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Polarimetric Radar Signatures of Supercell Thunderstorms in Tropical Cyclones

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Introduction

Background

It is necessary for operational meteorologists to forecast quickly and accurately when storms have the potential of producing severe weather such as tornadoes or hail. Presently, radar represents the most effective way to monitor storms in real time. The National Weather Service recently upgraded the national radar network to polarimetric capability. Much time and resources have been devoted to understanding the development of Great Plains supercells such that polarimetric radar schematics have been developed for them. Little, however, has been done for tropical cyclone supercells. In this study we wish to determine typical polarimetric radar structure for supercells in tropical cyclones.

Objectives

- Determine typical polarimetric radar signatures of supercell thunderstorms in tropical cyclones.
- Compare and contrast our findings with the typical polarimetric radar signatures of Great Plains supercells.
- Assess how to use polarimetric observations to better forecast severe weather threats in tropical cyclone supercells.

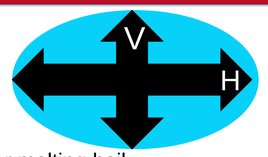
Methods

Only tropical cyclones occurring after the National Weather Service polarimetric radar upgrade were used in this study (2011-2015).

- Radar sites near the tropical cyclone were identified using historical data from the National Hurricane Center.
- The polarimetric WSR-88D radar datasets were obtained for those sites from the National Centers for Environmental Information (NCEI).
- Supercells were identified within the radar data by looking at reflectivity and radial velocity using the Weather and Climate toolkit. They were only included in further analysis if high reflectivity and strong rotation were present, the storm was within 50 km of the radar, and the storm lasted an hour or more.
- A database was created of these storms including:
  - Station site
  - Date
  - Beginning and end time
  - Beginning longitude and latitude
  - Brief description of the storm.
- Analysis of the 29 selected supercells looking at several polarimetric variables beginning with Z_{DR} using the data from the NCEI and the Weather and Climate toolkit

Differential Reflectivity (Z_{DR})

Z_{DR}: mean axis ratio of scatterers in a sample volume



H: length of the horizontal axis
V: length of the vertical axis

If H > V: Z_{DR} > 0 dB, then scatters are likely large raindrops or melting hail.
If H < V: Z_{DR} < 0 dB, then scatters are likely many ice crystals

Results

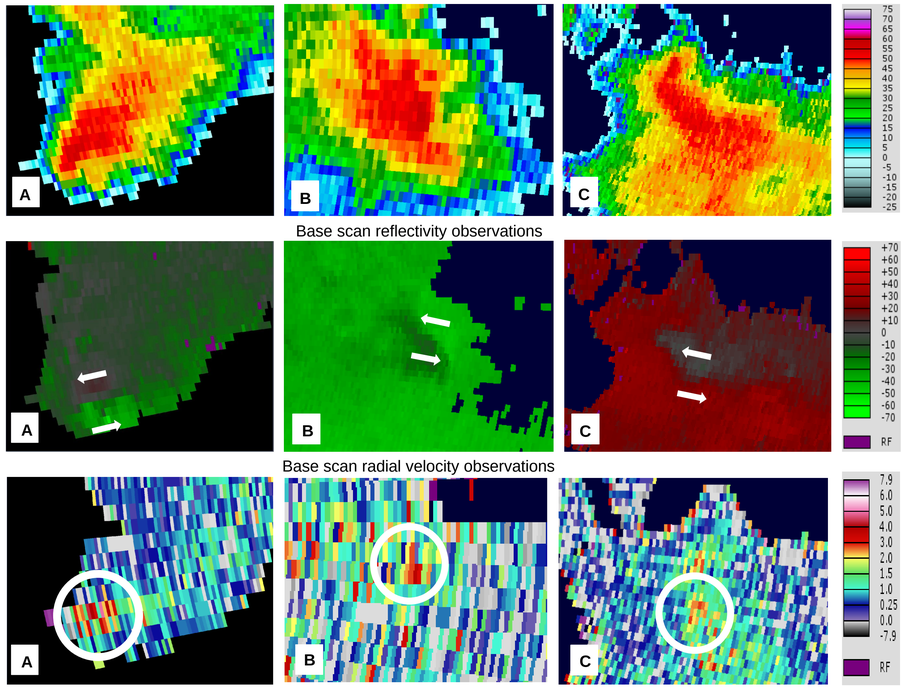


Figure 1: Comparison of (A) a supercell by the WSR-88D KDGX in Jackson, MS on December 20, 2013, (B) a supercell by the WSR-88D KLTX in Wilmington, North Carolina associated with tropical cyclone Arthur on July 3, 2014, and (C) a supercell by the WSR-88D KMLB in Melbourne, FL associated with tropical cyclone Dorian on August 3, 2013.

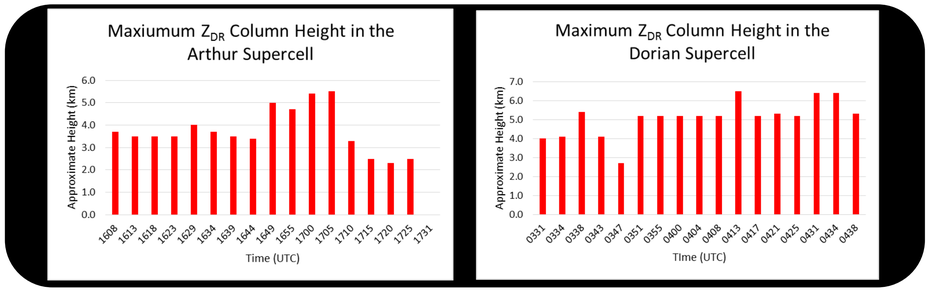
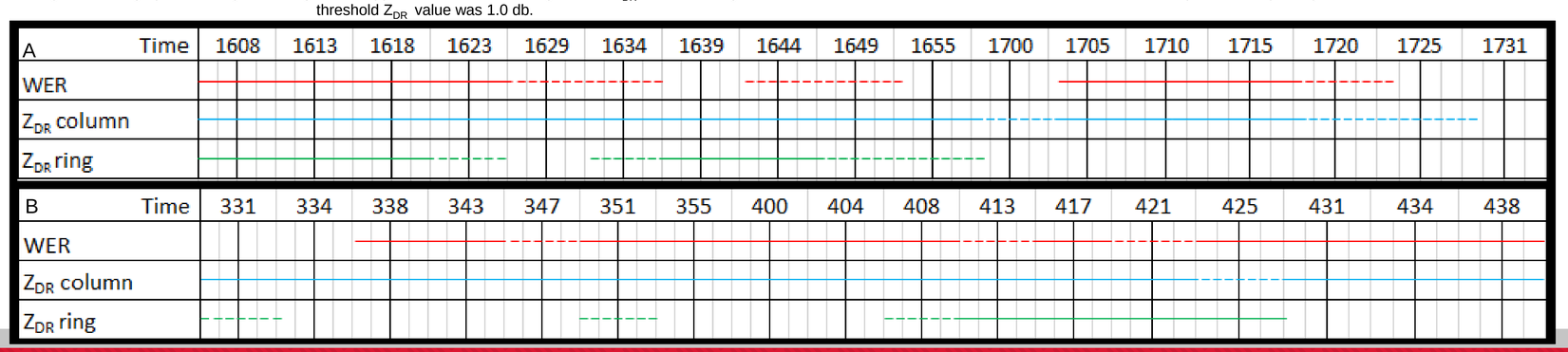


Figure 2: Bar graphs showing the change in the approximate maximum height of the Z_{DR} column through time. The threshold Z_{DR} value was 1.0 db.



Conclusions and Future Work

Preliminary Conclusions

Both tropical cyclone supercells have structures similar to the typical Great Plains supercell structure with the presence of a BWER/WER, high Z_{DR} column, and a Z_{DR} ring.

Future Work

- Continue analysis of various polarimetric variables in the selected supercells. Variables include:
  - Presence of WER or BWER
  - Base-scan maximum velocity difference
  - Base-scan horizontal shear
  - Presence of Z_{DR} ring, and approximate percentage
  - Presence of Rhohv ring, and approximate percentage
  - Presence of DRCs
  - Storm axis ratio
  - Echo appendage length
  - Echo appendage curvature
  - Hailfall areal extent and cyclicality
  - Rhohv mean value in appendage
  - Z_{DR} mean value in appendage
  - Z_{DR} arc areal extent
  - Z_{DR} arc width
  - Z_{DR} arc mean values
  - Z_{DR} column areal extent aloft
  - Z_{DR} column maximum altitude
  - Z_{HH} maximum storm-core value
- Determine how these signatures relate to severe weather reports from tropical cyclone supercells

Acknowledgements

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Figure 3: Charts indicating the presence of the weak echo region (WER), Z_{DR} column, and Z_{DR} ring. Solid lines indicate a strong presence. Dashed lines indicate a weak presence, and no line indicates that the variable was not present at that time.

A is the graph for the supercell in tropical cyclone Arthur.
B is the chart for the supercell in tropical cyclone Dorian.