FOR THE IMPROVEMENT OF WEATHER FORECASTS

By: Rachel Laughlin

Predicting the weather has long been a frustrating and difficult process, both for weather forecasters who bear the brunt of predictions that don't come true, and for people trying to plan their daily lives. Despite the difficulty, weather prediction is just what Erin Jones, Millersville undergraduate researcher, has tried to do. Jones' research project, and recently, successfully defended thesis, called "Assimilating Local Observations in WRF: A Case Study" attempts to use local temperature and weather information to better predict weather patterns on a larger-scale models. For this project, Jones examined a cold front moving through the Mid-Atlantic Coast from November 6th to 7th.

Jones' research project began with a unique, collaborative opportunity with four Mid-Atlantic universities from November 4-18th of 2017. This National Science Foundation funded program, called the Student Experience in Airborne Research in the Mid-Atlantic Region (SEAR-MAR), allowed meteorology students from Millersville University, Penn State University, Rutgers University, and University of Maryland Baltimore County (UMBC) to experience atmospheric data collection from the seats of an airplane in flight, as well as controlled weather balloon launches. Many types of data, including wind, speed, and temperature readings were recorded. The collection has benefitted and inspired research projects for Millersville students.

In January of 2018, Jones approached Dr. Alex DeCaria of the Millersville Earth Sciences department with the idea of conducting an analysis of the weather data collected during the SEAR-MAR experience. She wanted to use the data to determine if its incorporation into a large-scale weather model would improve or detract from a forecast. Together, Jones and DeCaria hypothesized that the inclusion of this data would improve forecast accuracy. Jones also used this research opportunity as basis for her thesis, which she successfully defended in December of 2018.

However, the analysis and thesis preparation faced setbacks. Jones began her assembly and analysis using data obtained from the weather balloon launch on November 6th, during the SEAR-MAR experience. This was done by assembling data into a four-dimensional variational system, nicknamed 4D-Var. 4D-Var would combine the weather balloon data with data from another model, called the North American Mesoscale Model (NAM), creating input for the Weather Research and Forecasting Model (WRF).

Problems with this program quickly became apparent, as the computational ability of the Millersville University

server was not enough to fully maintain and run the 4D-Var program. Jones, not to be daunted, kept attempting to run the program. The project was delayed for several weeks of the fall semester. Ultimately, Jones and DeCaria decided to finish the project and thesis by using a similar, but not as complex computer program, called the three-dimensional variational system (3D-Var) instead.

Finally, data from the 3D-Var system could be organized, analyzed, and entered within the Weather Research and Forecasting Model (WRF). With this, Jones was able to create a 24-hour forecast. For comparison, another forecast was made using control inputs, and was predicted for the same 24-hour period. Unlike the model with the 3D-Var data, the control model did not include the weather balloon data from SEAR-MAR—though it did still include the NAM model data. By comparing forecasts predicted from control and 3D-Var data or inputs, Jones was able to determine if the weather balloon data improved or detracted from the weather forecast. The results of Jones' data are observed and compared in these images, taken from her thesis defense presentation. Times in the following images are expressed in units of UTC, or Coordinated Universal Time, which is the same as Greenwich Mean Time (GMT), or five hours behind Eastern Standard Time (EST).

At first glance, Jones' data greatly resembles the control model, almost to exactness, although there are some discrepancies between them. However, as time continues, greater differences between the two models can be observed. Some differences in the 0000 UTC frame from November 7th, 2017 include the collection of orange and red spots clustered in the bottom right-hand corner, the tamer expression of dark blue lines almost centered at the top of the frame where areas of Canada exist, and the circular pattern of the yellow bands also to the right-hand side. Other differences are observed in the 0600 UTC frame, also from November 7th. These differences consist of the patterns of light blue in central and upper Pennsylvania, the red and orange clusters in the lower right-hand corner of the frame, and patterns of dark blue centered in the frame under which Canada lies. More differences can be found with the trained meteorological eye, but these examples are some of the few most pronounced. Overall, the forecast produced by the 3D-Var model lags a few hours behind the control, meaning the 3D-Var predictions demonstrate a slower moving cold front when compared to the control model.

Jones' models also expanded into pressure and temperature predications calculated from both her control model as well as the 3D-Var simulation from the collected SEAR-