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A Statistical Analysis of the Causes of Thunderstorm-Generated Wind Damage and Casualties

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RCEU Summer 2017 Project Proposal

Title: A Statistical Analysis of the Causes of Thunderstorm-Generated Wind Damage and Casualties

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Project Summary:

The National Weather Service (NWS) has begun the process of evaluating the efficacy of the severe weather warnings that it issues. The end goal of this warning improvement initiative is to increase public response to tornado warnings through improved communication and increased accuracy, particularly through the decrease of the rate of false alarm tornado warning issuances. One prominent contention that has recently arisen in discussions on tornado warning improvement, both in the NWS and in academia, is the value of issuing tornado warnings for quasi-linear convective systems (QLCSs). Since tornadoes form from these systems are often frequently small, relatively weak, and short-lived, many meteorologists contend that they pose nearly the same risk as non-tornadic severe thunderstorm winds. Additionally, the circulations that produce these tornadoes often form rapidly, making them extremely difficult to warn in advance. As a result, the argument has been made that tornado warnings should be reserved for larger, significant tornadoes and that severe thunderstorm warnings should be issued for these QLCS events, in order to diminish the public perception of "false alarms" created by these warnings.

However, the statement that "non-tornadic damaging thunderstorm winds can be just as destructive as wind from a small tornado" has not been thoroughly vetted in peer review or though research in the NWS or social science communities. The intensity at which wind damage produced by a thunderstorm transitions from being more likely to be non-tornadic than tornadic to being more likely to be tornadic than non-tornadic is unknown. Also, while it is well-documented that tornadoes that reach significant intensity (EF2+ intensity on the Enhanced Fujita Scale) are far more likely to produce casualties than their weak (EF0-EF1) counterparts, the exact point at which the probability of casualties increases and the relative casualty rates for tornadic and non-tornadic events with the same estimated maximum wind magnitude are relatively unknown. These unknowns pose significant challenges in deciding the best course of warning action to spur an appropriate response from the general public to take the safety precautions necessary for either level of threat.

This project will utilize the NWS's *Storm Data* publication, the official database for severe weather events in the United States, to diagnose the statistics of tornadic and non-tornadic thunderstorm wind damage events over the past ten years. These events will be subdivided and analyzed by characteristics such as wind damage or tornado intensity, parent storm mode, time of day, time of year, and geographic location in order to diagnose likely biases in the Storm Data entries for severe thunderstorm non-tornadic and tornadic wind damage. This work will be performed in collaboration with the NWS forecast offices in Huntsville, AL, and Chicago, IL, in order to expand upon questions that arise in the research process that could provide answers that assist in the warning improvement process. Additionally, this project will be run concurrently with a NOAA Ernest F. Hollings Scholarship project at NWS Chicago studying the ability to predict tornado intensity based on radar observations and environmental conditions. The combined results of these projects will be used to gauge forecasters' ability to estimate tornado intensity within a reasonable amount of error and then make a judgement – to issue or not to issue a tornado warning – based on whether the reasonable worst-case impacts anticipated from the tornado exceed what can reasonably be expected by non-tornadic severe thunderstorm wind events. Additionally, the results of this study will be used to assist in post-event damage surveys of severe thunderstorms, where differentiating between tornadic and non-tornadic damage can be challenging and knowledge of the likelihood of damage of a given intensity caused by tornadic or non-tornadic wind mechanisms could potentially prove extremely valuable in making a determination on the cause of the damage.

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 class or work experience using the Gibson Ridge Level 2 Analyst Edition (GR2Analyst) software to perform radar analyses on severe thunderstorms and have participated in UAH SWIRLL severe weather research operations.

Student Duties

In order to ensure sound deliverables from this project, a structured, three-phase approach will be employed. The phases of the project are broken into two-week, four-week, and six-week increments as follows.

Phase 1: The first two weeks of the project will focus on developing the student's background on supercells, QLCSs, tornadoes, NWS Storm Data, and general knowledge of radar meteorology. This development will be accomplished through a focused, intensive literature review. The literature reviewed by the student will offer insight into a variety of topics related to this case, and will include a student summary presentation of pertinent literature to the faculty and graduate student mentors. [2 weeks]

Phase 2: The next four weeks of the project will focus on building skills necessary to accomplish a detailed statistical analysis using NWS Storm Data and NWS radar data. These skills include downloading official Storm Data, plotting and subdividing Storm Data, and viewing radar data in order to diagnose storm mode and structure of damaging thunderstorms. To accomplish these tasks, the student will become familiar with several software tools common to severe storms meteorology. He or she will learn how to access Storm Data from the Storm Prediction Center (SPC) and utilize the ArcGIS software program to perform a spatial and statistical analyses on the dataset. The student will also learn how to download radar data from the National Centers for Environmental Information (NCEI) and view and interpret the data in the GRLevel2 Analyst software package in order to classify tornadoes and non-tornadic wind damage events by their parent storm mode. [4 weeks]

Phase 3: The remaining six weeks of the project will comprise analysis of the enhanced Storm Data dataset. This analysis will include: (a) inspection of damaging wind event causes, and (b) stratification by different storm environments, types, and intensity characteristics. The student will make informed conclusions about the robustness of the Storm Data database and how errors in the recorded data may affect his or her results. These results will be linked to the concurrent Hollings Scholarship project to inform future warning decisions based on expected impacts. [6 weeks]

The student will gain an appreciable insight into the challenges of the severe storm warning decision-making process through this project. He or she will gain experience with state-of-the-art tools to quality control and analyze Storm Data and radar data. Upon completion, the student will present his or her work to at least two NWS forecast offices in order to demonstrate the process of transitioning research to forecasting operations. Additionally, the student will be encouraged to gain presentation experience through both the Von Braun Research Symposium and potentially the 2018 American Meteorological Society (AMS) Annual Meeting.

Mentor Supervision and Interaction

Dr. Kevin Knupp, as well as a senior PhD student, Tony Lyza, from Dr. Knupp's research group, will supervise the student for the duration of the project. The PhD student mentor will meet up to several times per week with the student to ensure development of a solid foundation of background knowledge on the subject matter, ability to use the necessary tools for this project, and satisfactory progress in achieving the project goals stated above. The RCEU student will attend Dr. Knupp's bi-weekly research group meetings to allow the student to interact with other research group members, thereby benefiting from the availability of multiple "go-to" experts on polarimetric radar analysis. Additionally, the student will be stationed for the summer in the UAH SWIRLL Research Operations Center with other RCEU / REU students from the Carey 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.