Study of Ice Processes in Stratiform Precipitation using Polarimetric Radar

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**Project Title:** *Study of Ice Processes in Stratiform Precipitation using Polarimetric Radar*

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**Project Description:** A large fraction of summer rainfall in the United States (US) is produced by mesoscale convective systems (MCSs) that are comprised of convective and stratiform precipitation regions that span 100 km or more. Convection is characterized by cellular structure, strong vertical motions, and intense rain rates. By comparison, stratiform is more spatially extensive and homogenous and has weaker vertical motion and light rain rates. Much of the rainfall produced by MCSs is generated as ice that melts before reaching the ground. Ice growth in convection is via riming or the collection of supercooled cloud water by ice to produce larger graupel and hailstones. In stratiform, ice is primarily produced by depositional growth of ice crystals from water vapor and the clumping of crystals to form aggregates. Motions can sometimes be stronger in stratiform and ice can thus grow by riming. It is important to understand ice growth processes in order to improve their representation in cloud and climate models as they influence rain rate, heating profiles, electrification, cloud lifecycles and how MCS’s impact climate. Polarimetric radar observations can be used to infer precipitation properties (e.g., type, size, and shape) and growth processes (e.g., deposition, aggregation, and riming). Polarimetric radar data are available across the US via the Weather Surveillance Radar – 1988 Doppler Polarimetric (WSR-88DP) network since 2013. As such, the goal of this project is to use WSR-88DP observations of several archetypical MCS’s to identify and characterize ice types and growth mechanisms in the stratiform region. Specific objectives include documenting ice types and growth mechanisms relative to MCS structure and evolution, ascertaining the relative importance of riming in stratiform and documenting associated weather conditions. Outcomes include an improved understanding of stratiform microphysical processes and the refinement of the conceptual model of ice growth in stratiform that incorporates riming.

**Student Duties, Contributions, and Outcomes:** The project will consist of four phases designed to gradually increase the student’s capabilities with the research process, data, and analysis techniques while also defining expectations. **Phase 1 [2 weeks]:** The initial stage of the project will include a literature review of at least 5 peer-reviewed papers to gain an understanding of stratiform precipitation processes and polarimetric radar analysis and to refine research goals. The student will become familiar with basic radar visualization and analysis
software, including GR2Analyst. The student will also begin creating a set of MCS stratiform events. **Phase 2 [3 weeks]**: After becoming familiar with initial methods to assess radar data, the student will begin analysis of polarimetric radar signatures and ice characteristics in the selected stratiform cases. This portion of the project will implement the use of hypothesis-driven analysis, guided by knowledge obtained during the earlier literature review, focusing student efforts and project scope. During this phase, the student will develop more advanced radar analysis software tools to enable quantitative analysis, including Python-based Py-ART and quasi-vertical profiles (QVP’s). **Phase 3 [3 weeks]**: At the outset, the student should have a sizeable case list (of about 3 to 5 archetypical MCS stratiform events), downloaded needed radar and meteorological data and should have implemented Python-based analysis techniques. These case data and techniques will be then used to identify the location, prevalence and duration of ice properties and processes in stratiform as a function of MCS morphology, lifecycle and meteorological conditions. **Phase 4 [2 weeks]**: The student will integrate research outcomes from all cases and synthesize them into a coherent refinement of the conceptual model for ice growth processes in stratiform. The synthesized results and conceptual model will be summarized into a research poster. Student outcomes include the opportunity to develop knowledge and skills regarding polarimetric radar, atmospheric physics, radar data analysis methods, collaborative research and oral presentations. **Faculty Requirements and Mentorship:** The student should be of sophomore standing or higher, having completed ESS 112 (Severe Hazardous Weather) and ESS 301 (Intro to Earth Atmospheric Phys). The ideal candidate will have participated in UAH SWIRLL weather research operations and data collection, including launching atmospheric soundings or assisting with radar. Dr. Carey, as well as a senior PhD student from his research team, will supervise and mentor the student throughout the project. The student will attend weekly meetings with Dr. Carey and the PhD student mentor to provide updates, 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 team meetings to allow the RCEU student to interact with other team members and be exposed to other research. Members of Dr. Carey’s research team will aid the RCEU student in developing the software tools and critical thinking skills necessary to complete the proposed radar project. Lastly, the student will be stationed for the summer in the UAH SWIRLL Research Operations Center with other RCEU/REU students from ATS. 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.
Prior Awardees

1. Award Year: 2016

**Title:** Characterization of Polarimetric Radar Signatures in Supercells

**Student Contributions to Project:** The student conducted detailed analysis of polarimetric signatures in the March 31, 2016 tornadic supercell that occurred near Priceville, Alabama. Working in close collaboration with 2 graduate students on Dr. Carey’s research team, she was able to clarify the different locations, structures and properties of hail melting signatures and a differential reflectivity arc that is sometimes associated with tornadogenesis. These contributions were incorporated into an MS thesis and ongoing NOAA research project on tornadoes in the southeast and provided value feedback to the National Weather Service (NWS).

**Project Outcomes to Student:** Student learned polarimetric radar variables and signatures and their association with supercell structure, physical processes, and severity including tornadogenesis. She also became proficient in using GR2Analyst radar data visualization and analysis tool, developed team building and collaborative research skills by working directly with graduate students and the faculty mentor and developed oral communication skills by presenting her work at weekly team meetings and creating and presenting a formal poster presentation.

2. Award Year: 2017

**Title:** Radar Characterization of Precursors to Cyclic Mesocyclogenesis in Supercell Storms

**Student Contributions to Project:** Another student continued analysis of the March 31, 2016 tornadic supercell. She identified the location and properties of several polarimetric signatures, including the hook echo, differential reflectivity arc, the differential reflectivity column and specific differential phase column that were associated with the evolution of the mesocyclone and tornado occurrence. Found that only the specific differential phase column persisted during the occlusion of the mesocyclone while all other signatures dissipated. The findings were incorporated into NOAA research and were provided as feedback to NWS forecasters.

**Project Outcomes to Student:** Student learned polarimetric and Doppler radar variables and signatures and their association with supercell structure, physical processes, and tornadogenesis. She also became proficient in using GR2Analyst and Python-based DOE Py-ART radar data visualization and analysis tools, developed team building and collaborative research skills by working directly with graduate students and the faculty mentor and developed oral communication skills by presenting her work at weekly team meetings and creating and presenting a formal research poster presentation.