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Analysis of Tornadogenesis Failure Using Rapid-Scan Data from the Atmospheric Imaging Radar

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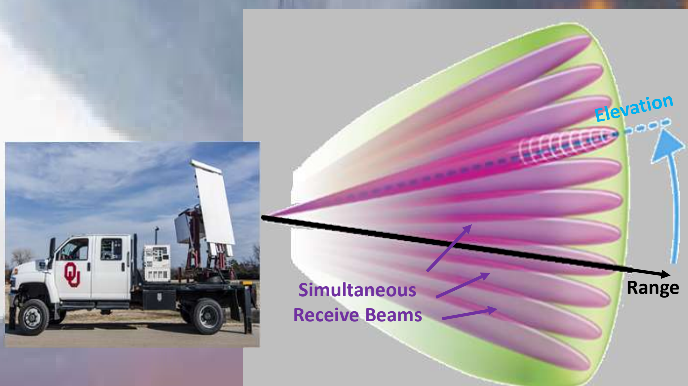
Tornadogenesis Failure

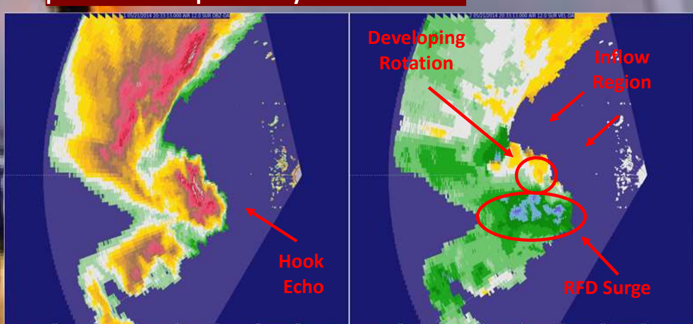
- Tornadogenesis is still not a fully understood process (Markowski et al. 2009, French et al. 2013)
- Some supercells appearing capable of tornadogenesis (low, rotating wall cloud visible, and strong rotation evident on radar) fail to produce tornadoes (Trapp 1999).
- Understanding the mechanics that cause tornadogenesis failure may provide better insight into tornado formation
- This is the first full study devoted to examining volumetric tornadogenesis failure at extremely high temporal resolution.



The AIR, and the Transmit/Receive "Fan Beam" pattern it uses to collect data (Figure 1 from Kurdzo et al. 2017)

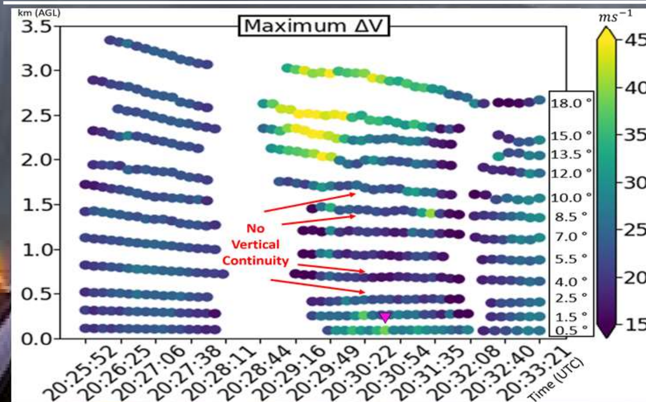
The AIR (Atmospheric Imaging Radar)

- Rapid-scan, X-band mobile phased array radar (Isom et al. 2013)
- Volume scans every 5-10 seconds
- Uses imaging and digital beamforming techniques to capture multiple elevations of data simultaneously
- AIR resolves the temporal scales needed to study short-lived phenomena in potentially tornadic storms



Quality Controlled AIR Data, with significant supercell features noted

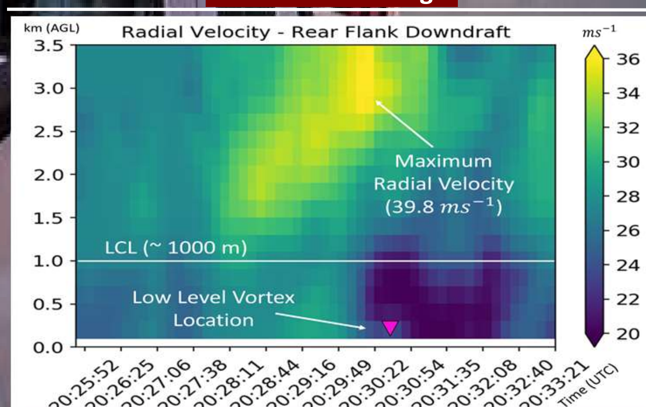
Results: Rotational Strength (ΔV)



A plot of rotation strength (ΔV) w/ respect to time for 12 of the elevations analyzed in the Denver Supercell. The strongest rotation is represented by green and gold colors. The approximate time of the funnel cloud is denoted by the pink triangle.

- Rotation strength increases at lowest levels (~100 m AGL) near time of funnel
- Intensity surge aloft (mid-level meso) precedes the funnel cloud
- No vertical continuity between low and mid-level rotation observed

Results: RFD Strength



A plot of radar radial velocities (w/ respect to time) observed in the rear flank downdraft region of the Denver Supercell. The highest velocities are represented by the green and gold colors. The approximate time of the funnel cloud is denoted by the pink triangle

- Intense RFD radial velocities detected by radar aloft are nearly simultaneous with weakest observed values in lower elevations – indicates significant horizontal shear
- This happens near the time the low-level vortex was also observed

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For a full list of references or the complete written report on this study, please scan or visit: sites.google.com/view/kylepittman/research-projects

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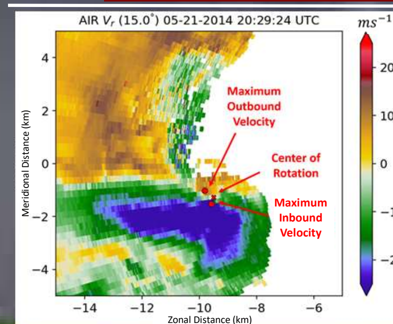
Case Study: Denver, CO 21 May 2014

The low rotating wall cloud produced by the Denver Supercell

- Storm formed in an ideal environment for supercells and tornadoes
- AIR Deployment Period: 20:25:52 – 20:33:21 UTC (Kurdzo et al. 2017)
- 54 volumes of data collected over the 449 s (~7.5 minutes) deployment
- Strong rotation and RFD signature observed on radar
- Low, rotating wall cloud observed by many trained spotters
- Funnel cloud/ brief tornado occurred (~20:30:30 UTC)

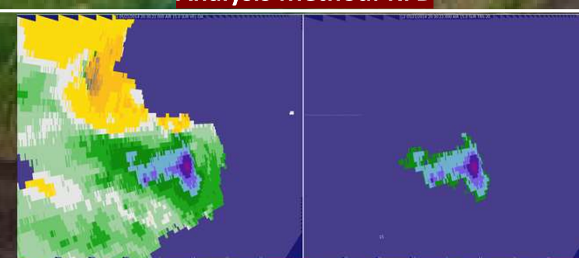
Analysis Method: Rotational Strength (ΔV)



Example of the radial velocity data at the 15° elevation angle, with the center of rotation, and location of maximum inbound/outbound velocities (within a 500 m radius of the center of rotation). Note: The radar is located approximately 10 km east of the center of rotation in this image.

- Centers of rotation were manually selected for each volume of data at 16 different elevation angles, to track the evolution thru time and height
- Maximum inbound/outbound radial velocities were identified within in a 500 m search radius from the center of rotation.
- Differential velocity (ΔV) was computed from the difference between the maximum inbound and maximum outbound velocities in the 500 m radius.

Analysis Method: RFD



Comparison of the original quality controlled radial velocity data, and the isolated radial velocity data (> 20 ms^{-1}) within the rear flank downdraft region.

- RFD radial velocities (> 20 ms^{-1}) were isolated at 16 different elevation angles, to track how this feature evolved with time and height
- Occurrence of these velocities was logged for each volume and elevation angle analyzed, in order to create a time-height plot of RFD intensity