University: University of Hawaii

Name of University Researcher Preparing Report: Yi-Leng Chen

NWS Office: National Weather Service Honolulu Forecast Office

Name of NWS Researcher Preparing Report: Robert Ballard

Partners or Cooperative Project: Partners Project (Period: 06/03/09-09/30/10)

Project Title: High-Resolution Weather Modeling to Improve Local Weather Forecasts over the Hawaiian Islands

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Section 1: Summary of Project Objectives:

The main objectives of this research are: (1) to continue to bring daily high-resolution WRF-NMM experimental 48-h forecasts to the numerical model suite at NWS Honolulu; (2) to improve high-resolution WRF-NMM experimental forecasts (with grid size as small as 1.5 km) with two-way nesting procedures and better representations of island terrain and land surface conditions over the Hawaiian Islands; (3) to study the island flow response and weather during non-trade-wind conditions during the winter months using the historical high resolution model output. The result from objective (3) will help forecasters generate subjective high-resolution graphical forecasts beyond 48 hours under non-trade wind low level flow regimes, which occur about 50 percent of the time in winter.

Section 2: Project Accomplishments and Findings:

a) Update of the high resolution WRF-NMM model over the Hawaiian Islands to version 3 with two-way nested procedures. The daily high resolution forecast is extended from 48 hours to 72 hours (http://www.soest.hawaii.edu/MET/Faculty/mm5/WRF/index.html). One of the main problems we found is that the land surface properties, such as: land use, vegetation fraction, soil type and coastlines for the inner domains are interpolated from the mother domain even if we have input high resolution ground cover landuse and soil type data to WRF-NMM. We have communicated this issue to DaNa Carlis. In August 2010, Mathew Pyle of EMC/NCEP responded to our question on nesting. He indicated that it didn't appear that there was an easy way around the issue with the way nesting is done within WRF-NMM. WRF-NMM's nesting was built with moving nests and feedback to the parent domain in mind, and this objective was achieved most cleanly by forcing the land states on the parent and nest to be consistent. Since hurricanes over water were the biggest concern, the relatively poor resolution of coastlines and land states was a secondary matter. He suggested that the quickest option to utilize higher-resolution land states would be to use a "fake nesting" approach. A better, long term approach might be to shift toward the NEMS/NMMB system that is under development here at EMC.

b) Continue to bring daily high-resolution WRF-NMM experimental 72-h forecasts to the numerical model suite at NWS Honolulu.

c) Evaluate the usefulness of experimental high resolution WRF-NMM daily forecasts for graphical forecast products with a grid-size of 2.5 km, with feedback provided to the UH team.

d) Dr. Chen worked with DaNa Carlis (now at NCEP) who was funded by the NOAA Educational Partnership Program (EPP) Graduate Scientists Program (GSP) and the National Weather Service Pacific Region to study the physical process involved in the regular occurrence of the Maui Vortex over Central Maui Valley under summer trade-wind conditions using the MM5 model with improved land surface properties. A joint paper was published in the Monthly Weather Review.

e) We found that classification of flow regimes according to low-level wind direction may not be advisable as the island flow response also depends on stability and vertical wind profiles. Unlike summer trade-wind conditions, the flow patterns over Hawaii have large case to case variations. Frequently, there are also large spatial variations in low-level wind direction and weather patterns related to synoptic settings. We have performed a preliminary case study of trapped mountain waves that occurred in the lee of Kauai and Oahu during January 27, 2010 under a southwesterly flow regime before the passage of a surface cold front. The WRF high resolution model is capable of simulating trapped lee waves which have been confirmed by visible satellite images. Similar to a strong downslope wind case studied by Zhang et al (2005; WAF), with strong winds on the lee-side slopes of mountains, an inversion is present above the ridge tops and the low-level wind has a significant wind component impinging directly on the mountains. The main differences are in the vertical wind profiles. For the strong downslope flow case, the low-level winds are northeasterlies and shift to westerlies at higher levels with a critical level where the windshift occurs (Zhang et al. 2005; WAF). For the trapped lee-wave case, the flow is southwesterly throughout the entire troposphere with *increasing* speed and veering with respect to height *without a critical level* above the ridge tops.

Section 3: Benefits and Lessons Learned: Operational Partner Perspective

The National Weather Service in Honolulu is creating post-processed output from the WRF-NMM model to produce high resolution hourly Probability of Precipitation and sensible weather grids to be used as guidance for NWS forecasters. This guidance is of a higher temporal and spatial resolution than other post-processed model guidance for those parameters and allows forecasters to better monitor and evaluate the potential evolution of significant events in the short term. In similar fashion, work is ongoing to create bias-corrected WRF-NMM temperature guidance for the forecasters. Finally, the high resolution model continues to provide the forecasters with enhanced wind guidance that can help them evaluate local wind effects, as well as assist them with the determination of the location of the volcanic haze plume.

Section 4: Benefits and Lessons Learned: University Partner Perspective

The main benefits to the university are the exposure of students to operational forecasting and better understanding of the forecast challenge in the operational environment. Our students attend weather briefings at the NWS forecast office. One of my former students (Nathan Smith) worked at the NWS forecast office as a volunteer.

Section 5: Publications and Presentations

Carlis, D. L., Y.-L. Chen, and V. R. Morris, 2010: Numerical simulation of island-scale airflow over Maui and the Maui vortex under summer trade-wind conditions. *Mon. Wea. Rev*., **138**, 2706-2736.

Section 6: Summary of University/Operational Partner Interactions and Roles;

Part 2(a) and (e), are done by the UH team. Part 2(b) and (d) are joint efforts between UH and NWS. Pact 2(c) is done by the NWS Honolulu forecast office.