Hurricane Model Transitions to Operations
1st year report
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Statement of Work

The primary task area is to contribute in Hurricane WRF (Weather Research and Forecasting) modeldevelopment and the further improvement of HWRF forecast system. The operational HWRF was successfully installed for the 2007 and ran in a robust fashion with relatively few problems. This ongoing year (2008) has been quite active (~280 cases) and therefore quite a test for the relatively new HWRF system. The HWRF 2008 system has performed admirably and like 2007 has run with few failures. Preliminary statistics indicate that the track error of HWRF was relatively small compared to Cliper and was ~ the 2nd best of all model guidance (GFDL being the best) when integrated over all forecast periods. Of course more cases may occur later in the 2008 season. In addition the intensity forecast has been quite competitive with the GFDL and statistical models especially in the mid-range 2-3 day forecast period. Both GFDL and HWRF have spin up/down problems from the initial forecast time which continue to plague dynamical intensity forecasts. Figure 1 shows a preliminary comparison of the HWRF system with the GFDL track guidance for the 2008 season for the Atlantic. Figure 2 shows a preliminary comparison of the HWRF system with other intensity guidance for the 2008 season for the Atlantic. With knowledge of both the GFDL and HWRF systems, Tuleya and SAIC will continue to contribute expertise to improve WRF physics, initialization and nesting.

In the following pages, the 1st year time line is shown with the work progress in those areas.

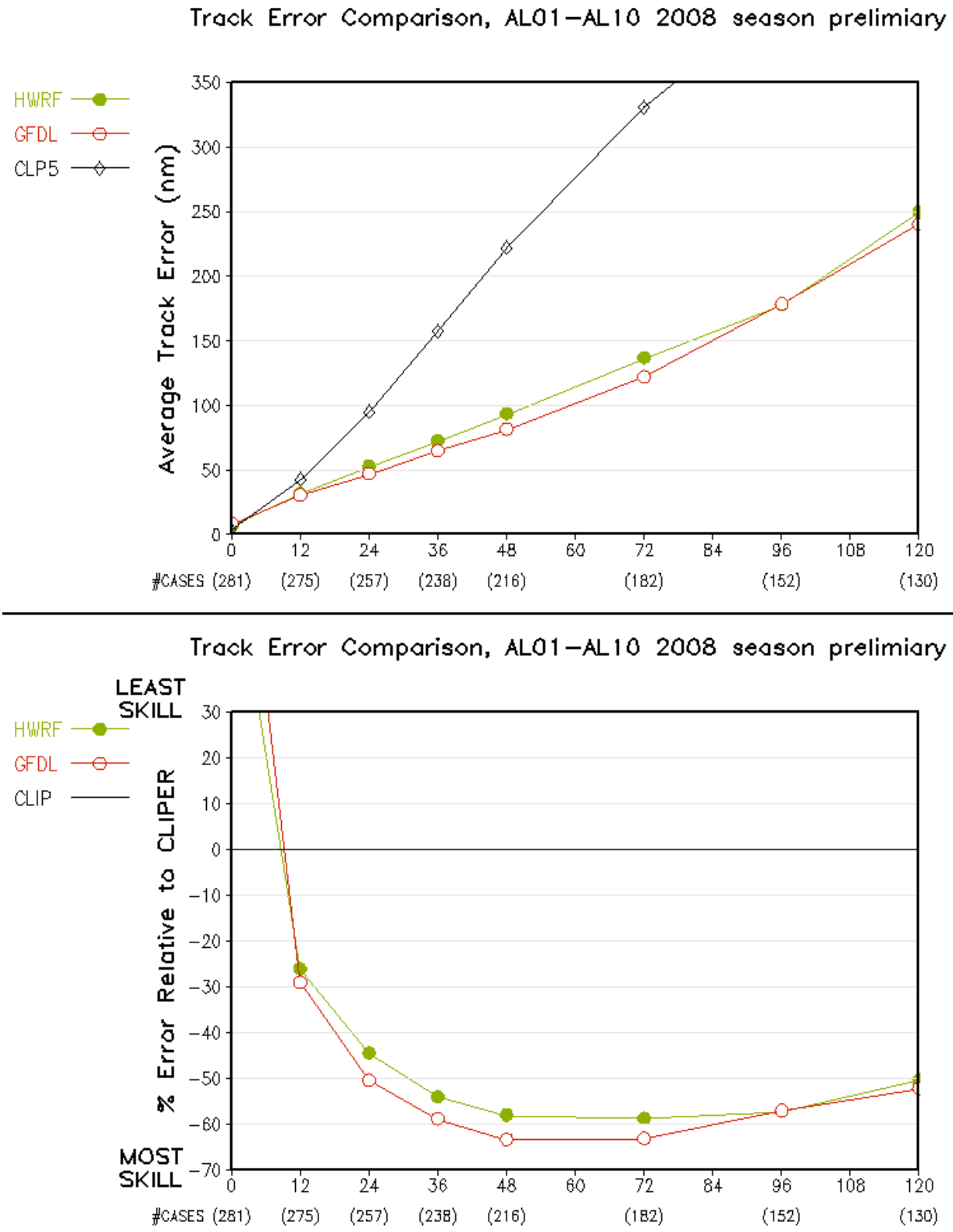

Fig.1. Preliminary track error comparison of the operational HWRF with the GFDL model for the 2008 Atlantic tropical season for forecast periods up to 120 hours.

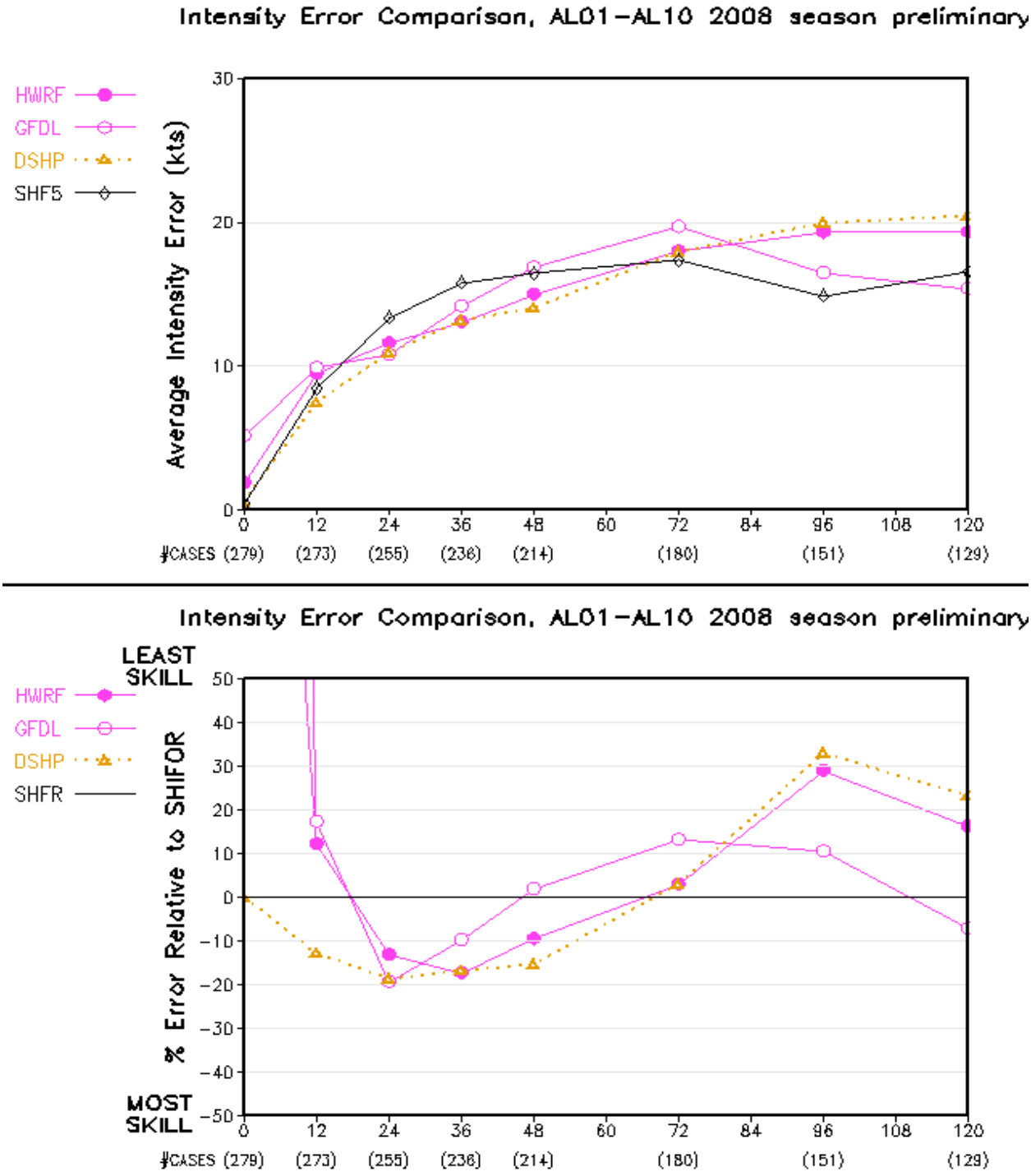

Fig.2. Preliminary intensity error comparison of the operational HWRF to other intensity guidance for the 2008 tropical Atlantic season for forecast periods up to 120 hours.

Work Plan and Time Line

Year One: 1 September 2007 through 30 August 2008

1. Test and evaluate present physics packages that are installed in the HWRF system and tune for performance skill in track and intensity. Check for physical deficiencies compared to the 2006 GFDL hurricane model. Investigate the role of cloud-radiation feedback in the determination of storm track and intensity. Compare with GFDL and other models. (EMC-1,EMC-2,TPC-1).

There are some issues with spin-up/down so that for some specific cases, model intensity is reduced rapidly. Tuleya has collaborated with other EMC personnel (Qing Fu Liu) to attempt to understand and rectify this problem. Another issue noticed is the occasional erroneous movement of the nest for weak disturbances. This problem has several components and is being investigated. Since the HWRF system uses the Marchok universal tracker, the reported storm position is not affected by this problem. Synoptic views of the nest within the parent grid, however, will show this distortion.

A major effort has been the recent evaluation of surface temperature in HWRF. It has been noted by NCO/NCEP that non-physical surface temperature fields occasionally occur over land and in the nest. Initially this was thought to be a post-processing problem, but a more thorough investigation reveals that a modeling problem may exist in the nest. The severity of the problem varies from case to case and from one physics option to another.

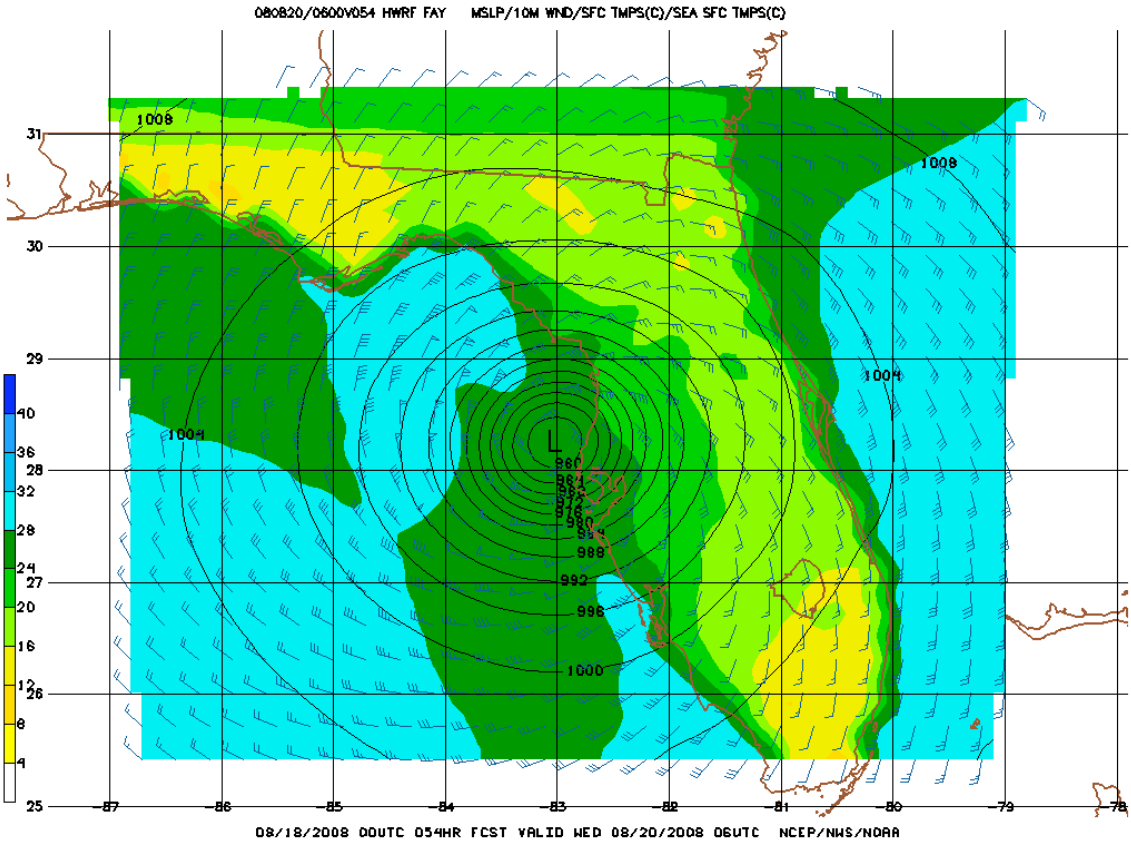

Fig.3. Surface wind and temperature HWRF 54h forecast for 2008081800 indicating abnormally cold surface temperatures (yellow).

2. Continue to contribute to the implementation of the HWRF into an efficient operational system which timely produces the products necessary for operational hurricane prediction. Test and evaluate the initialization, model, and post-processing steps. (EMC-1,TPC-4)

As one knows, the HWRF system is a complex forecast system with a forecast/analysis cycle. Tuleya generalized a software package together with Young Kwon of EMC whereby one can look at the raw data model output on native HWRF grid for both parent and nest and for model output variables including land and soil parameters. Tuleya has also collaborated with Vijay Tallapragada of the HWRF group in generalizing the HWRF forecast system to be able to start directly from the initial HWRF model conditions rather than execute the entire system from the beginning of data ingestion and interpolation. This feature has several unique options including running historic cases run in test mode or rerunning production cases which are presently active or those archived internally at NCEP. These options are/will be critical when developers/researchers want to investigate only a portion of the forecast system; for example, to investigate the role of model physics for the same exact initial condition. In addition, the HWRF group (Zhan Zhang) is testing a restart option which will enable a five day forecast to be split into several steps. In going to higher resolution and more computationally intensive forecasts, this is necessary in the NCEP computer environment where wall clock time is limited for a specific job. Tuleya has been consulting with the HWRF group on this task.

3. Collaborate with EMC developers in the continued improvement of the forecast/analysis portion of the system which specifies the initial condition of the storm. Collaborate with EMC developers in the evaluation of the coupled HWRF-ocean system. (EMC-1,TPC-4)

Surface flux parameterization sensitivity tests have been carried out which hopefully will be more consistent with the specified initial condition which is targeted to the maximum 10m wind and minimum central surface pressure. Several experiments have been carried out in collaboration with EMC personnel (Qing Fu Liu) tasked with improving the initial condition. Further investigation is warranted especially on how to specify the enthalpy flux.

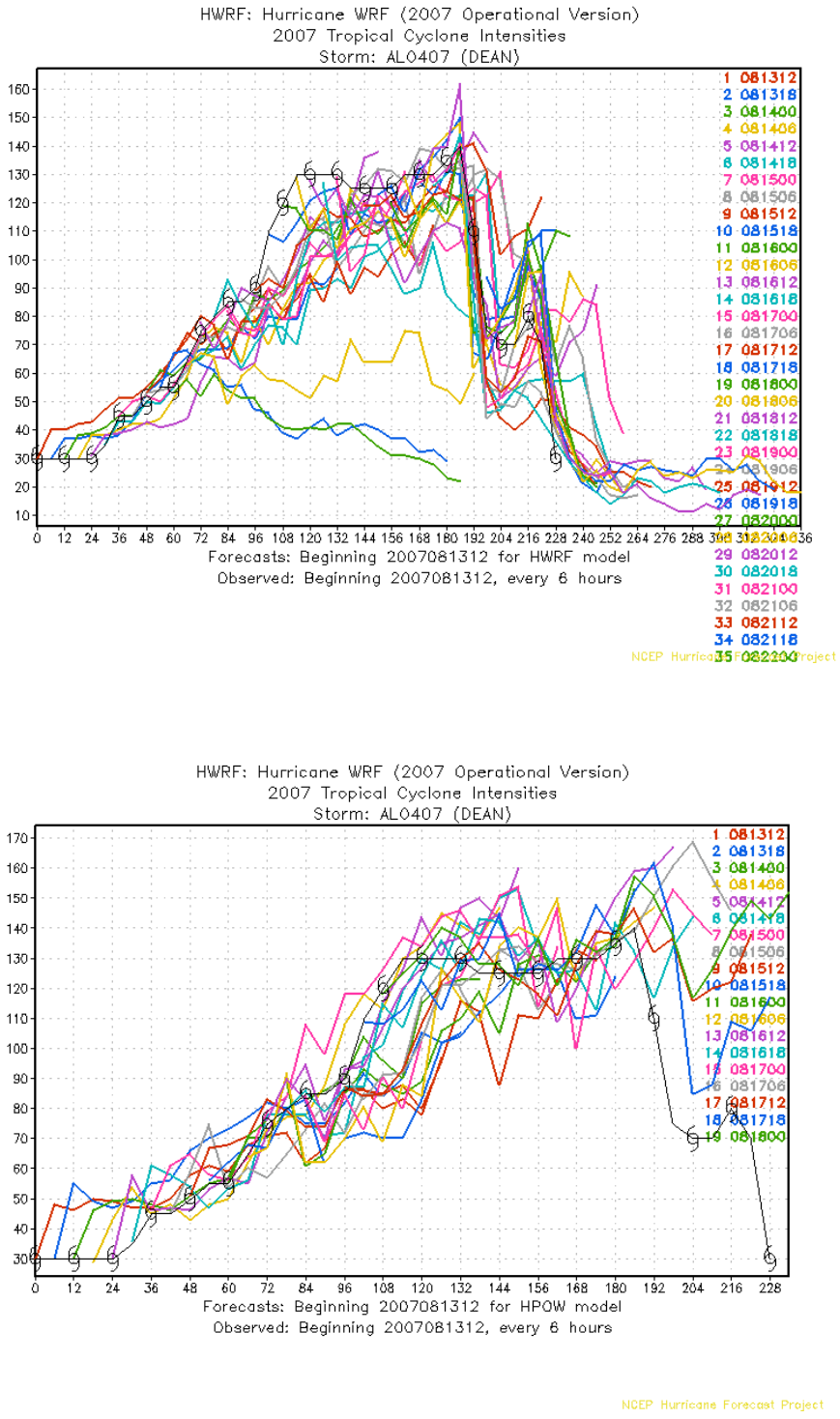

Fig.4. Comparison for a suite of HWRF Dean(2007) forecasts made with two different specifications of surface roughness. The top figure is the HWRF production version while the lower half indicates those run with a lower roughness at high winds as estimated recently by Powell.

In addition, Tuleya has collaborated in the development of the new coupled HWRF-HYCOM system. The EMC ocean group has now run some sensitivity tests for the entire suite of Gustav and Ike. The track forecasts are quite comparable with the HWRF production versions, but there appears to be a strong negative bias in the wind intensity. Tuleya is helping in that evaluation.

4. Investigate the skill of the HWRF system in forecasting rainfall using hurricane-specific validation techniques. This may be done in collaboration with other NOAA investigators. (TPC-8,EMC-3)

The code has been ported to EMC to do hurricane-specific rainfall validation, but needs to be tested. There are plenty of 2008 cases to investigate. A qualitative comparison has been made with HPC gauge estimates for Gustuv, Hanna, and Ike. The swaths of rain appear quite realistic although the amounts for Ike are under-predicted. More quantitative comparisons need to be made with both observations and with the GFDL model.

5. Investigate the impact of the NOAH LSM (land surface model) on the prediction of the distribution of low level surface winds and rainfall amounts and the overall decay rate upon landfall. This will be contrasted with the simpler one-layer GFDL slab model which is presently used in both the benchmark HWRF and operational GFDL hurricane models. (EMC-2,EMC-3,TPC-7)

This effort has been in collaboration with EMC land surface group (Yihua Wu**)**. Several cases of landfall have been investigated. A hybrid land flux parameterization was attempted in which the NAM surface flux/boundary layer schemes were utilized over land and with the GFDL/GFS surface flux/boundary layer schemes over water. As far as rainfall it appears as though the NOAH LSM reduces the spuriously large amounts of HWRF rainfall. At least for three test cases, rainfall appears more realistic using the NOAH LSM and GFDL/GFS surface physics. The production version of HWRF with and without the NOAH LSM retains storm structure further inland than with the NAM surface physics options.

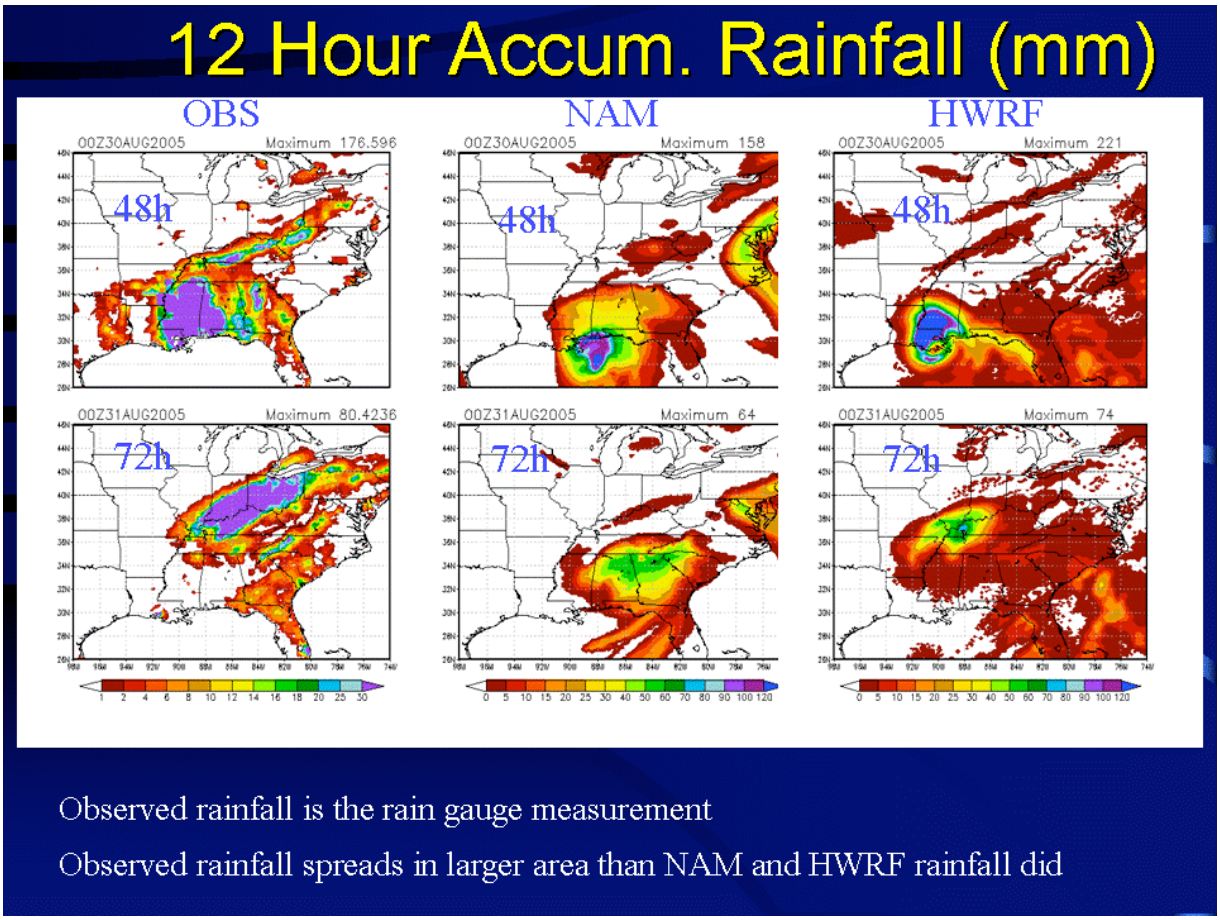

Fig. 5 Comparison of 12hour rainfall for a case of Katrina with the NAM model and the HWRF model with the NOAH LSM model included at 48 and 72h. Notice that the HWRF with the NOAH LSM has a better representation of 72h rainfall in the Ohio River Valley.

In an exciting additional effort, a simple runoff model has been utilized using runoff prediction from the HWRF/NOAH LSM model. In the operational HWRF model there is no provision to simulate runoff utilizing the present slab soil model. Preliminary evaluation indicates that the stream flow would be more realistic if the initial soil moisture was more accurate.

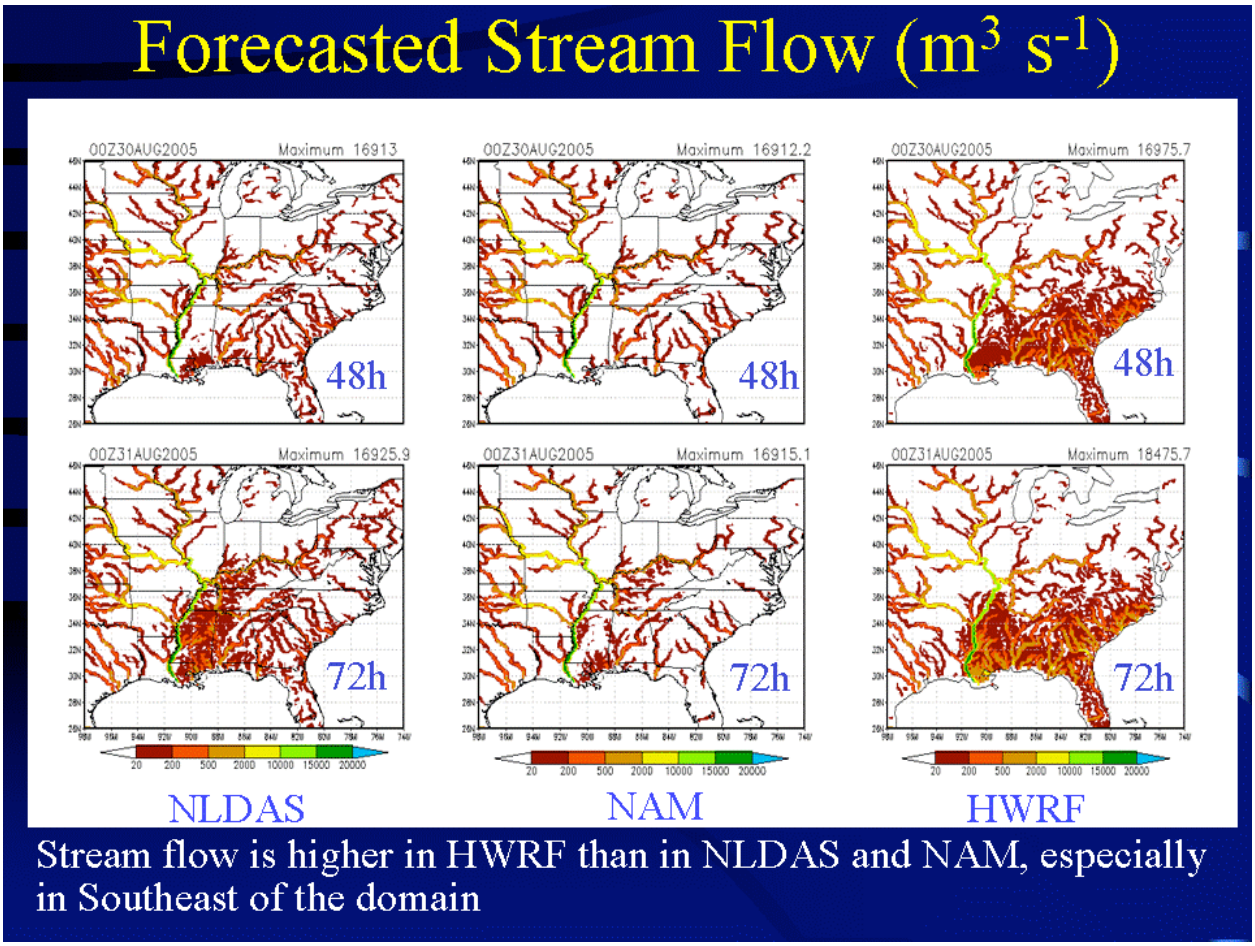

Fig. 6. Comparison of stream flow using EMC's Streamflow Routing Scheme (Lohmann et al., 2004) driven by the Land Data assimilation system utilizing observations, the NAM forecast model, and a test version of HWRF.