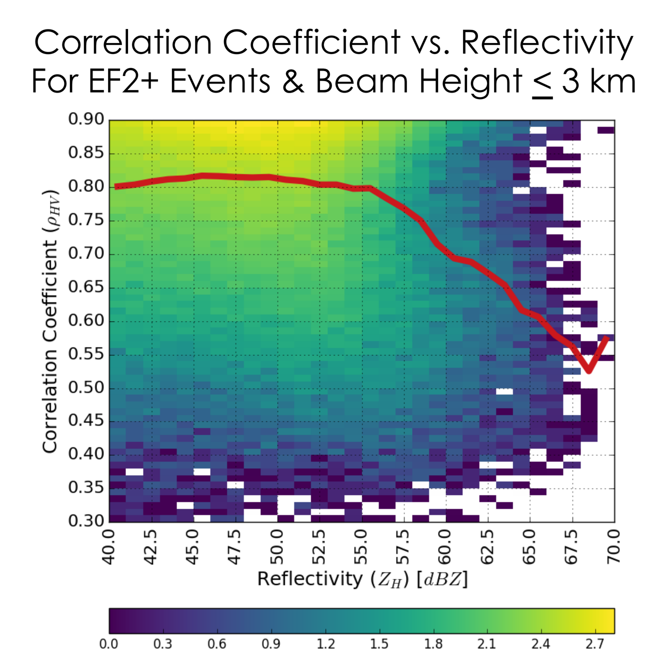


- Linear relationship between the EF rating and the height of the TDS
- Height increases as the certainty of the signature decreases.

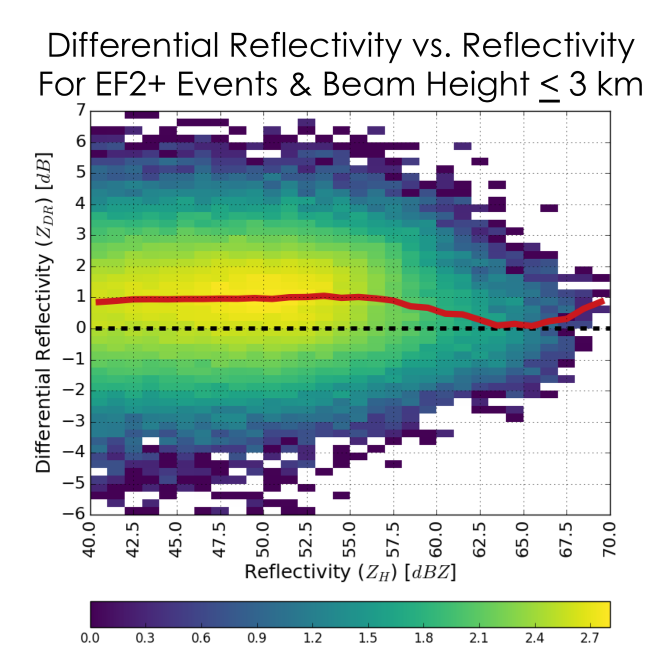
The analyzed/manually tracked dataset included 286 tornadoes and 701 volumes.



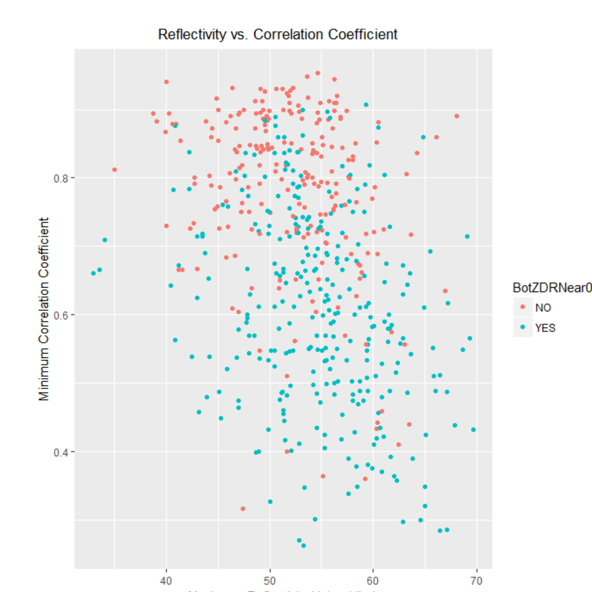
- Thresholds by minimum height does little to separate lower intensity tornadoes (≤ EF2)
- Further discrimination analyses needed



- Sharper decline in median ρ_{HV} at $Z_H \geq 55$ dBZ



- Similar trend in full dataset, Z_{DR} near 0 associated with higher Z_H values



- A TDS showing Z_{DR} Near 0dB will result in larger reflectivity values and a lower correlation coefficient.

Future Work

- Expanding the dataset to include more recent tornado events
- Build a training dataset based on specific geospatial thresholds (beam height, elevation, range) and temporal thresholds (TDS longevity)
- Examine the influence of Z_{DR} biases
- Land cover characteristics

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