Hurricane Model Transitions to Operations at NCEP/EMC

Final report of the Joint Hurricane Testbed (JHT)

Robert E. Tuleya, SAIC

8/30/2007

The 2005-2007 JHT project has concentrated on HWRF development with the goal of operational implementation for the 2007 Hurricane season. HWRF became operational at NCEP in June. This goal therefore was reached with the SAIC JHT project contributing in several critical areas. As mentioned previously, the HWRF forecast system has progressed from a uniform-mesh WRF proto-type system installed and run at NCEP for the 2004 season to a moving nested HWRF automated system run for numerous cases for the 2005 season. For the 2006 season numerous cases were run with a two-way nested moving system. In the Fall 2006 and early Winter 2007 further refinements were made to the system. The physics packages were also brought in line with the GFDL model with changes to the momentum mixing in the cumulus parameterization and the inclusion of a refined surface roughness and flux parameterization. In addition the atmospheric HWRF system was coupled to the URI POM ocean model system. With the inclusion of the Ferrier cloud microphysics package into the 2006 GFDL operational system, the physics packages of the HWRF and the GFDL model are nearly identical.

Over the last few months, the JHT project developed and tested the last remaining component of the HWRF operational system. The "TPC post" component delivers the swaths of maximum wind and well as the total rainfall swept out by the moving nest of HWRF. These swaths are quite similar to those used and analyzed in the GFDL operational system. Early results for the 2007 season in the Eastern Pacific and Atlantic indicate that HWRF is performing admirably. For the most part the HWRF system is running smoothly with few failures. The SAIC project is busy working with EMC staff in identifying some problem areas that need attention.

The accomplishments of the proposal will now be indicated in the proposal time line:

1. Compare developmental nested HWRF runs with the uniform nest version of HWRF. **The HWRF structure is run-time configurable such that a one-nest experiment can be run quite easily without compilation if only the parent domain configuration is used. In several cases, the uniform nest version has been used as a test tool to indicate whether low resolution and a uniform nest would change the forecast compared to the operational version of the HWRF forecast. In general, the parent uniform nest version yields similar tracks but reduced intensity. A more thorough analysis of the sensitivity of the moving nest configurations will take place when improving the HWRF model this coming year.**

2. Collaborate with EMC and university personnel in the development and integration of ocean and wave model components into the HWRF forecast system. **SAIC has worked with EMC and URI to install and run the**

entire HWRF-coupled system. Tuleya has used his expertise in the GFDL coupled system to indentify which are the pertinent variables needed to exchange from the atmosphere to the ocean and to interact with URI and EMC personel involved in the ocean coupling.

3. Continue to evaluate the physics and dynamics packages in HWRF that give the best skill in track and intensity compared with the GFDL benchmark **A major task has been to update the physics packages of HWRF to make them as consistent as possible to that of the latest GFDL model. The latest change made was to make the HWRF have options to have surface enthalpy either consistent with the 2005 GFDL model or consistent with the reduced roughness that was installed in the 2006 GFDL model. HWRF now has the option to use the effectively high enthalpy flux to compensate for the reduced effect of ocean coupling. In addition, sensitivity tests were performed to see the relative effects on tracks from changes in radiation parameters compared to changes in momentum mixing. The figure below indicates sensitivity of the enthalpy flux parameterizations for HWRF(Fall 2006 version). There is less error and reduced bias in intensity when the enthalpy flux parameterization of the 2006 GFDL model was used.**

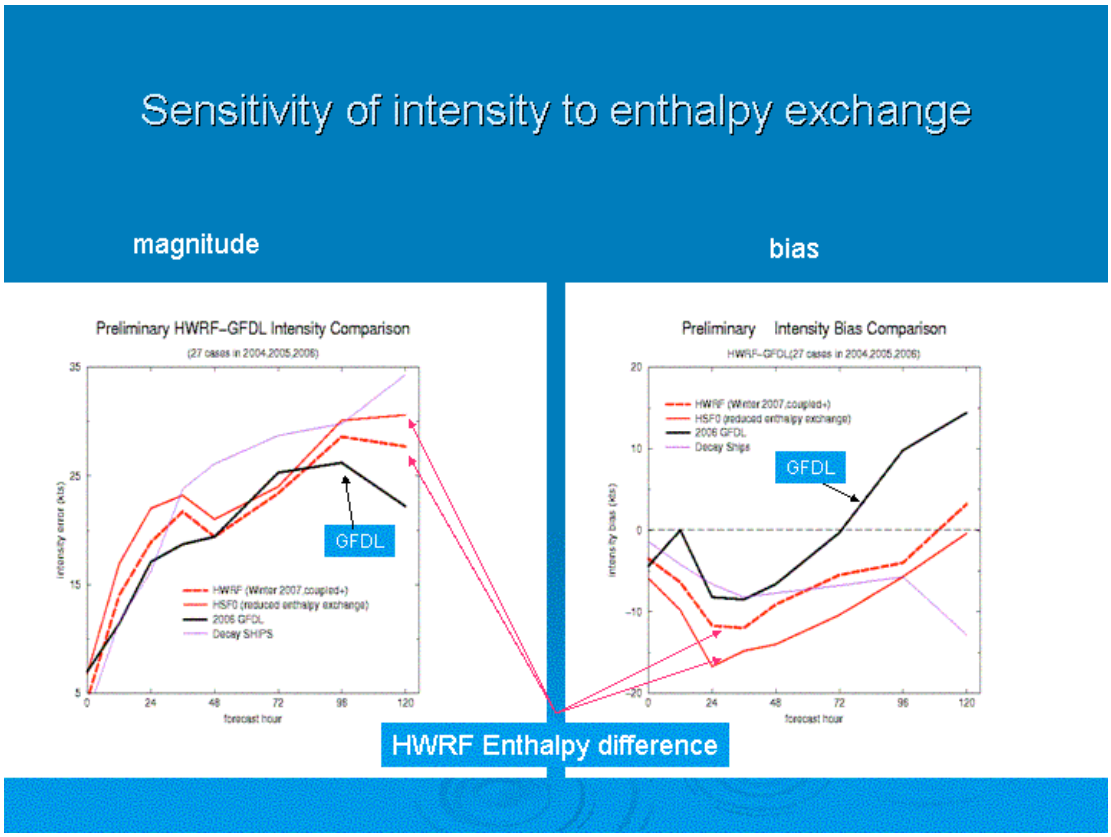

Fig.1. Comparison of the HWRF with the GFDL model and with sensitivity test of HWRF with reduced enthalpy fluxes.

4. Run both the nested and uniform resolution versions of HWRF in parallel for the 2006 hurricane season. **As mentioned in #1., HWRF can be run both in moving nested mode and with a uniform coarse parent domain. Some experiments were performed in uniform mode, but the HWRF runs were run in moving nested mode in near real time for the 2006 season. After the 2006 season, there have been quite a few upgrades made. The major accomplishments of the SAIC JHT project was the correction of an inconsistency in momentum mixing in the HWRF runs and the installation of the 2006 GFDL surface package in the Fall of 2006. Together with the installation of the forecast/analysis cycle into HWRF, these changes have led to a signficance advance in HWRF's ability to forecast track and intensity. As was mentioned, HWRF is now run operationally. The track statistics for Dean are shown in the figure below. For this case the HWRF out-performed the GFDL model.**

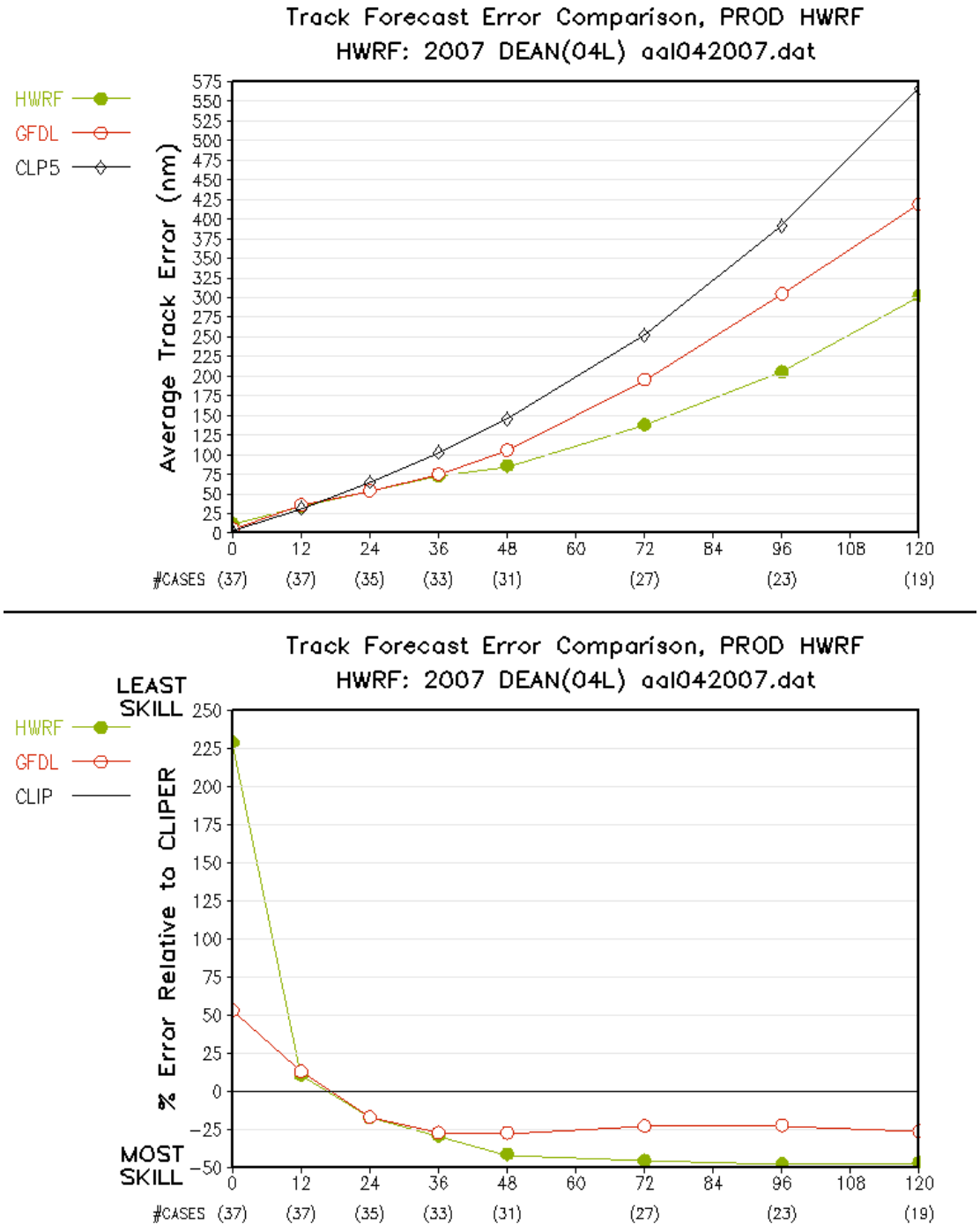

Fig. 2. A comparison of the operational track errors of the HWRF model with the GFDL model for Dean(2007).

5. Continue to collaborate with university and NOAA components in running and evaluating different versions of EMC HWRF. **As mentioned previously, SAIC has worked with URI to enable them to install and run the entire HWRF-coupled system. Tuleya has worked closely with Morris Bender of GFDL/NOAA and Isaac Ginis of URI in evaluating the comparison of HWRF with GFDL. Recently both the vertical diffusion and the surface flux components of the GFDL and HWRF model were compared in collaboration with URI personel. In addition, HWRF operational forecasts are available on the web. FSU has pointed out some sporadic problems with sea level pressure over topography. SAIC and Tuleya are activley investigating this phenomena.**

6. Continue to compare the HWRF results with the operational GFDL benchmark.This will involve continued collaboration with GFDL model developers. **Tuleya has worked closely with Morris Bender and Tim Marchok of GFDL/NOAA in evaluating the comparison of HWRF with GFDL. This work has emphasized remaining differences between the GFDL and HWRF model and how they may contribute to differences in performance between models. One area of concern is the inability of the HWRF model to simulate a more realistic wind-pressure relationship. Recently, SAIC and Tuleya has been involved in evaluating both the horizontal and vertical diffusion parameterizations for this difficiency. Differences between the GFDL and HWRF schemes are being evaluated. The HWRF operational model has done well in comparison with the GFDL model for intensity performance for Dean(2007). Note that in this case both dynamic models were unable to match the performance of decay Ships. This can be seen in the figure below.**

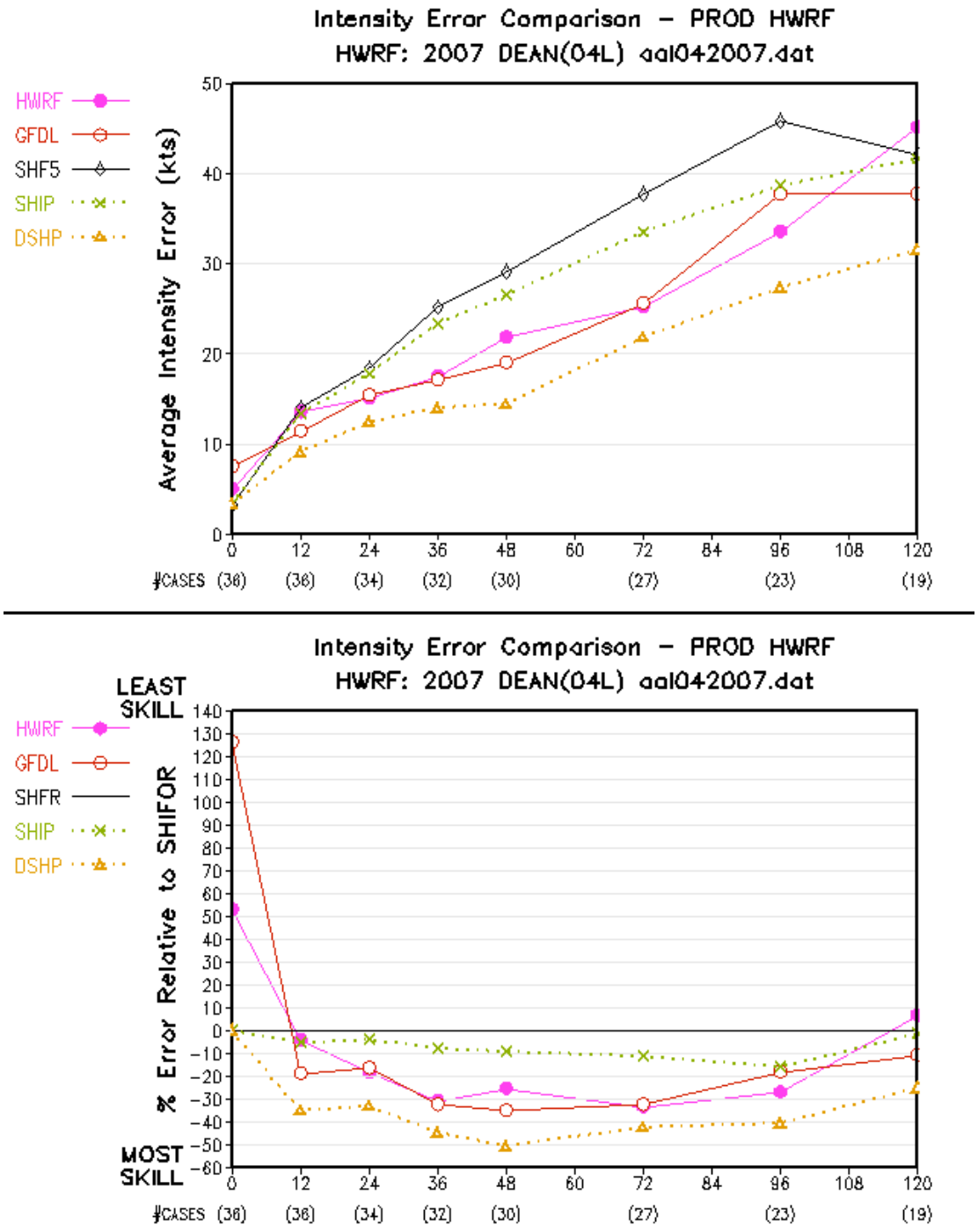

Fig 3. A comparison of the operational intensity errors of the HWRF model with the GFDL model for Dean(2007).

7. Determine the feasibility of running operationally a Hurricane WRF forecast system for the 2007 season. **The HWRF system is now being run operationally. NHC requested that some additonal guidance tools be developed for the hurricane season including wind and rainfall swaths**

together with text files giving concise forecast storm location and intensities. This software was developed by SAIC and Tuleya. The swath software was quite envolved because of the complexities of the moving nested domain and the HWRF rotated E-grid. The figure below shows a wind swath from the operational run of HWRF for Dean indicating the effect of two Mexican landfalls. Also shown below are the results of analyzing another text output of HWRF indicating hourly intensities of HWRF between the standard 6hr ATCF times. The hourly interval gives an improved overall picture of model intensity behavior because of the increased frequency and results are not subject to horizontal interpolations in the post-processing.

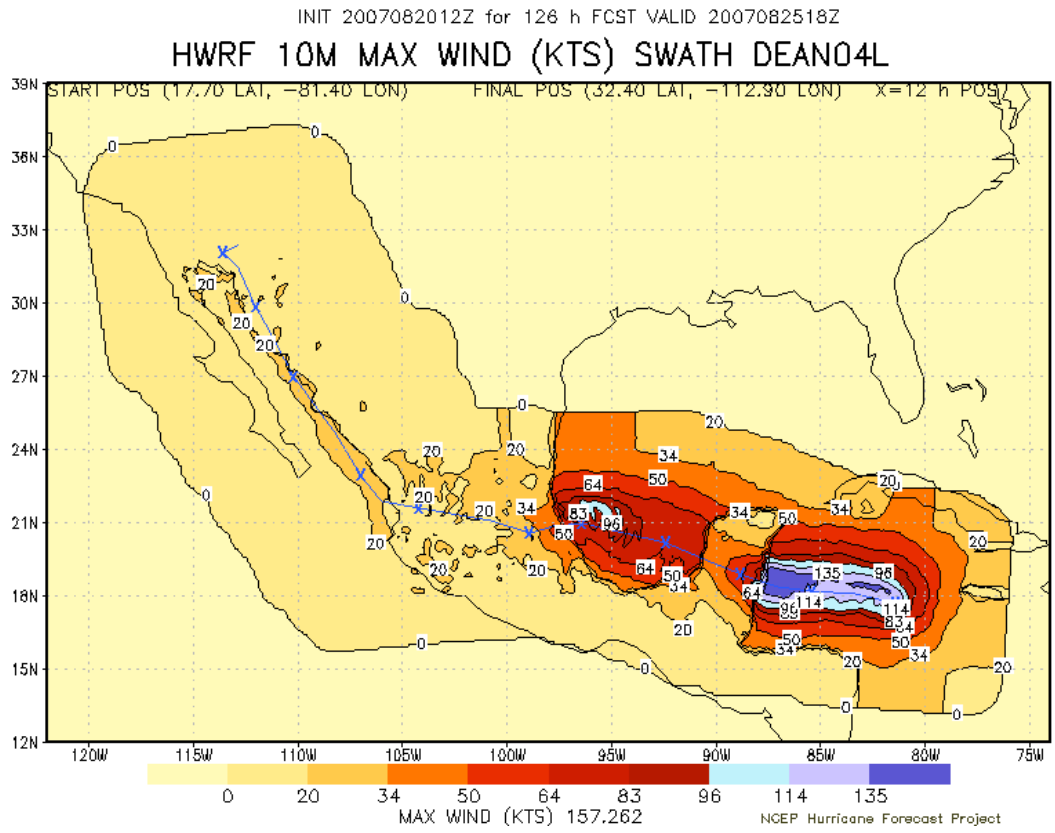

Fig. 4 An example of a 10m wind swath indicating the maximum 10m wind experienced at any point during the passage of Hurricane Dean(2007).

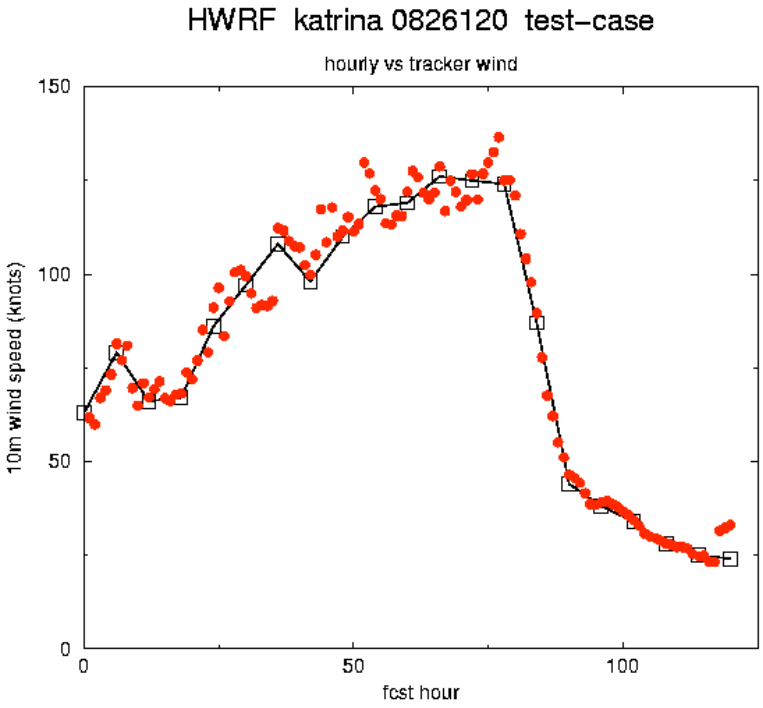

Fig.5. A comparison of 10m wind speeds from HWRF for a test experiment of Katrina(2005). This compares intensity obtained hourly with those from standard 6 hour intervals. The hourly output is obtained directly from the native HWRF model grid.