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Cloud-Resolving Modeling Studies of Convective systems

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RCEU Summer 2018 Project Proposal

Title: Cloud-Resolving Modeling Studies of Convective Systems

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Project Summary:

This RCEU will be done so to introduce students to the basic aspects of obtaining, compiling and running a weather forecast model on a multi-processor Linux computer facility. The forecast models to be considered here will be either the Weather Research and Forecasting (WRF) or the CM1 community modeling systems, which are freely available. The forecast model can be set up in a number of configurations, depending on the student's familiarity with computers, and also their specific interest in weather forecasting. Either regional (1000's of kilometers) to local or storm-scale analysis (100's of kilometers) could be done. The project will have an end goal of helping students visualize model forecast output using readily available software package.

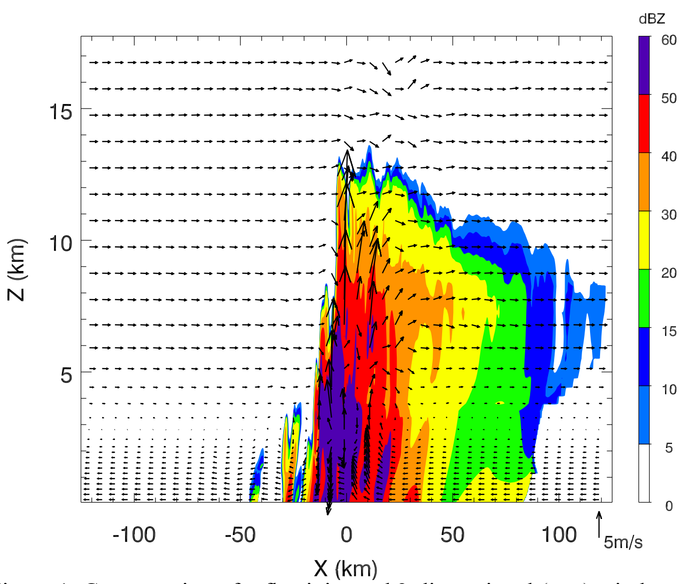

Figure 1: Cross-section of reflectivity and 2-dimensional (*u*-*w*) wind vectors from 2.75-h forecast from the CM1 model for an idealized supercell storm (wind vector is plotted with horizontal interval of 30 and vertical interval of 2). The model simulation has a horizontal resolution of 200-m, and vertical resolution stretching from 100-m below 2-km height and 500-m above 8-km height.

Use of cloud-resolving numerical weather forecasting models that simulate atmospheric phenomena at resolutions of 1 km to 250 meters or higher are becoming increasingly common in the atmospheric science community, especially as computational resources increase. At high spatial resolutions, details of cloud and turbulence processes greatly increases, such that one can learn significantly more about weather events that are otherwise very hard to directly observe in nature. In particular, it is basically impossible to fly aircraft through or to send instruments (balloons or unmanned aircraft) into convective storms, yet they can be represented quite accurately by cloud resolving models (Figure 1). For this project, student will use the WRF or CM1 cloud-resolving model to study aspects of convective storms, namely their cloud-top characteristics, precipitation and hydrometeor fields, as well as other internal flow patterns. Students can also instead study more regional phenomena, including tropical storms or midlatitude winter systems.

Students can therefore take this project in a number of directions based on their specific interests. These include: (1) forming an understanding of the computer facilities, computational codes and numerical methods used to solve the governing equations of these models, (2) developing ways to visualize output of the WRF or CM1 simulations to highlight key cloud processes, and (3) comparing the output of the WRF or CM1 model to actual observed storms in radar or satellite.

The final component of this project will be to help the students become familiar with visualization software that affords them the ability to analyze the forecast model output fields. Use of freely available UAH software (e.g., Matlab, IDL, Python) will be the focus, and the students then can develop a simple presentation of their weather forecast results.

Student Prerequisites

The student should be (a) sophomore standing or higher, (b) have completed ESS 112 (Severe and Hazardous Weather) and ESS 301 (Intro to Earth & Atmos Physics), and (c) have completed one UAH computer science course, and possess some level of familiarity with coding (in one or more languages, such as Matlab, IDL or Python). The ideal student should also be willing to gain familiarity on Linux computer systems, and also possess some prior familiarity with computer operating systems (e.g., Windows, Linux). It is expected that the RCEU project will be the selected student's sole focus for the summer term, thus other internships are prohibited and other employment is discouraged.

Student Duties

To ensure the student has the background to conduct local to regional weather forecasting experiments and research, as well as manageable undergraduate deliverables, a structured, scale-up three-phase approach has been designed during the summer term. Students can advance their knowledge by looking through the significant amount of on-line resources related to high-resolution modeling.

Phase 1: The first two weeks will focus on 1) ***WRF/CM1 model download and basic installation on the UAH-NSSTC "matrix" multi-processing computer system***, and 2) developing the student's background on the Linux operating system command, and also develop understanding through a ***review of on-line weather forecast model literature***. The student will meet with an experienced faculty and graduate student mentors to receive training on the WRF/CM1 models and Linux-based matrix computer system. [2 weeks]

Phase 2: The next four weeks will focus on 1) ***identifying a meaningful historical weather event to study***, 2) ***setting up the WRF/CM1 model for 1 pre-defined historical weather event***, and 3) ***running an actual weather forecast simulation*** which will lead to the generation of forecast output datasets. The student will be instructed by mentors on the Linux operating system, matrix computer architecture, and data display software such as ***Matlab, IDL or Python-based tools***). [4 weeks]

Phase 3: The final portion of the project will focus on ***displaying the actual forecast model output fields in a way that conveys key information on the chosen historical weather event***. The student will analyze the evolution of the forecasted case, over time and in various model domains (i.e. resolution). The student could chose to run additional or extend the given model simulation, and will be encouraged to analyze from 3-6 different meteorological fields, such we winds, moisture, rainfall, temperature and clouds. [6 weeks]

Benefit to the Student: The student will be provided with the unique opportunity to learn valuable information on a widely used community weather forecast model (CM1 or WRF), which may be carried over to either a Masters of Science degree or a future career. Upon project completion, the student will present research findings at the Von Braun Memorial Symposium, as well as potentially an American Meteorological Society conference. These experiences will make the student a strong candidate for graduate school-level GRA funding, applying for NSF/NASA fellowships, and internships, and employment with NASA and NOAA.

Mentor Supervision and Interaction

John Mecikalski, as well as an experienced senior graduate student (David Haliczer), 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 NSSTC Building/Cramer Research Hall, or the SWIRLL Research Operations Center, along with other RCEU / REU students. Experience from this collaborative RCEU environment will be used as a demonstrated proof of concept for an upcoming NSF Site REU proposal.