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Characterization of Polarimetric Radar Signatures in Supercells

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RCEU Summer 2016 Project Proposal

Title: Characterization of Polarimetric Radar Signatures in Supercells

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Project Summary and Objectives

Supercell thunderstorms are the primary producers of impactful severe weather, including large hail, strong winds, and tornadoes, because of their unique environmental catalysts and dynamic composition. With the advent of polarimetric radar, many studies have identified specific, robust polarimetric signatures found in supercell thunderstorms that provide insight into complex microphysical and kinematic processes that contribute to and characterize production of these severe phenomena. Examples include the Z_{DR} arc, K_{DP} and Z_{DR} columns, Z_{DR} and ρ_{HV} rings, and Z_{DR} hail signatures, among others (Kumjian and Ryzhkov 2008; Romine *et al.* 2008; Van den Broeke *et al.* 2008).

Polarimetric radar data at S-band have become increasingly available across the nation through the Weather Surveillance Radar – 1988 Doppler (WSR-88D) network as site upgrades were completed between the summer of 2011 and spring of 2013. However, studies involving polarimetric signatures date back over several decades primarily using either research-quality C-band polarimetric radars or regionally non-diverse S-band polarimetric radars. While polarimetric C-band data reveal microphysical and kinematic signatures associated with supercells, their relative signatures tend to be more pronounced than those observed at S-band because of effects stemming from the smaller electromagnetic wavelength.

To aid in understanding how supercell polarimetric signatures compare between radar wavelengths, collocated S-band and C-band radars are of optimum use. The Huntsville, Alabama area is ideal for such a comparative study with the UAH ARMOR C-band research radar (Huntsville International Airport) located within 70 km of the polarimetric KHTX WSR-88DP (Polarimetric WSR-88D, Hytop) installation, upgraded in January of 2012. With a growing dataset in which supercell measurements can be compared at the two wavelengths, the foundation of this project would stem from a detailed understanding of the characterization of specific signatures at each wavelength using a set of example cases. To keep project goals manageable and to allow for complete analysis, no more than three signatures should be selected for study.

Once a characterization of these signature(s) has been developed and the appreciable differences from those observed at C-band have been assessed, the second important objective would be to build a characterization of the signature(s) in different regions, accomplished by using the expanding dataset afforded by the WSR-88DP network.

Running themes during the project would include:

- Development of understanding of the microphysical and kinematic implications of radar signatures
- Hands-on approach to learning the differences between observed S- and C-band signatures
- Practical applications of signatures in radar and severe weather forecasting operations

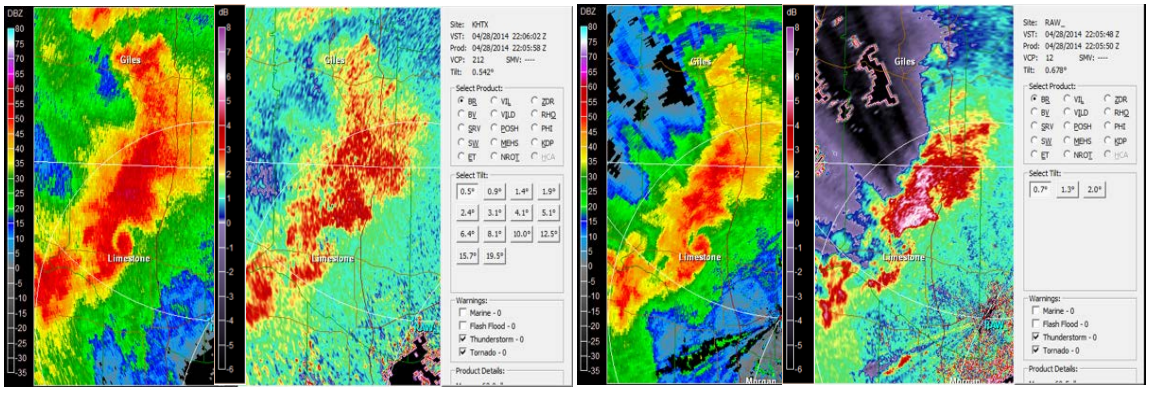

Figure 1: Example of comparison between a supercell from ARMOR and KHTX in Z_H and Z_{DR}. This type of broad analysis represents the first stage of research exploration using C- and S-band radars in the Huntsville, Alabama region.

Student Prerequisites

The student should be of sophomore standing or higher, with the student having completed ESS 112 (Severe and Hazardous Weather) and ESS 301 (Intro to Earth & Atmos Science). The ideal candidate will have participated in UAH SWIRLL severe weather research operations and collected data through the launching of atmospheric soundings or assisted with real-time UAH radar operations.

Student Duties

The project will consist of four main components designed to gradually increase the student's comfort level with the data and analysis techniques. Toward the later stages of the project, individualized, hypothesis-driven exploration is increasingly encouraged once foundational skillsets are developed.

Phase 1: The initial stages of the project will involve a literature review to gain an understanding of the variety of polarimetric supercell signatures and the general expected behavior of different variables. Simultaneously, the student will also begin to familiarize with data collection from the NCDC Radar Data Archive as well as basic radar interrogation software, including GR2Analyst. The student will also begin creating, with guidance, a set of supercell event cases from the North Alabama region. [Duration – 2 weeks]

Phase 2: After familiarizing with the variety of polarimetric signatures, the student will begin an in-depth assessment of how specific signatures of choice vary between the two radar frequencies over a sample of cases. The student will develop a detailed characterization of the magnitudes and timing of the evolution of signatures at S-band with respect to C-band. The student will assess the relative significance of any differences and operational implications. During this phase, the student will also begin learning more advanced radar analysis software, including SOLO3, to be able to assess processed research data. [Duration – 4 weeks]

Part 3: Following characterization of S-band signatures in the North Alabama region, the student will begin to collect data from supercell cases in a variety of regions. This expanded dataset will allow the student to assess any differences related to unique storm environments along with variations in storm morphology and intensity. During this phase, the student will become more familiar with Python-based radar interrogation and analysis code for gridding and more efficient quantitative analysis. [Duration – 6 weeks]

During the 10 to 12 week period of the project, the student will also continuously work on a written report of the motivation and background of their work (i.e., background on the polarimetric signatures chosen for study and why they are of significance), methods used for analysis, and different types of results. The report conclusions should consider not only their accomplishment of project goals and key findings, but also areas for future work or ways they would enhance analysis. The student will submit this report to Dr Carey and the RCEU committee. Additionally, the student will be strongly encouraged to present the research results at the annual Werner Von Braun Memorial Symposium, as well as the AMS Severe Local Storms Conference in Nov. 2016.

Benefit to the Student: Through the framework of the proposed research project, the student will have the opportunity to develop theoretical understanding of an area of radar science, learn practical data analysis techniques and tools, as well as have the opportunity to consider broader applications and methods for expansion of the project. The student will also work in close proximity with other undergraduates undertaking similar but varied research projects and will benefit from collaboration and team building.

Mentor Supervision and Interaction

Dr. Larry Carey, as well as a senior PhD student from Dr. Carey's research group, will supervise the student throughout the duration of the project. The student will attend weekly meetings with Dr Carey and the PhD student mentor to provide feedback and foster a collaborative research environment to assist in the student's progress and success. Additionally, the student will attend Dr. Carey's weekly research group meetings to allow the RCEU student to interact with other group members and be exposed to other radar and severe storms research. Members of the Dr. Carey's graduate student team will aid the student in learning the tools necessary to complete the proposed radar analyses. They will also assist in guiding critical thinking to motivate hypothesis-driven research through each portion of the project. Lastly, the student will be stationed for the summer in the UAH SWIRLL Research Operations Center with other RCEU / REU students from the Knupp, Bitzer, and Wade research groups. These RCEU / REU students will interact with one another, participate in group radar training sessions, attend seminar talks, and participate in other planned group team building exercises.