Field Data Collection and Analysis of Nocturnal Mesoscale Convective System Initiation & Propagation Mechanisms

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RCEU Summer 2016 Project Proposal

**Title:** Field Data Collection and Analysis of Nocturnal Mesoscale Convective System Initiation & Propagation Mechanisms

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**Project Summary:**

A significant number of severe weather and heavy precipitation events during the warm season in the Southeastern U.S. and the Great Plains occur during the nighttime hours from nocturnal mesoscale convective systems (NMCSs). Accurate forecasting of NMCSs and subsequent impacts are highly dependent on the knowledge of NMCS convective initiation (CI) timing and location, as well as the propagation method and direction of movement. Understanding the interaction between NMCS density currents and the evolving stable nocturnal boundary layer (NBL) is critical to improve forecasts of CI and NMCS evolution. However, the current scientific knowledge of these systems are limited to several idealized modeling and observational studies that are incomplete with respect to the dynamical evolution of NMCSs as the convection becomes decoupled from the afternoon convective boundary layer and the NBL begins to stabilize. Secondary CI is often observed with upscale growth of the thunderstorm complex as the NBL stabilizes. The exact mechanisms and dynamics leading to this secondary storm initiation, growth, and propagation are still the subject of debate, and are the subject of research for two current UAH SWIRLL research projects: 1) The Atmospheric Boundary Identification and Delineation Experiment (ABIDE-3), and 2) The Plains Elevated Convection At Night (PECAN) field project.

This project will leverage high resolution data collected by UAH faculty, staff, and students during the ABIDE-3 and PECAN field campaigns. Additionally, the student will participate in local field deployments of the UAH Mobile Alabama X-band Radar (MAX) and Mobile Integrated Profiling System (MIPS) during the summer RCEU period to collect data on NMCSs as these storm systems propagate across North Alabama. Measurements from multiple UAH radar platforms (MAX, MIPS, & ARMOR radar systems) provide a unique opportunity to integrate external data from the environment outside the convective system with internal NMCS measurements. These integrated data will allow for a better understanding of the NBL evolution, how NMCSs interact with the stable NBL, and the internal mechanisms that drive NMCS propagation.

![Figure 1: a) NMCS vertical reflectivity structure from the UAH MIPS. b) NMCS vertical velocity structure from the UAH MIPS. c) Same NMCS from a UAH MAX PPI scan. d) The UAH MAX dual-polarization radar.](image-url)
**Student Prerequisites**

The student should be (a) sophomore standing or higher, (b) have completed ESS 112 (Severe and Hazardous Weather) and ESS 351 (Dynamic Meteorology) by the start of the summer semester. The ideal candidate will have participated in UAH SWIRLL severe weather research deployments, operated the UAH MAX and MIPS radar systems, and received Python-based radar software training.

**Student Duties**

To ensure the student has the background to conduct radar research, as well as manageable undergraduate deliverables, a structured, scale-up three-phase approach has been designed.

**Phase 1:** The first two weeks will focus on 1) **MAX and MIPS instrument training**, and 2) developing the student’s background on NMCSs through an intensive literature review. The student will meet with an experienced graduate student mentor during the morning to receive training on the MAX and MIPS systems, and participate in mock deployments of these systems. The student will meet with the faculty mentor each afternoon to receive instruction on NMCS structure and direction on how to accomplish the literature review. [2 weeks]

**Phase 2:** The next four weeks will focus on 1) **radar data analysis software / techniques**, and 2) **cataloging NMCSs events** in the UAH radar case events database. The student will meet with the graduate student mentor during mornings to familiarize with radar software (XPR / Proftool profiling radar software, GR2Analyst and **Python-based radar tools**), and radar analysis techniques (editing, dealiasing, gridding, and multiple-Doppler syntheses). The student will spend afternoons searching through the UAH radar database for NMCSs events, and cataloging NMCS properties such as initiation time / location, propagation direction, severe weather reports, and instrument data availability. Phase 2 will feature **field deployments** of instruments for data collection on NMCSs near UAH. [4 weeks]

**Phase 3:** The final portion of the project will focus on performing **advanced radar analyses** on selected NMCS case events (1-3 cases). Case selection preference will be given to data actually collected by the student during a severe weather field deployment. The student will analyze the evolution of the stable NBL through data from weather balloon soundings and the UAH MIPS Microwave Profiling Radiometer, note changes in NBL structure as new storms initiate, and accomplish multiple-Doppler syntheses on new storm cells. Lastly, multiple-Doppler analyses will be compared UAH MIPS vertically-pointing radar for detailed analyses of internal NMCS structure. [6 weeks]

**Benefit to the Student:** The student will be provided with the unique opportunity to be involved with the entire hands-on process of instrument operation, data collection, data quality control, and data analysis. Upon project completion, the student will present research findings at the Von Braun Memorial Symposium, as well as an American Meteorological Society conference (Mesoscale or Severe Local Storms). These experiences will make the student a strong candidate for graduate school GRA / funding, NSF / NASA fellowships, and internships / employment with NASA and NOAA.

**Mentor Supervision and Interaction**

Ryan Wade, as well as an experienced senior graduate student, will supervise the RCEU student for the duration of the project. During the first 2-4 weeks, both the faculty and graduate student mentors will meet with the student every day (see above) to ensure that appropriate background knowledge and instrument training are being successfully achieved. It is expected that the student will become more independent after the first few weeks, thus the mentors will alternate daily meetings for the last 6-8 weeks of the project (meeting frequency and length will change as needed). The RCEU student will attend research group meetings to allow the student to interact with other research group members, thereby gaining exposure to other research projects. Additionally, the student will be stationed for the summer in the UAH SWIRLL Research Operations Center with other RCEU / REU students from the Knupp, Carey, and Bitzer 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. Experience from this collaborative RCEU environment will be used as a demonstrated proof of concept for an upcoming NSF Site REU proposal.