Joint Hurricane Testbed (JHT) Program

For the

Environmental Modeling Center/National Centers for Environmental Prediction
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Hurricane Model Transitions to Operations at NCEP/EMC

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This proposal called for the continuation of funded work on the GFDL hurricane model upgrades as well as the initiation of a prototype Hurricane WRF forecast system. Several upgrades to the GFDL model were implemented and tested. Some of these upgrades involved changes to the present physics packages, while others involved the addition of packages that can be run in conjunction with the present GFDL physics packages. This effort involved quite a bit of model coding and development over the past two years. There is no guarantee that the "upgraded" codes, although more advanced in scientific principle, will lead to improvements in the two metrics used to implement operational hurricane models, namely mean track and intensity error. The second area of work is the commencement of the transition from the GFDL to the HWRF model that is scheduled to become the next operational hurricane model in ~2007. Both of these projects will be described below.

Upgrading of the GFDL Model

1) Surface Physics
    The general goal of the changes to the GFDL system were to install upgraded physics packages into the GFDL model. In recent years the GFDL model was improved in track and intensity with the addition of GFS boundary layer and SAS convection schemes. In a similar vein, sensitivy tests were performed to test the sensitivity of the GFS surface flux parameterizations. The GFS and GFDL methods both used Monin-Obukov formulation, but there were some differences. Rather recently, the GFS surface package, itself, was upgraded through comparison to observations which indicate a reduced CH realative to CD. Unfortunately, these observations were only at wind speeds below 15m/s and may not apply at the high wind speeds of hurricanes. Furthermore, complications arise because neither scheme accounts for the effect of sea spray. Recently, Tuleya recoded the GFDL surface flux parameterization to have an option for different znot for momentum and heat/moisture. This enabled URI to make model runs using the observed fact that momentum znot is reduced at high wind speed. Furthermore, the new code enabled the ratio of CH/CD to be formulated by the GFS method. Model integrations were performed by URI and GFDL and indicated a degradation in intensity and track when using the GFS formulation. Sensitivity tests are now underway with HWRF to assess the impact of GFS vs GFDL surface flux parameterization.

Early tests indicates that the GFS formulation may also have degraded effects on the HWRF runs.

2)   Coupling the Noah Land surface model with the GFDL model

It was decided to run the 3-nesed version of the GFDL model in operations this year. Bender has reported impressive improvements in track especially at day 4 and 5 with a high resolution inner nest. Before making this decision, Weixing Shen created an operational version of the coupled NOAH land model for the 2004 GFDL configuration. Earlier preliminary experiments found that precipitation and, to a lesser extent, track forecasts were superior to the operational GFDL model which uses a slab land model. However, these experiments were only run for 3 days. A more complete suite of experiments were run for 5 days forecasts emphasizing landfall cases. Quite surprisingly, degradation was found in the track forecasts in the day four and five day forecast positions. The enclosed table illustrates the track degradation beyond one day.(GLND is the GFDL model coupled with the NOAH land model;GNIT is an upgraded GFDL with improved initial vortex specification.) Considerable time has been spent on diagnosing the reasons. One of the issues is the rather high values of land temperatures predicted with the NOAH LSM. As a whole, there are indications that the overall synoptic forecasts may be at least a good, if not superior, to the operational GFDL forecast. However, shortcomings like spurious ridge breakdown, have led to track deviation, especially at day four and five. Therefore, the operational implementation of the coupled GFDL NOAH LSM has to be delayed. The enclosed figure shows the increased 800mb height error of the GLND compared to the operational GFDL. Notice the increase of error in GLND (negative height anomalies) compared to the operational GFDL along the eastern seaboard emanating from Jeanne off the Florida coast. Studies will continue to correct this problem and to verify the GFDL coupled land rainfall fields more objectively using rainfall verification techniques specifically designed for hurricanes. Presently, the coupled LSM has beed recoded to interface with the new high resolution 2005 GFDL model. If improvements can be demonstrated, this new coupled GFDL LSM model may be implemented for the 2006 tropical season.

AVERAGE TRACK ERRORS (NM) FOR HOMOGENEOUS SAMPLE

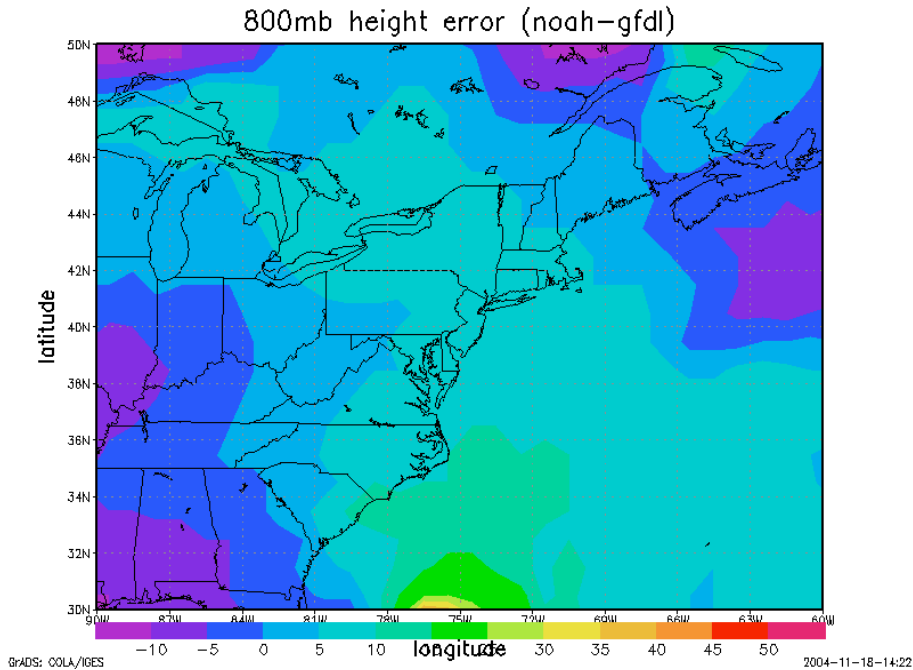|	00	12	24	36	48	72	96	120
GLND	6.0	25.0	38.8	55.8	66.0	104.5	194.4	331.6
GNIT	5.6	24.8	38.8	52.6	63.1	94.8	173.6	288.4
GFDL	6.2	24.9	41.4	54.5	65.5	103.2	180.6	289.0
CLP5	4.8	28.4	60.7	105.2	156.0	278.4	399.5	519.6
#CASES	48	48	48	48	48	48	48	46

Figure: Height error differences between the noah and operational gfdl model.

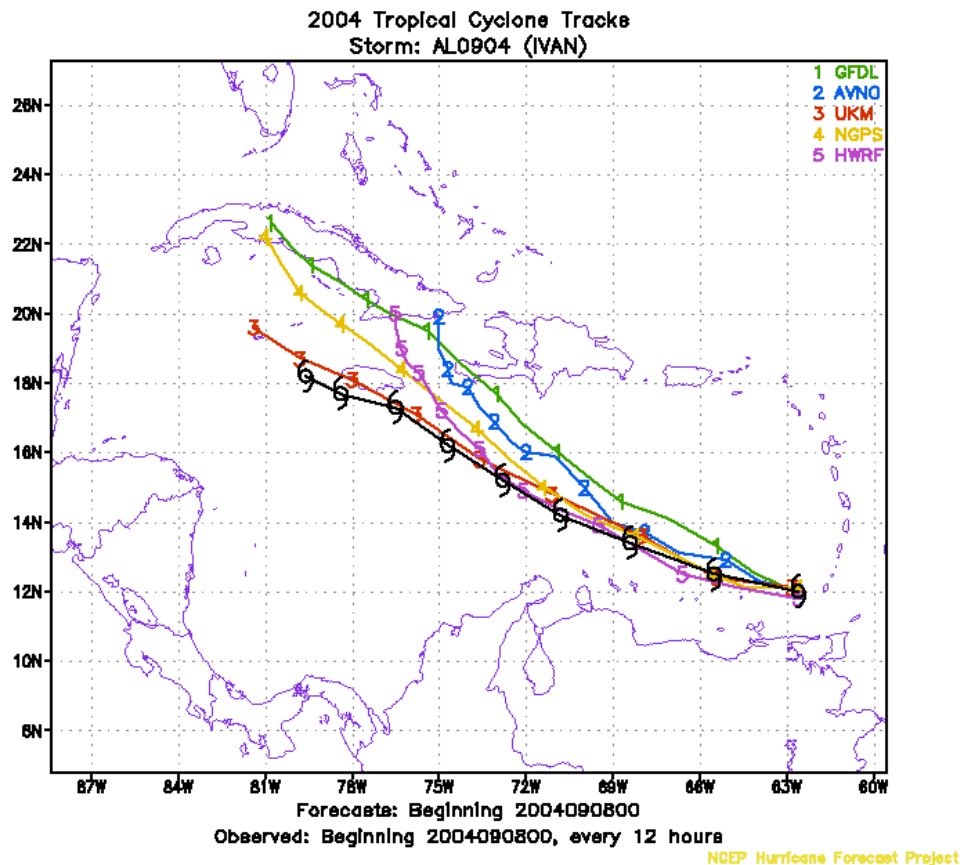3) Run bulk microphysics packages in GFDL model to test forecast performance.

Code has been successfully implemented into GFDL system for the Ferrier scheme. Several cases have been tested including Hurricane Frances. The code was generalized to be able to use either the Lin or the Ferrier scheme. In making comparisons with the Lin scheme it was found that the Ferrier scheme led to stronger storms which should be an advantage. Bender found that cloud microsphysics resulted in a physically more realistic storm, but the intensity and track of the forecsts were somewhat degraded. Since the high resolution 3-nest GFDL configuration will be operational and consume considerable computer resources, it has been decided that cloud microphysics at the high resolution will be more physically consistent and will be run in test mode this summer. There remains issues implementing microphysics into a nested configuration. Problem areas include how to blend the microphysics package with other convective parameterizations and also with large scale condensation. The code has been handed over to Bender, the GFDL model custodian, who is presently testing the Ferrier code in close collaboration with Ferrier and Tuleya. Some inconsistencies have been discovered. It appears for the case of Franklin(2005) that the shear was handled much better with microphysics, but with some cost to the forecast track. More case studies and model tuning will be required. If improvements can be demonstrated, this new GFDL model with bulk microphysics may be implemented for the 2006 tropical season.

HWRF Model Development

As mentioned much work has been done on this project. The plan of this project has been to leverage the work of WRF and the NMM core at EMC and to use the positive aspects of the successful GFDL hurricane forecast system. During the past year talks and discussions have been made by Gopal and Tuleya concerning HWRF at the Fall EMC HWRF tutorial, the Winter IHC meeting, and the June WRF/MM5 workshop.

4)   Evaluate Hurricane WRF proto-type model and forecast system.

A uniform-mesh WRF proto-type system was successfully installed and run at NCEP for the 2004 season. Forecasts were made on a routine basis at 00UTC and at other times as well. The system included making 4-day forecasts starting from GFS initial conditions using the NMM dynamic core at a uniform resolution of ~18km with 42 levels. An entire automated system was utilized which monitored NHC storm requests and initiated an HWRF forecast. The system included a post-processing system which had a storm tracker system which generated storm information identical to the operationall atcf-unix format. Over 120 forecasts were made. The system was found to be robust with few failures and competitive with the operational guidance. Most of these runs were with Eta-type physics and GFS initial conditions. Recently progress has been made with using GFDL initial conditions (GFDL specified vortex) and GFDL and GFS physics packages. The figure below shows an example of the comparsion of the HWRF system with some standard operational models. A more objective validation of the HWRF system will be made now that the HWRF can be run from GFDL initial conditions and with a physics package similar to the operational GFDL model.

2004 Tropical Cyclone Tracks
Storm: AL0904 (IVAN)

Forecasts: Beginning 2004090800
Observed: Beginning 2004090800, every 12 hours

5)   Determine the feasibility of running operationally Hurricane WRF in nested mode.

Last year's 2004 success of running the proto-type version of HWRF leads to the conclusion that an upgraded version of HWRF will be run this season. Recently, nested integrations have been started with emphasis on one-way interaction between nests. Presently HWRF is being run in three modes: 1) 9km resolution, GFDL initial condition static nest with outer domain placed within the 75° x75^o GFDL domain; 2) 9km,GFDL initial condition moving 5° nest with outer domain placed within the GFDL model domain; and 3) 27km resolution with GFS intial conditions. Close attention is being paid to the track and intensity results. The figure below displays the tracks for Dennis(2005) from the HWRF and GFDL nested forecast systems. For many cases the HWRF appears competitive with the operational suite of guidance. More testing and tuning is required this upcoming year. The next task in nesting will be 2-way interaction. In addition, coding is underway to combine the output from both nests into one output grid to be used for both synoptic maps and storm tracking and intensity evaluation. The HWRF plan calls for HWRF to have its own forecast analysis cycle with the ability to assimilate high resolution data. With the 27km uniform resolution runs, some experiments will likely be made using the HWRF data assimilation system which is under development. Some of these tasks will hopefully be carried over in the upcoming 2005-2007 JHT proposal.
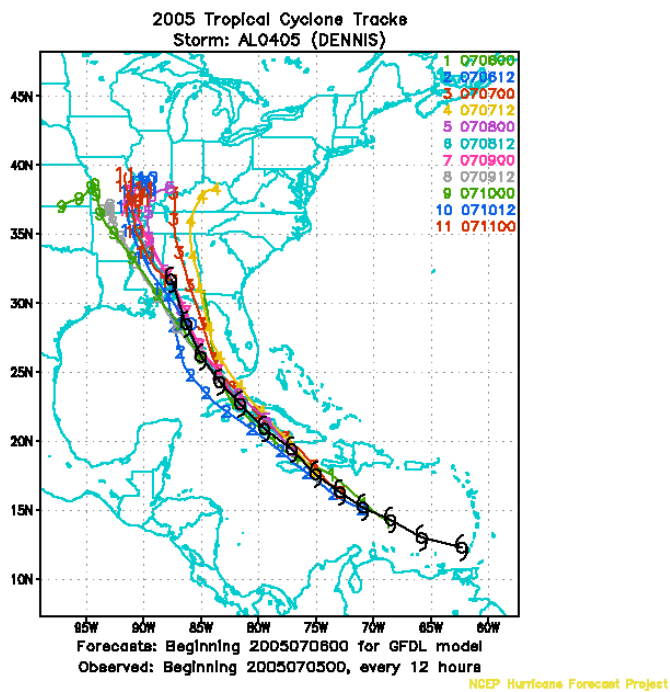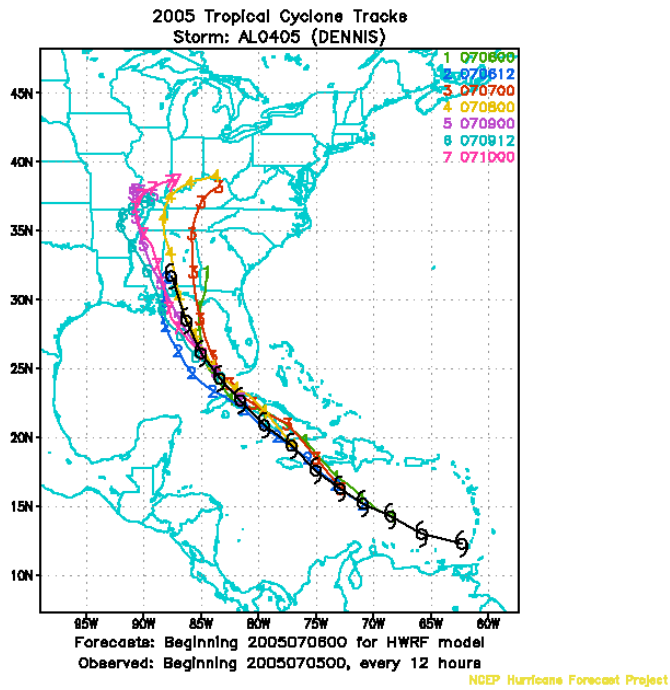
Figure.   A suite of both nested HWRF and operational GFDL forecasts for Dennis(2005)