# Hurricane Model Transitions to Operations at NCEP/EMC

Mid-year progress report of the Joint Hurricane Testbed (JHT)

Robert E. Tuleya, SAIC

2/28/2007

The emphasis for this 2005-2007 JHT project has concentrated on HWRF development. Continued progress has been made in the development of HWRF into an operational hurricane forecast system. 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. During this past six months 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. 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.

As mentioned, the design of the hurricane forecast system has progressed with new components added for both physical integrity and operational expediency. Options are available to run a forecast analysis cycle in a NOAA hurricane model system for the first time. An ocean initialization and coupled atmospheric-ocean model has recently been integrated into the HWRF hurricane system. Another major task of this project has been checking and tuning of the physics packages to attain high forecast skill. It has long been known that physics packages are key to successful forecasts in the tropics, especially that of hurricanes. Considerable time has been spent in testing and incorporating physics packages comparable to the GFDL forecast system which has been undergoing considerable changes over the last few years.

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 the HWRF framework this is analogous to a no feedback option of running which was run in 2005. It is anticipated that a more thorough analysis of the sensitivity of the moving nest configurations will ensue 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 URI to enable 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 2006 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. So far the effects on momentum mixing are more dramatic. The figure below indicates such effects for a case of HWRF(Fall 2006 version) where there was degradation of track relative to the operational 2006 GFDL.**

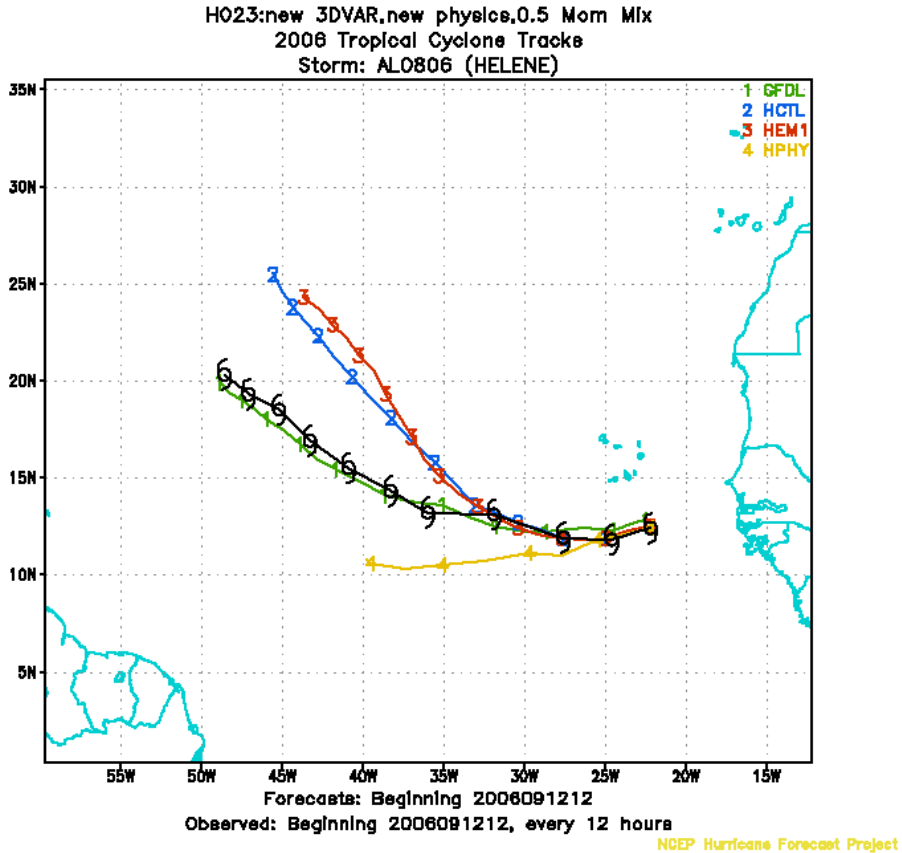


*Fig.1. Comparison of the HWRF (Fall 2006 version, labelled as H023 and HCTL) with the GFDL model and with sensitivity test of HWRF with cloud emissivities of 1.0(HEM1) and of HWRF experiment, HPHY, with strong momentum mixing in the SAS convective scheme.*

**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 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 forecast track and intensity. Over 200 cases were compared to the GFDL model for selected cases of 2004-2006. This can be seen in the figure below in which the forecast track accuracy is seen approaching that of the 2006 GFDL model.**

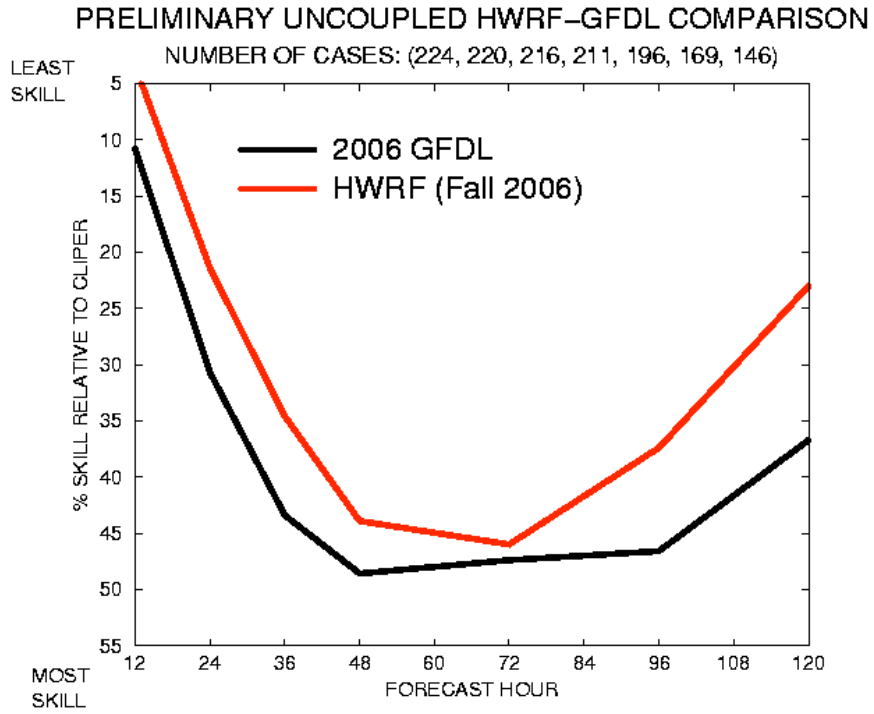


*Fig. 2. A comparison oftrack errors of the 2006 GFDL model with the Fall 2006 version of HWRF for selected cases of 2004-2006. The HWRF version is the same as the control version shown in Fig.1 and includes 2006 GFDL surface momentum flux parameterization,a preliminary forecast/analysis cycle and without ocean coupling.*

5. Continue to collaborate with university and NOAA components in running and evaluating different versions of EMC HWRF. **As mention in #2, 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. This work has emphasized the surface flux components of the GFDL and HWRF model.**

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. Tim Marchok has contributed plotting, tracker, and forecast verification code and has interacted with the SAIC team at EMC on HWRF system implementation.**

7. Determine the feasibility of running operationally a Hurricane WRF forecast system for the 2007 season. **As mentioned above, further improvements were recently made in the HWRF system, including preliminary ocean coupling, enhanced enthalpy flux formulation and interpolation directly from native GFS model grids. The figures below indicate the further improvement in track and intensity from the Fall 2006 HWRF version. Cases include those of Frances, Ivan and Lisa of 2004, Dennis, Katrina, Philippe, Rita and Wilma of 2005, and Ernesto and Helene of 2006. The next step will be a more numerous, representative comparison of HWRF forecast skill with that of GFDL after further changes of the ocean coupling are completed. It is anticipated that both GFDL and HWRF will be run for the upcoming hurricane season.**

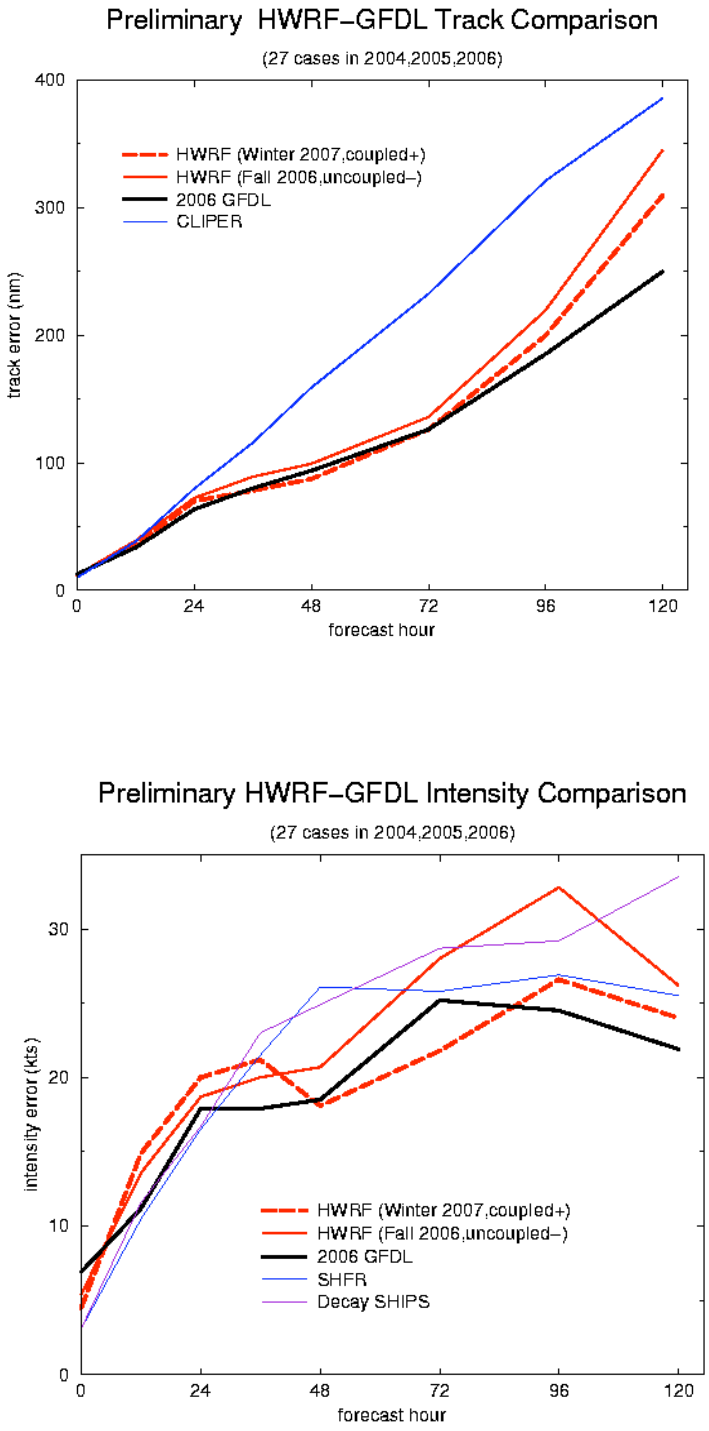


***Fig. 3*** *A comparison of track and intensity skill for a recent 2007 HWRF version with 2006 GFDL model and the Fall 2006 version of HWRF for 27 selected cases of 2004-2006. The 2006 HWRF version is the same as that shown in Fig.2. The 200 7 Winter HWRF system, includes preliminary ocean coupling, enhanced enthalpy flux formulation and a start-up directly from input native GFS model grids.*