Development of Tornadic Debris Signature Guidance Using Polarimetric WSR-88D Data

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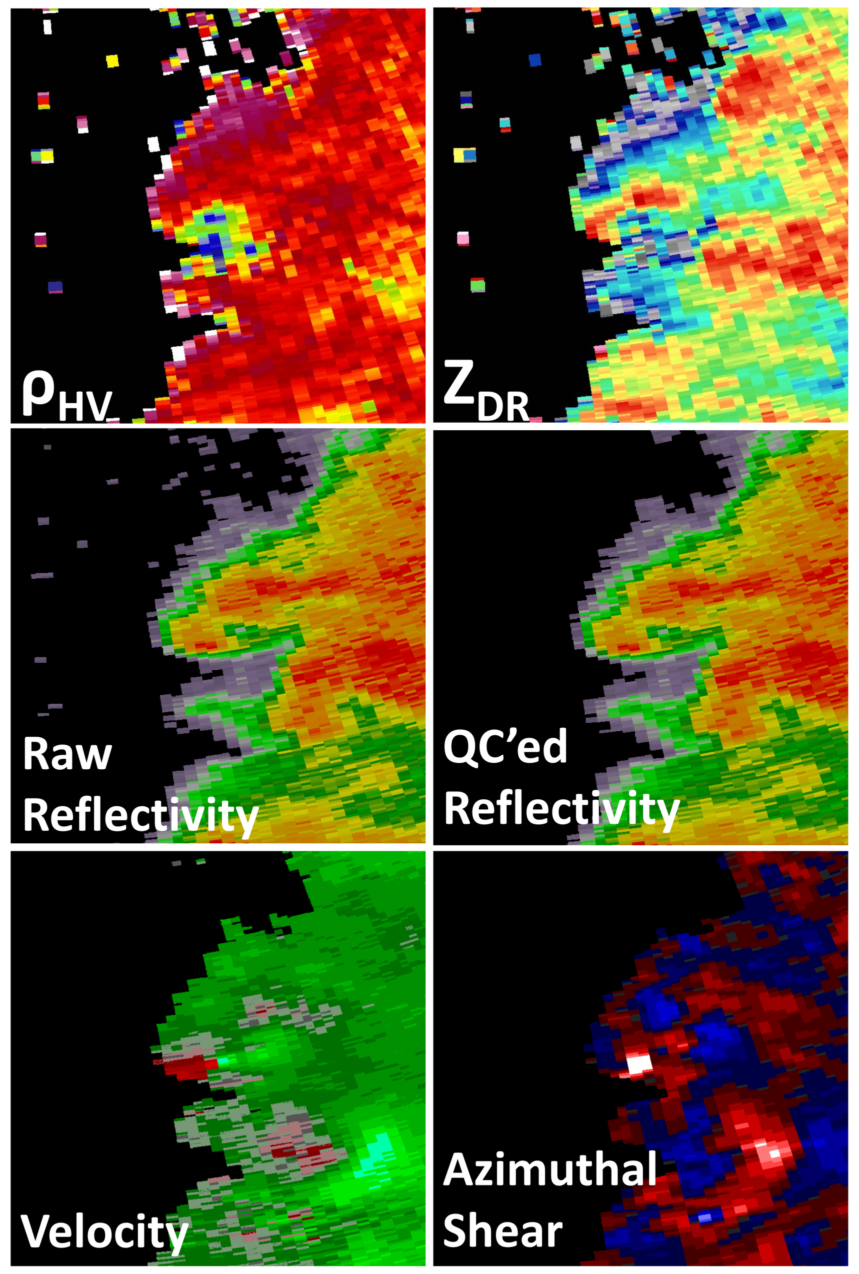
Introduction

- The diversity of shapes, orientation, and composition of meteorological and non-meteorological scatterers in tornadic debris produces a distinct signature when scanned with polarimetric radar called the Tornadic Debris Signature (TDS)
- This signature is usually identified by a decrease in co-polar cross correlation coefficient (ρ_{HV}), a decrease in differential reflectivity (Z_{DR}) to around zero, and an increase in horizontal reflectivity (Z_{HH})
- This presentation introduces the development of a geographically and climatologically diverse dataset at NSSL to identify these signatures along with a comparison of trends observed in the above radar variables though automated and manual identification techniques

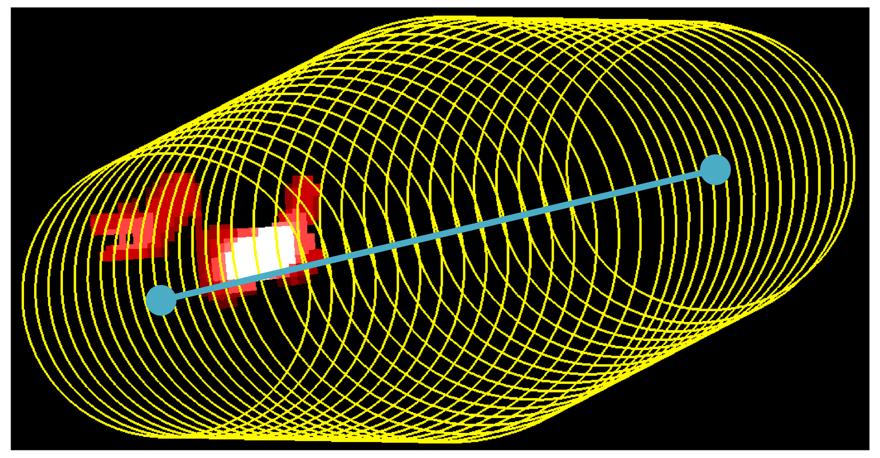
Processing Methodology

- 1169 tornado paths within 140 km of a WSR-88D were recorded in Storm Data from 09 May 2010 – 31 December 2013
- Level-II data +/- 30 min. from each event were processed in the Warning Decision Support System – Integrated Information (WDSS-II) environment through the following steps:

1. Generate RPG quality polarimetric data fields (w2dualpol)
2. Quality control reflectivity to censor artifacts (w2qcnn)
3. Dealias the velocity field using a 2D dealiasing technique and near-storm environment information from the RUC/RAP model (dealias2d)
4. Run a local linear least squares derivatives (LLSD) technique to generate an azimuthal shear (AzShear) field (w2circ)



Automated & Manual Spatial Evaluation



- To correct for potential space/time inaccuracies in the record and non-linear characteristics of storm motion, a 5-7.5 km spatial window (above) was added to each track to constrain the search window for both the automatic and manual analyses

- Two different strategies were evaluated to assess the variability in the distributions between radar variables

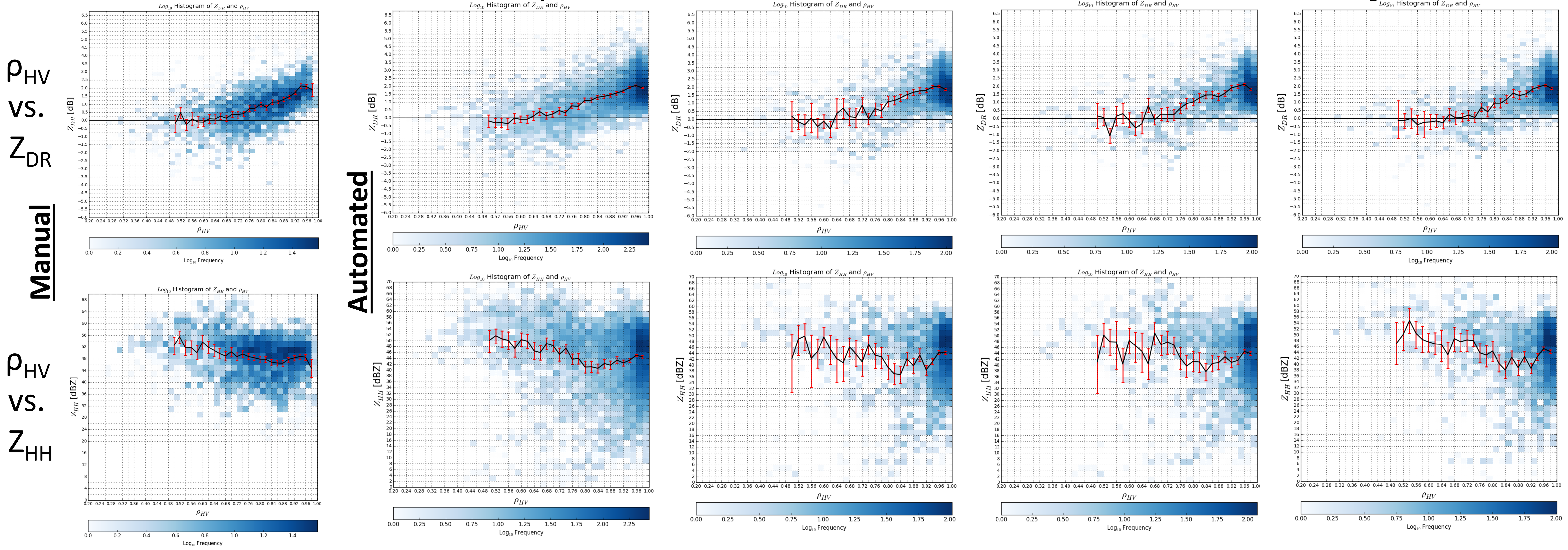
AUTOMATED

1. Track peak AzShear at 0.5° angle through spatial uncertainty window
2. Assemble 3x3 window around highest AzShear pixel for each scan
3. Create distributions leveraging:
   - All scans along the track
   - The scan with the highest Az Shear
   - The scan with the lowest ρ_{HV}
   - The scan with the highest Z_{HH}

MANUAL

1. Determine lat/lon position of TDS through multi-moment interrogation
2. Assemble 3x3 window around this location

Comparison: Manual vs. Automated Analyses



Manual – Scans by EF Rating

EF0	EF1	EF2	EF3	EF4	EF5
29	104	78	83	45	0

Automated, all scans along tornado path – Scans by EF Rating

EF0	EF1	EF2	EF3	EF4	EF5
203	389	142	144	34	24

Automated, scan with lowest ρ_{HV} – Scans by EF Rating

EF0	EF1	EF2	EF3	EF4	EF5
99	150	48	30	7	2

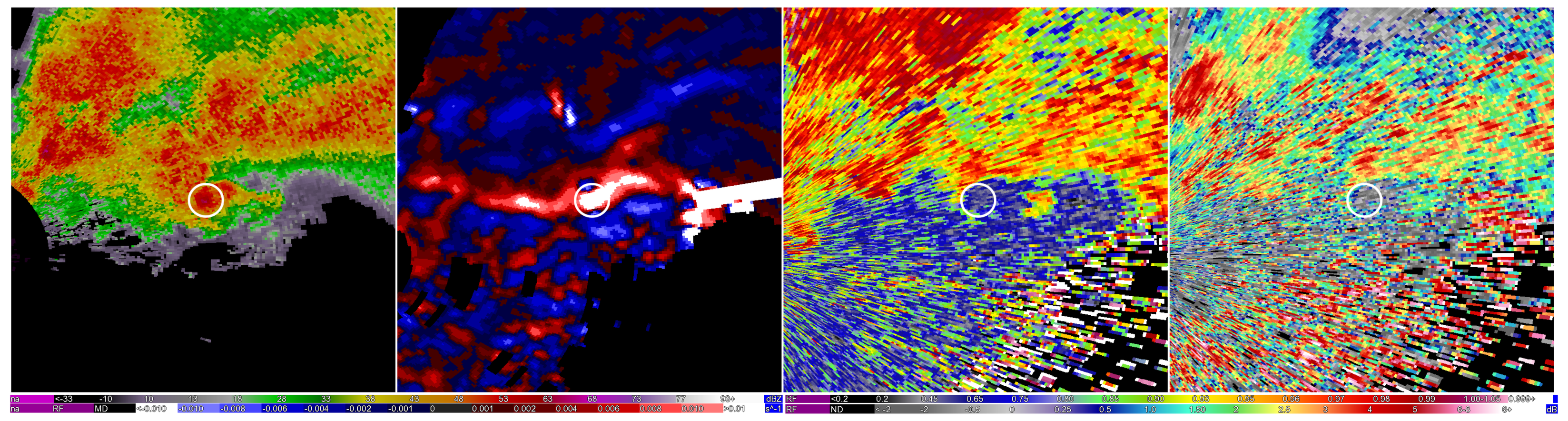
Automated, scan with highest Z_{HH} – Scans by EF Rating

EF0	EF1	EF2	EF3	EF4	EF5
99	150	48	30	7	2

Automated, scan with highest AzShear – Scans by EF Rating

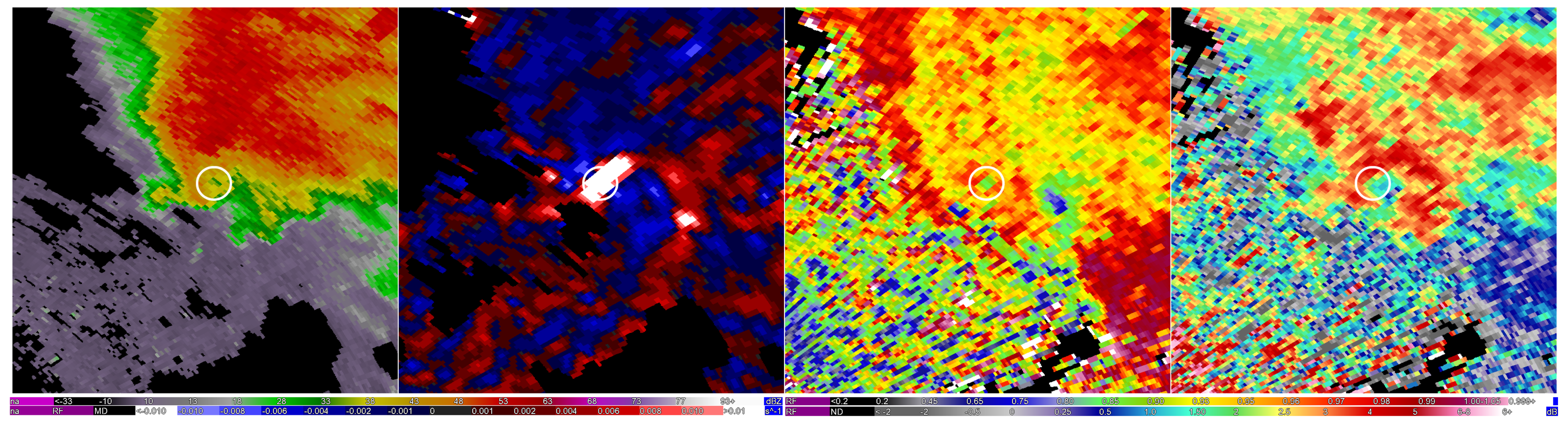
EF0	EF1	EF2	EF3	EF4	EF5
99	150	48	30	7	2

Case Study: 2013 May 19 – EF4 from KTLX – 23:44 UTC



- 14 min. after touchdown, the tornado is around 15 km from KTLX
- Z_{HH} > 60 dBZ and AzShear of 0.032 s^{-1} measured at the center of rotation
- ρ_{HV} < 0.60 and Z_{DR} < 0 dB in hook region and extends further eastward into the inflow region
- **Automated techniques fail to distinguish between debris and inflow due to signature range**

Case Study: 2013 May 19 – EF4 from KDDC – 00:32 UTC



- 14 min. after touchdown, the tornado is around 60 km from KDDC
- Z_{HH} ≈ 40 dBZ and AzShear of 0.027 s^{-1} measured at the center of rotation
- Small area of ρ_{HV} ≈ 0.85 near center of tornado, Z_{DR} ≈ 1.5 dB with decreasing values further northeast
- **Signal degradation by range serves as a motivator to explore variable membership functions by range**

Discussion & Summary

- The automated system (either leveraging all scans or single variable peaks) consistently pulls in more pixels corresponding to precipitation over debris:
  - Around 55% of pixels have a ρ_{HV} > 0.95 in the automated system compared to 7% of pixels in the manual analysis
- The manual analysis provides evidence that a higher Z_{HH} threshold can minimize classification of the inflow region (< 30 dBZ) as debris:
  - Around 47% of pixels have a Z_{HH} > 50 dBZ in the manual analysis compared to 27% of pixels in the automated system
- Strength of signature is dependent on range from the radar, particularly for ρ_{HV} and Z_{DR}:

Range	0-20km	20-40km	40-60km	60-80km	80-100km	100-120km	120-140km
Frequency	22	75	53	85	50	44	10
Median ρ_{HV}	0.72	0.74	0.82	0.83	0.86	0.85	0.83
Median Z_{HH}	49.39	49.77	49.92	48.61	49.40	48.88	52.13
Median Z_{DR}	0.51	0.32	0.82	1.11	1.14	1.41	1.31

  - A larger sample of signatures will be necessary for the generation of stronger associations

Future Work

- Expand dataset to incorporate tornadoes from 2014
- Continue manual analysis of geographically diverse dataset of various magnitudes and distances
- Build range-dependent membership functions from variable spatial windows around TDS center

Acknowledgements

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