Hurricane Model Transitions to Operations at NCEP/EMC

February 2006 Progress Report

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The JHT project deals with the transition from the GFDL to the WRF model that is scheduled to become the next operational hurricane model in the 2007 tropical season. The progress is indicated below in the August to February Timeline.

Work Plan and Time Line
Year One: August 1, 2005 – February 1, 2006

1) Continue to install, run and evaluate WRF prototype systems for 2005 hurricane season with upgraded GFDL initial conditions. This system has both uniform resolution domain and one-way nesting.

An end-to-end, automated system of the NMM-WRF with the one-way moving nest initialized from real-time storm positions was run nearly for one full season in 2005, twice a day. Each forecast was run 5 days. The grib files from the GFDL forecast was used as an input to the NMM-WRFSI. The initial and boundary conditions along with the static, land surface data for the parent domain was obtained by running the WRFSI. The parent domain was set to about 60°x 60° at about 27-km-resolution and the one-way moving nest was set to a domain size of approximately 7°x 7° at 9 km resolution. The SAS convection, GFS surface, GFS boundary layer, NOAH-LSM scheme, Ferrier microphysics, GFDL radiation for the physics options were used. The aim here was to test the robustness of the one-way moving nest dynamics and algorithm related to the nest motion. There were very few failures noticed in the end to end system and each of the NMM-WRF runs (excluding the wrfsi initialization) for a five-day-forecast took about 50 minutes using 72 processors. Fig. 1, for instance, shows the position of the moving nest for one of the forecasts from Hurricane Wilma.

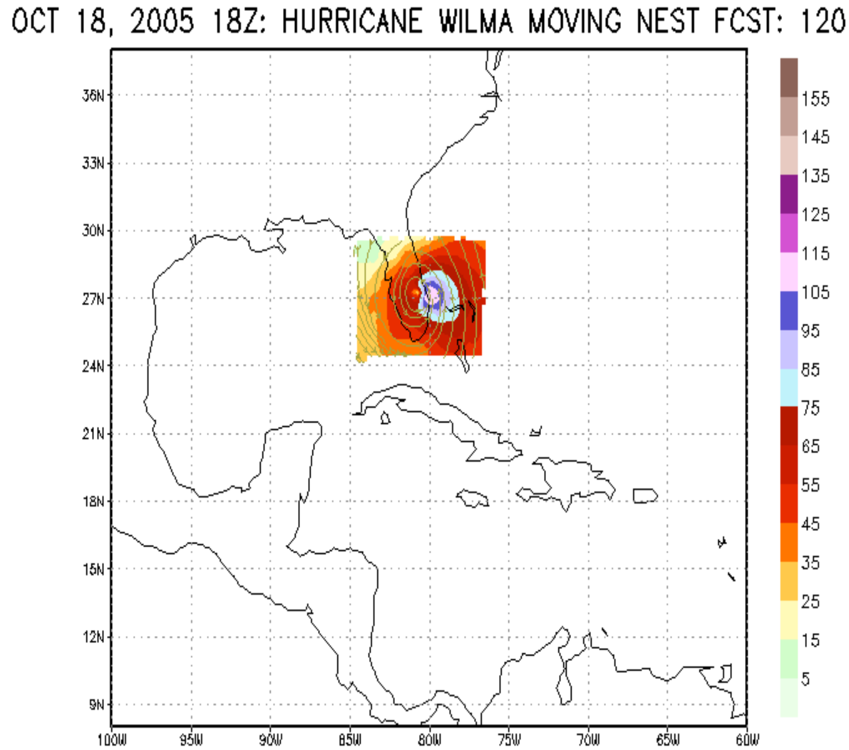

Fig 1: semi-operational forecast of *Hurricane Wilma, 2005.*

2) Compare 2005 HWRF prototype model runs with the GFDL operational/upgraded model. The GFDL upgraded model may include physics packages coded in WRF software framework to insure code integrity. The HWRF model will include changes to the 2005 HWRF prototype model with migration from GFS to GFDL physics for some physics processes.

The WRF physics codes have been assembled to provide a physically realistic, yet computationally efficient hurricane forecast model and forecast system. In transitioning to NCEP's next generational Hurricane WRF model, the benchmark physics will be the physics package presently used in the GFDL model. This physics package includes the Simplified Arakawa convective scheme and a Monin-Obukov surface scheme. These schemes will be compared to the present Global Forecasts System (GFS) parameterizations as well as with some other parameterizations deemed appropriate for meso-scale forecasting. One example of the difference between the GFDL and GFS model can be seen in Fig 2. Emphasis will be placed on the surface package presently used in the GFDL model and it's comparison with schemes that have separate surface roughness estimates for heat and momentum. This is especially important since intensity is known to be quite sensitive to these parameterizations and that hurricane maintenance can only be sustained through surface energy fluxes, especially that of moisture. On the other hand, surface friction has a retarding effect on hurricanes.

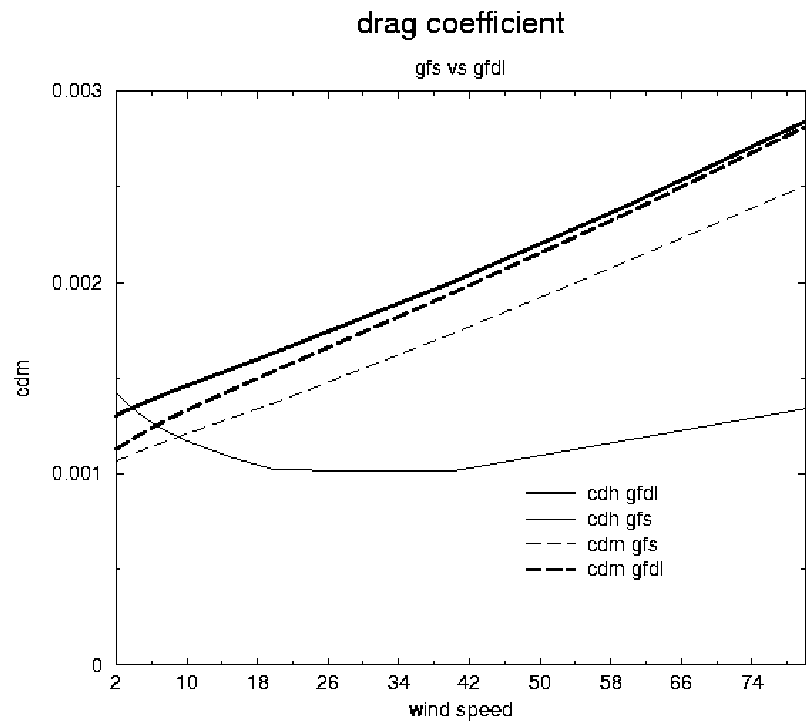

Fig.2 Comparison of exchange coefficients of heat/moisture and momentum for the GFDL and GFS models.

The surface exchange processes are still poorly understood and still under investigation. Recently, wave models and observations appear to indicate that the long used parameterizations that increase drag with wind speed may not apply under hurricane conditions. On the other hand, surface evaporation is complicated due to the effect of spray and the chaotic nature of the ocean interface under hurricane conditions.

HWRF Offline and model code comparisons indicate that surface evaporation in the GFDL model increases monotonically with wind speed while the GFS physics package increases evaporation at a lesser rate. Furthermore, the GFDL surface drag appears to be more dissipative even with a reduced coefficient.

3) Compare LSM characteristics including rainfall and runoff in HWRF with the GFDL model run.

A 3-day forecast for each of 25 historical landfall hurricanes was run for both slab (operational) and Noah LSM model couplings in the GFDL model. For the chosen cases, all hurricanes made landfall less than a day. The model results for hurricane track, intensity and (accumulated) precipitation over land were compared to the observations from the rain gauge data and the National Hurricane Center best track reanalysis. It was found (not shown) that the impact of the Noah LSM coupling on track and intensity are insignificant. For example, the track difference is smaller than 50 km for most of the cases. Appreciable differences are found in the precipitation particularly in local accumulation. The hurricane-Noah LSM coupled system in general improves the precipitation forecast (such as in total rainfall, equitable threat score and QPF bias score). An example is given in Fig. 3 for QPF bias score. Recently, the GFDL slab model was coded in the WRF framework for comparison with the NOAH LSM. An objective comparison of track, intensity and precipitation is ongoing in the HWRF system.

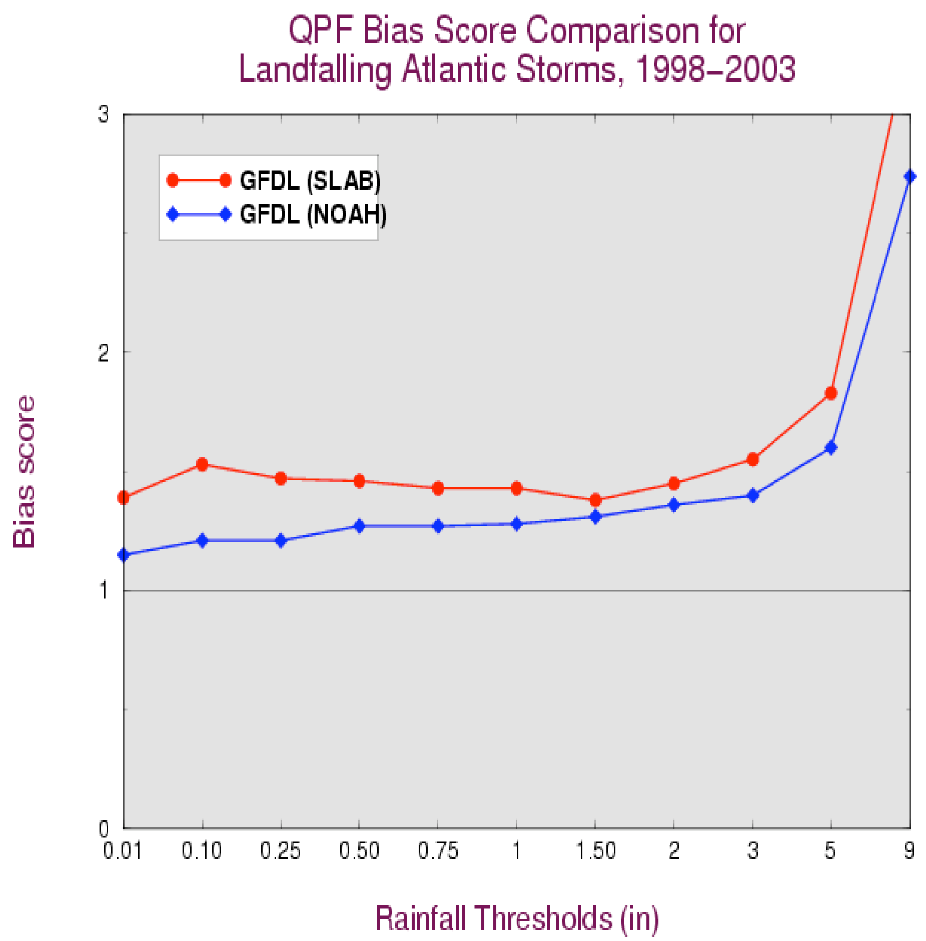

Figure 3. Rainfall bias statistics for 25 historical landfall hurricanes over the Gulf ofMexico and western Atlantic basins from 1998 to 2003.

Fig.4 presents a comparison of the sensitivity of the surface temperature using the NOAH LSM model and the more simple GFDL slab model in HWRF for a case of Dennis (2005). The effect of surface and convective parameterization on storm track and intensity are also being analyzed for a more complete suite of cases.

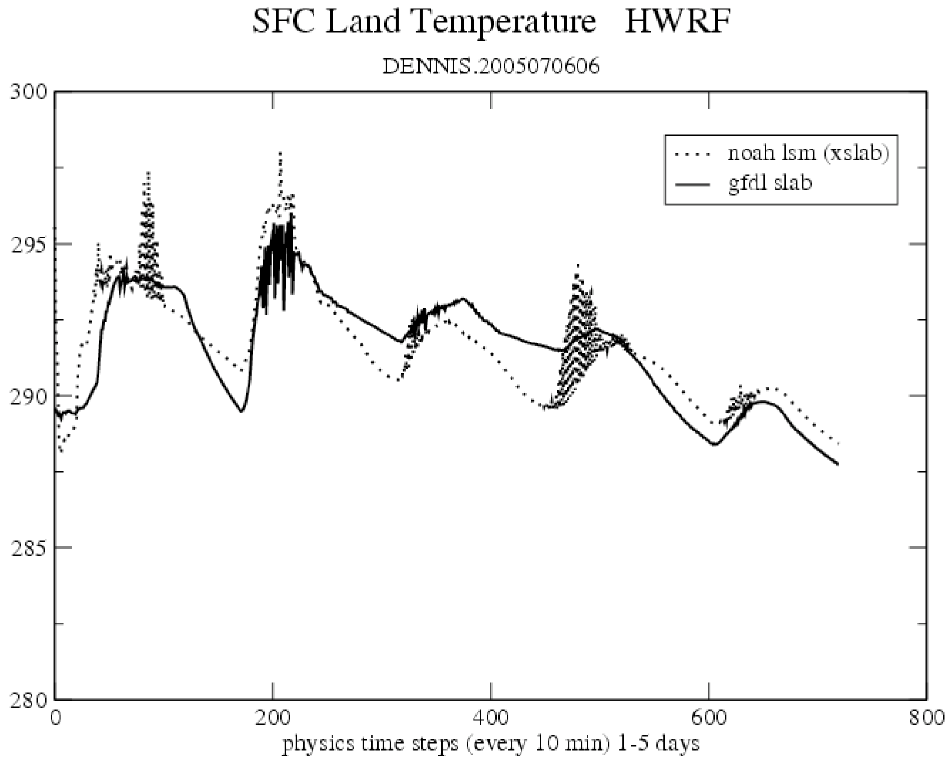

Fig.4 Comparison between surface temperatures predicted using the NOAH LSM and the GFDL slab.

4) Collaborate with EMC developers in the design, running and evaluation of the first moveable, 2-way nested version of HWRF. Also collaborate with university and NOAA components in running and evaluating different versions of EMC HWRF.

Two different approaches have been adopted in the design of a movable nested mesh, especially for hurricane forecasting. In one approach two non-overlapping adjacent meshes may be dynamically coupled when the time integration for the grid points near the mesh interface is performed on each side with the use of the information in the other mesh domain (e.g., Kurihara et al., 1979). A fairly easier method is to transfer meteorological information from a fine to a course mesh and vice versa over the region of coinciding grid points (e.g., Phillips and Shukla, 1973). The nested grid NMM-WRF modeling system is broadly based on the latter approach.
The two-way system is presently under development and it will be ready for parrllell testing for the 2006 year.
An active participation with Floridida State University has resulted in HWRF being run for a variety of spacial resolutions.

5) Compare developmental nested HWRF runs with the uniform resolution versions of HWRF.

One difference between GFDL and HWRF nested runs are that the uniform resolution parent grid is integrated throughout the parent domain so the comparison with the nested HWRF domain is more straight forward. For post-processing, software has been developed to combine the parent and nest domain into one fine resolution domaind for verification of tracks and intensity. Fig.5 indicates the design of parent and nest grid domains for HWRF in a 3 to 1 grid configuration.

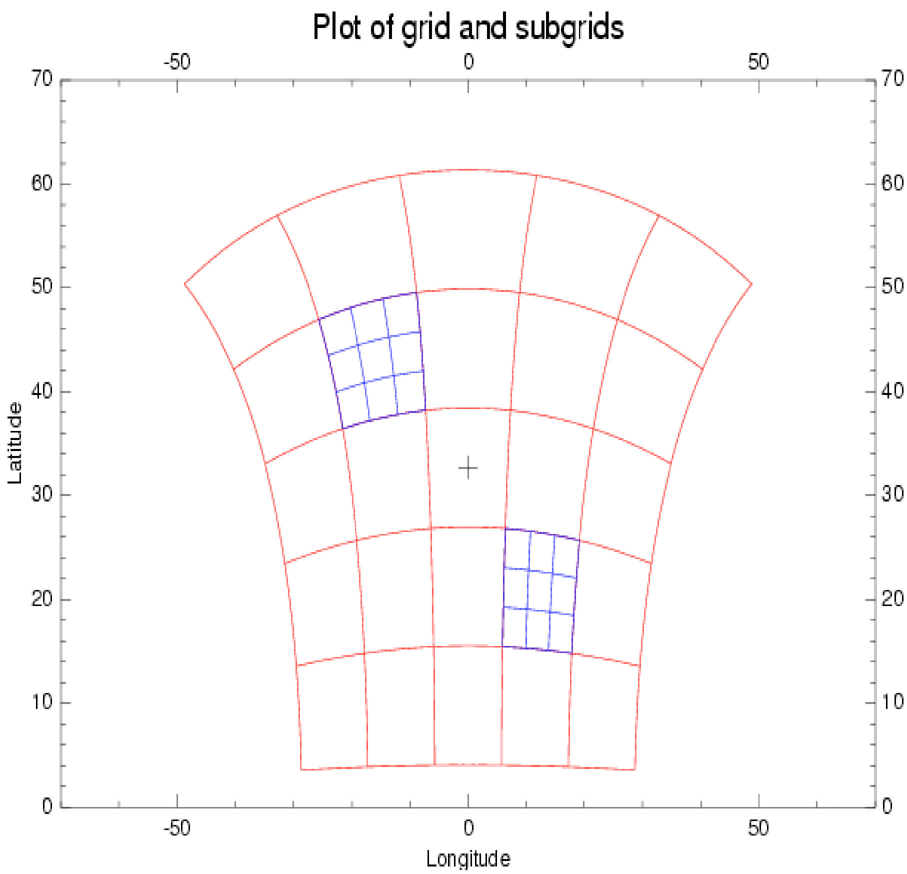

Fig 5: The NMM telescopic nest as it appears on a true latitude-longitude coordinate system.