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Partners or Cooperative Project: Partners

Project Title: Evaluating HWRF forecasts of tropical cyclone intensity and structure in the North Atlantic Basin

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SECTION 1: Summary of Project Objectives

1.1 The focus areas for this Hurricane Weather Research and Forecasting (HWRF) modeling project have been organized as such: 1) to evaluate the several primary cyclone circulations represented in the 0.18^o (27km), 0.06^o (9km) and 0.02^o (3km) resolution model domains; 2) to examine the magnitude of low-level inflow and its effect upon intensity changes within HWRF; and 3) to evaluate the sensitivity of the cloud microphysics scheme in the HWRF model with different number concentration of droplets (NCW). To address the project objectives, two cases were identified and pursued for numerical simulation. Tropical Storm (TS) Fay (2008) was used as the landfalling tropical cyclone simulation case, while the Columbus Day Weekend storm (2011) was used as a challenging hybrid case simulation to consider performance comparisons. Both cyclones made landfall in Peninsular Florida and produced considerable amounts of precipitation (Fig. 1).

1.2 Much of the early work was centered on HWRF installation and optimized NWP configuration; this was predominately conducted at San Jose State University by the PI and students. The Weather Forecast Office in Melbourne provided operational perspective on these matters, and provided an increasing measure of contribution as results became available. Particular contributions were initially planned for the Hurricane Irene and Columbus Day Weekend events as each brought inherent challenges to the forecast area of East Central Florida. Operational challenges with Irene were related to the distribution of the wind field along the western flanks. Tropical cyclone warnings were issued for the adjacent marine waters right up to the coast, but did not include any Peninsular Florida land areas. Traditional wind radii guidance was insufficient, so output was to be deliberately scrutinized here. However, for expedience Tropical Storm Fay was used to leverage earlier work by the PI and given that Fay had

also been a significant forecast challenge for MLB. As for the Columbus Day Weekend cyclone, the dilemma was genesis, rate of growth, and intensity.

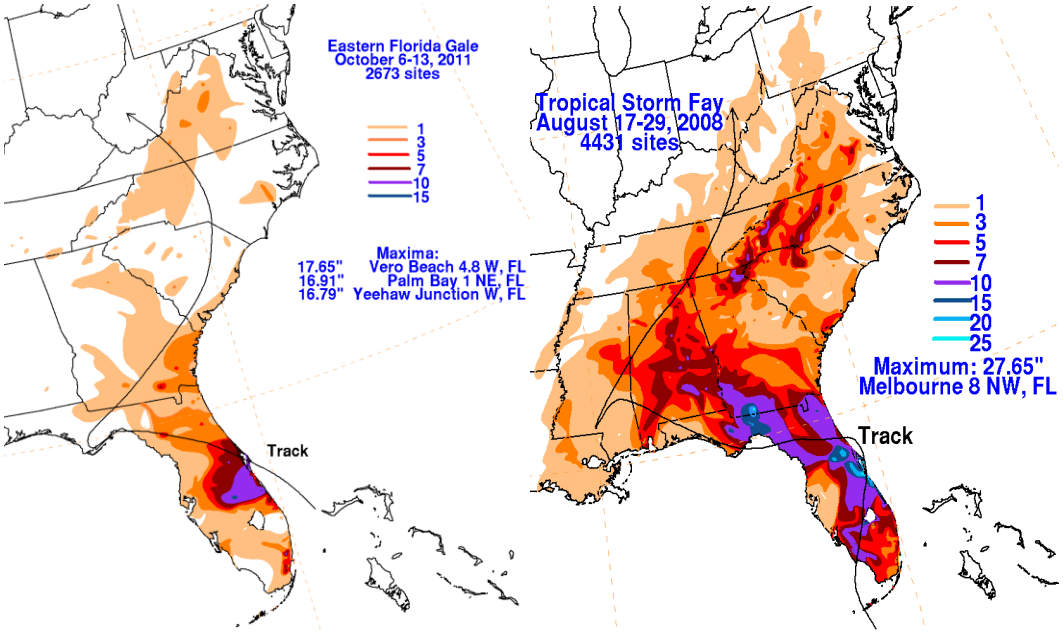

Figure 1: Observations of the track and cumulative precipitation for (a) the Columbus Day Storm (2011), and (b) TS Fay (2008). Images via The Hydrological Prediction Center (HPC).

SECTION 2: Project Accomplishments and Findings

2.1 Through remote collaborations, two graduate students, Travis Washington at the Florida Institute of Technology (FIT) and Dany Tran at San Jose State University (SJSU) successfully installed the HWRF model, and configured it on a local workstation. Data from both the TS Fay and Columbus Day storms were loaded and simulated using the model.

Travis Washington presented a poster entitled *"Modeling studies of rapid intensification of tropical cyclones using HWRF"* at the 30th AMS Conference on Hurricanes and Tropical Meteorology in April 2012. A new display approach was presented in the poster. Figure 2 shows the example of using the Integrated Data Viewer (IDV) to depict Hurricane Earl and Tropical Storm Fiona.

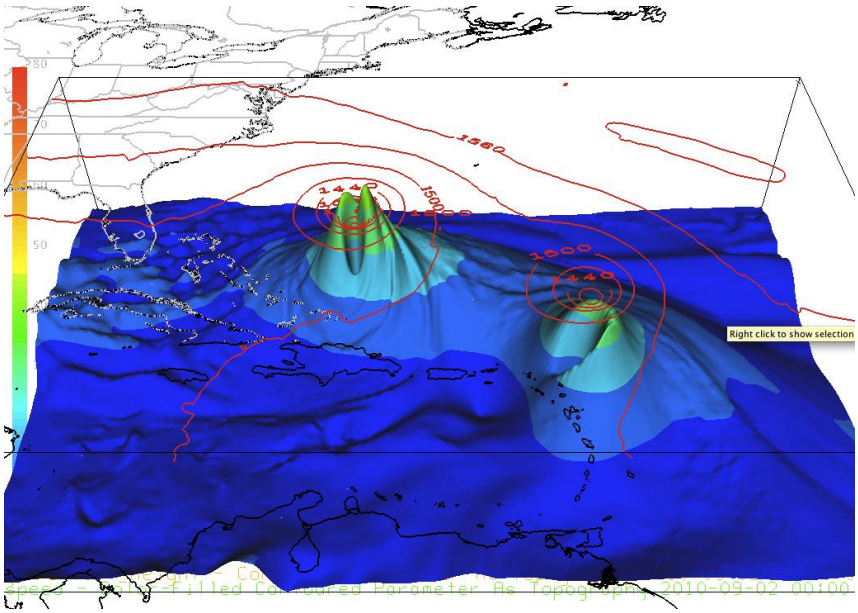

Figure 2: HWRF model output analysis using the Integrated Data Viewer (IDV).

More so, there were two formal presentations related to the project that have been delivered in the PI's research group (see Section 5). The presentation materials (i.e., slides, and figures) are posted at http://blizzard.met.sjsu.edu/~tran/presentations.

Figures 3a-c show the simulated low pressure centers from the moveable 3 km domain for the three simulations performed for the Columbus Day Storm. It appears that only slight changes in track (denoted by the +) for both the 100 and 500 cm^{-3} NCW compared to the default simulation (250 cm^{-3}) were observed. Areas of cumulative precipitation at the 3 km domain for the three simulations are provided in Figure 3d-f. Based on observations, the area of the most cumulative precipitation is located over the central portion of the Florida panhandle (Fig. 1a). The model simulations capture the general structure of the cumulative precipitation compared to observations fairly well. However, the model tended to underestimate the amount of maximum rainfall compared to observations. The observations showed 15 inches of precipitation where the models only showed approximately 4 inches of rainfall at 0000 UTC. Overall, minimal changes in the pressure were observed with each run indicating that the changes in NCW may not be the factor to substantially change the storm's intensity in association with precipitation processes. We are still working to more thoroughly analyze the model output as well as to validate its performance against observations.

2.2. The Melbourne WFO has prepared a presentation entitled *"The 2011 Columbus Day Weekend Storm: Overcoming Challenges in Diagnosing a Rapidly Strengthening Maritime Low Pressure System and Communicating the Associated Warning Message"* at the 30th AMS Conference on Hurricanes and Tropical

Meteorology in April 2012. This paper highlighted operational forecast issues, some of which were addressed by the HWRF evaluation.

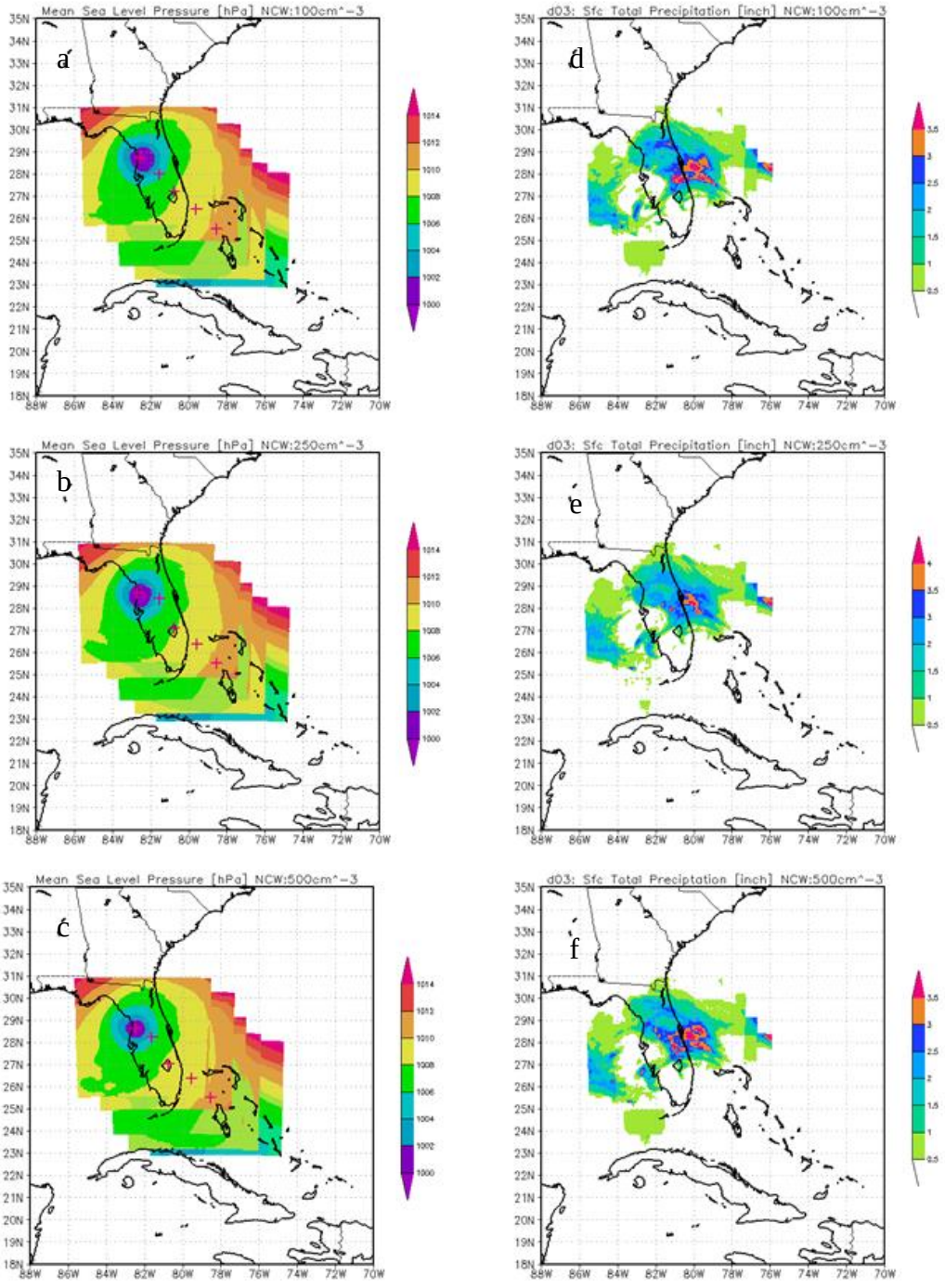

Figure 3: The 3 km nested domain simulated MSLP for the Columbus Day Storm at (a) 100 cm^{-3}, (b) 250 cm^{-3}, and (e) 500 cm^{-3}. (d), (e) and (f) have the same sequential but for precipitation. The storm center at 6 hour increments are denoted by the "+".

SECTION 3: Benefits and Lessons Learned: Operational Partner Perspective

A local version of the WRF-ARW model (as currently run within the WFO; configured by Peter Blottman) has aided in the timing and expected areal coverage of mid-latitude convective systems forecast to impact Peninsular Florida. It is anticipated that HWRF modeling efforts will provide needed guidance when dealing with cyclones originating in the tropics. Thus far, the WFO has benefitted from the professional exchange among tropical cyclone modelers. It has increased our understanding of the HWRF infrastructure and its potential support to WFO tropical cyclone operations regarding storm intensity and structure.

SECTION 4: Benefits and Lessons Learned: University Partner Perspective

The partners group has gained greater experience with HWRF configuration and optimization issues, with particular emphasis toward enhanced learning for MS thesis research. The collaboration between the San Jose State University and WFO Melbourne (and WFO Miami) provides a unique opportunity to consider the advantages/disadvantages of using high-resolution HWRF modeling output to advance our understanding of hurricane intensity changes in the North Atlantic basin, perhaps leading to improved hurricane operations at the field office level. This partnership provides San Jose State University with an opportunity to contribute to our discipline in a very significant way.

SECTION 5: Publications and Presentations

Washington, T., and S. Chiao, 2012: Modeling studies of rapid intensification of tropical cyclones using HWRF. The 30th AMS Conference on Hurricanes and Tropical Meteorology, Ponte Vedra Beach, FL, April 15-20, 2012

Tran, D., and S. Chiao, 2013: Evaluating HWRF Modeling of landfallling Tropical Cyclones over Florida. The 17th Conference on Integrated Observing and Assimilation Systems for the Atmosphere, Oceans, and Land Surface, Austin, TX. [Extended abstract is available at https://ams.confex.com/ams/93Annual/webprogram/Paper218647.html

Tran, D., and S. Chiao, 2013: Evaluating HWRF Modeling of landfallling Tropical Cyclones over Florida. The 11th Atmospheric Science Symposium at the UC Berkeley Atmospheric Sciences Center (BASC), Feb 7, 2013.

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

6.1 From the start, project participants were forced to repeatedly overcome many technical issues that relate to installing HWRF on a local workstation. The model

has a huge infrastructure, but fortunately we have received assistance from the larger HWRF community. Although communications were somewhat limited between the PI and WFO Melbourne (could no longer meet face-to-face due to PI relocation from FIT to SJSU), the PI and his students worked diligently to carry out this project. For example, excellent correspondence was established with Dr. Brad Ferrier who designed the microphysics scheme in HWRF. Subsequently, strategies were discussed with David Sharp, the MLB Science Officer. During the 2013 AMS annual meeting in Austin, TX, we were also able to meet briefly with the MIC (Dr. Pablo Santos) at WFO Miami for a short discussion.

6.2 Except for the limited interaction during the PI's relocation period, WFO Melbourne did not encounter problems. WFO Melbourne has a greater understanding of the potential advantages that HWRF and the associated tropical cyclone modeling community may bring to future operations, but also has a deeper appreciation of the journey that is entailed. Track and intensity forecasts are important, but there is increasing importance for depicting the forecast structure of cyclones as they approach coastal populations.