FINAL REPORT

University: University of Hawaii at Manoa

Name of University Researcher Preparing Report: Yi-Leng Chen

NWS Office: NWS WFO Honolulu Office

Name of NWS Researcher Preparing Report: Bill Ward

Partners or Cooperative Project: Partners Project

Project Title: Improvements to an Experimental High-Resolution Numerical Weather Prediction System for the Northern Mariana Islands/Guam

UCAR Award No.: Z16-23456

Date: 4/25/2017

Section 1: Summary of Project Objectives

In this project, we would like to 1) test the performance of the Weather Research and Forecast Model with data assimilation over the Northern Mariana Islands/Guam and adjacent waters; 2) test the performance of the new model initialization techniques on the performance of typhoon forecasts over the Northern Mariana Islands/Guam; 3) bring the model data to NWS operations as guidance grids within NWS' Interactive Forecast Preparation System/Graphic Forecast Editor (IFPS/GFE) at a 2.5-km resolution. The NWS Forecast Office will provide the UHM team with feedback on the performance of the modeling system in operational settings.

Section 2: Project Accomplishments and Findings

The UHM team has implemented WRF data assimilation to include GPS Radio Occultation (RO) refractivity profiles, satellite data (including atmospheric motion wind vectors from Himawari, and radiance data from polar orbiters), synoptic, ships, aviation routine weather reports, pilot, aircraft reports, and buoy data in the model initial conditions provided by the GFS (Global Forecast System) (Tu et al., 2017) for the Northern Mariana Islands/Guam domain. Daily high-resolution (with grid size as small as 1 km) experimental forecasts are conducted for both the Northern Mariana Islands/Guam and American Samoa (http://www.soest.hawaii.edu/MET/Faculty/wrf/arwGS/). The high-resolution model results are available to forecasters in real-time operational settings for evaluation. UH-WRF nested domains are the only ones which do an adequate job capturing significant orographic effects on winds and precipitation and local winds during the diurnal heating cycle.

The UHM team also tested the performance of the TC initialization scheme (Nguyen and Chen 2014) (NC2014) throughout the entire life cycle for super-typhoon Jelawat (2012) including the rapid deepening stage (Chen et al., 2016, AMS 32nd Conference on Hurricanes and Tropical Meteorology). The UHM team also initialized Soulder (2015) from 0000 UTC 1 August to 1200 UTC 3 August every 12 hours using NC 2014 with a 6-km grid for 48 h hindcasts. Results show that NC2014 improves the structure and intensity of TC for the first 12-24 hours. From discussions with Dr. Mark Lander (University of Guam), we nest a 2-km grid domain within the 6-km grid domain for this small TC resulting in a better TC structure. However, the main limitation in running real-time forecast using a 2-km grid covering the TC inner core region is on the availability of computing time from a high performance supercomputer.

On 22 Feb., 2016, Dr. Chen gave a presentation entitled, "Applications of a New Tropical Cyclone Initialization Scheme on Improving Intensity, Structure and Track Forecasts" during the United Nations Economic Commission for Asia and the Far East (UNECAFE) and the World Meteorological Organization (WMO) Typhoon Committee Meeting held in Honolulu during 22-25 February. The meeting was hosted by the National Weather Service Pacific

Region. After the meeting, Dr. Chen was nominated by Raymond Tanabe, the Director of the NWS Pacific Region Headquarter to attend the Typhoon Committee Journal Tropical Cyclone Research and Review (TCRR) editorial board meeting. He was invited as a Visiting Editor of TCRR, Shanghai, China during 17–21 October 2016.

Section 3: Benefits and Lessons Learned: Operational Partner Perspective

The daily UHM-WRF model is the only high-resolution model guidance with grid size as small as 1 km for the Northern Mariana Islands/Guam and American Samoa. The TC initialization scheme developed by the UHM team shows promises for better forecasts of TC structure, track and intensity, especially the intensity and structure during the first 12-36 hours (Nguyen and Chen, 2014, MWR; and Chen et al, 2016a).

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 forecast challenges in the operational environment. The National Weather Service Honolulu Forecast Office is collocated with our department in the same building on campus. This allows close interaction between the NWS forecasters and our department. For example, our students, faculty and staff have the opportunity to participate in twice weekly weather briefings at the NWS Honolulu Forecast Office.

Section 5: Publications and Presentations

Tu, C.-C., Y.-L. Chen, S.-Y. Chen, Y.-H. Kuo, and P.-L. Lin, 2017: Impacts of including rain evaporative cooling in the initial conditions on the prediction of a coastal heavy rainfall event. *Mon. Wea. Rev.* **14**5, 253-277.

Chen, Y.-L., C.-Y. Chen, H. V. Nguyen and F. Hsiao, 2016a: Applications of a new tropical cyclone initialization scheme on improving intensity, structure and track forecasts. 48th Annual Session of the UNESCAP/WMO Typhoon Committee, 22-25 Feb, Honolulu, HI.

Chen, Y.-L., C.-Y. Chen, and H. V. Nguyen, 2016b: Applications of a new tropical cyclone initialization scheme on improving TC track, intensity and structure forecasts. The AMS 32nd Conference on Hurricanes and Tropical Meteorology, 18–22 April, San Juan, PR.

Chen, Y.-L., 2016: Initialization of high resolution models for simulations of extreme weather events in the subtropics. OCONUS Technical Interchange Meeting, 26-30 June, University of Hawaii at Manoa, Honolulu, HI 96822.

Chen, Y.-L., C.-Y. Chen and H. V. Nguyen, and F. Hsiao, 2016c: Is the TC storm-scale circulation and the large-scale flow in quasi-equilibrium? The 2nd US-Taiwan Extreme Precipitation Workshop, 6-8 September, University of Hawaii at Manoa, Honolulu, HI 96822.

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

The UHM team is responsible for providing daily 7 and ½ days high resolution (with grid size as small as 1.5 km) experimental high resolution forecasts to the NWS Forecast Office. The NWS Forecast Office evaluates the output and provides feedback to the UHM regarding suggestions for improvements to the models.

In the TCRR editorial board meeting, it was decided that forecasters are encouraged to submit articles to TCRR. Contributions are not limited to basic original research. Forecasters are encouraged to review specific events from a forecasting perspective including success, failure, and challenges in real-time operation settings. Tracey Dorian of NWS has prepared a brief report on Amos (2016) which missed making a direct landfall on the Samoan Islands as a possible article to be submitted to TCRR. In addition to significant track errors, the intensity changes (rapid intensification and rapid weakening) of TC Amos (2016) were not accurately predicted by models more than 48 hours in advance. Dr. Chen has reviewed the report with great interests. According to Bill Ward, "TC Amos (2016) was one of the most interesting and difficult tropical cyclones Pacific Region has had to work in a very long time. It appears that it was sheared off just prior to going over American Samoa and unfortunately it does not look like the models picked up on this." TC Amos (2016) will be a very interesting case to study in a hindcast mode in the future.