Hurricane Model Transitions to Operations at NCEP/EMC

Semi-Annual Report of the Joint Hurricane Testbed (JHT)

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Since the operational implementation of the Hurricane WRF system at the NCEP modeling center this past 2007 tropical season, the goal of the SAIC JHT project has migrated from system installation to system evaluation and upgrade. As a whole the HWRF forecast system performed well and was competitive with the other reliable guidance tools of TPC. SAIC and Tuleya contributed in several critical areas and interacted with the Hurricane program manager at EMC and with other EMC personnel in the scientific and computer code development of improvements to the HWRF system. SAIC and Tuleya used their expertise from the designing the nested grid system of the GFDL hurricane model system to apply similar techniques to the HWRF system. SAIC was responsible for most of the physics packages and key post processing packages used in the successful implementation of HWRF into the NCEP production suite. As mentioned previously, 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. HWRF swaths has been quite robust with little failure. In addition, SAIC has spent time evaluating and trouble shooting some problems including alleviating troubling sea level pressure noise over topography. The overall goal of the project over the next year is to make improvements in the HWRF system to achieve track and intensity skill over and above the GFDL system which is run in parallel.

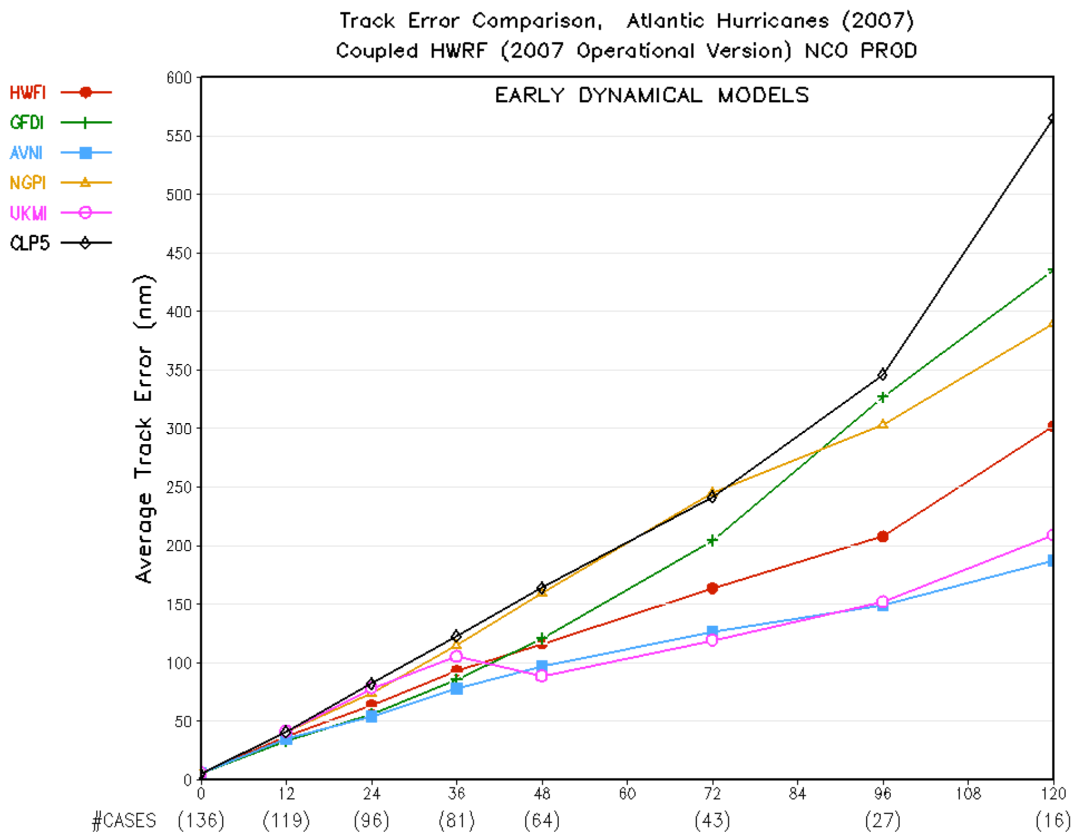

Fig: Track errors of "early" operational models including HWRF for the Atlantic 2007 season.

As far as the overall model performance, SAIC and Tuleya have monitored and evaluated the performance of the HWRF prediction system for the 2007 tropical season. This past year the HWRF system ran successfully with few failures and in a timely manner. The HWRF system was competitive with the GFDL system showing improvements in track compared with the GFDL system in the Atlantic basin, especially beyond 2 days (see figure above). On the other hand, it was a better track year for GFS which had track errors below 200nm at 5 days. Note that the 2007 Atlantic season was unusual in that there were few long-lasting storms. It was not an especially good year for intensity prediction for dynamic models including HWRF; the statistical intensity models did better after land effects were considered. In addition, HWRF had both track and intensity forecast problems in the Eastern Pacific. HWRF was inferior to both the GFS and GFDL in track, especially in the first few forecast days. All model intensity guidance had problems in the Eastern Pacific in 2007. The HWRF team is looking into improving Eastern Pacific forecast skill. Presently, there is no ocean coupling in this basin.

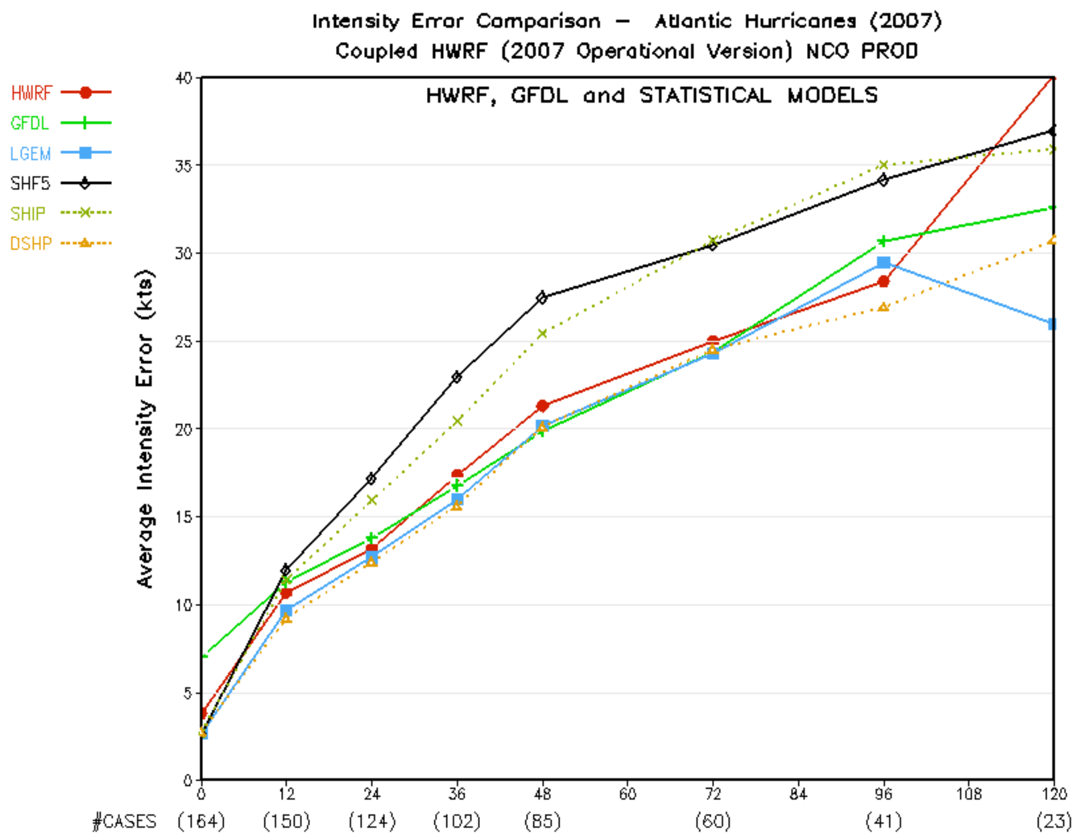

Fig: Comparison of HWRF intensity forecast skill with those of other guidance for the 2007 Atlantic season.

Note that in the figure above, HWRF 2007 forecast skill was quite competitive with the GFDL intensity forecast through day four. The HWRF intensity skill relative to GFDL from the initial forecast hour through one day is believed to be the result of the superior HWRF initialization of the model low level winds toward the observed intensity level. Note that these results include landfalls which degrades the SHF5 and SHIP forecasts.

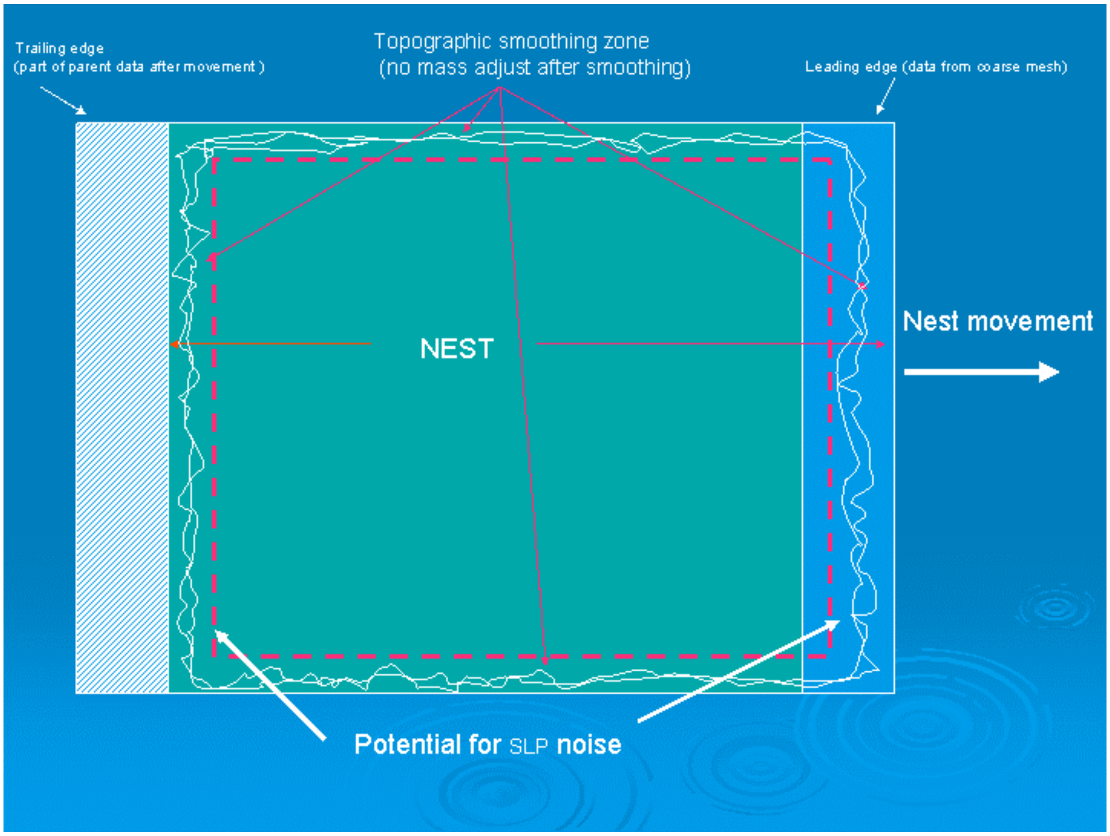

Fig: Schematic diagram showing moving nest with leading and trailing edge. Topographical smoothing zone is shown along perimeter of the nest. This zone has potential to create noise in sea level pressure if mass is not adjusted.

During the 2007 season, several problem areas in the HWRF system have been identified and are being investigated. As mentioned, one such problem area was that of noise in the sea level pressure fields. SAIC and Tuleya identified the problem to be in the HWRF model moving nest system and not post-processing as previously believed. SAIC and Tuleya have done a thorough review of the moving algorithms and has identified the problem as the lack of adjustment of the mass fields after topographic changes to the moving nest. Unlike the GFDL hurricane movement strategy, HWRF does some smoothing of the small scale topography field in the moving nest. This leads to erroneous sea level pressure values just after nest movement along the perimeter of the moving nest. SAIC and Tuleya have designed several fixes to this problem

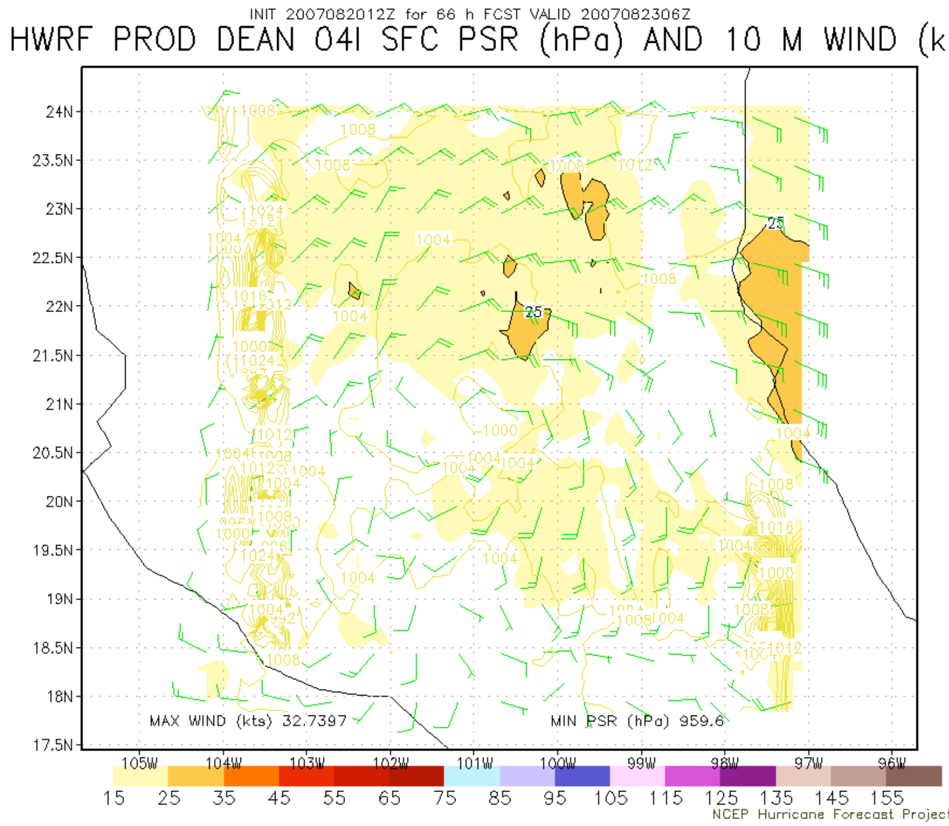

Fig: Operational HWRF sea level pressure and 10m winds in case of Dean 082012 at 66h just after grid movement. Note noise along east and west sides.

If the movement code is modified to account for the topographic differences, the fields can be made much smoother as indicated in the figure below showing the second Mexican landfall of Dean. Further evaluation of the mesh movement algorithm is continuing. Tuleya and SAIC are closely investigating details on how the various fields are moved and what improvements can be made with the moving algorithm. Presently, the position of the storm in HWRF is determined by the post-processor tracker rather than by the internal algorithm that specfies grid movement. In addition, SAIC has also studied the difference in topographical fields used by NAM, GFDL and HWRF. It was found that these differences are small and don't lead to any differences in hurricane forecast qualitiy.

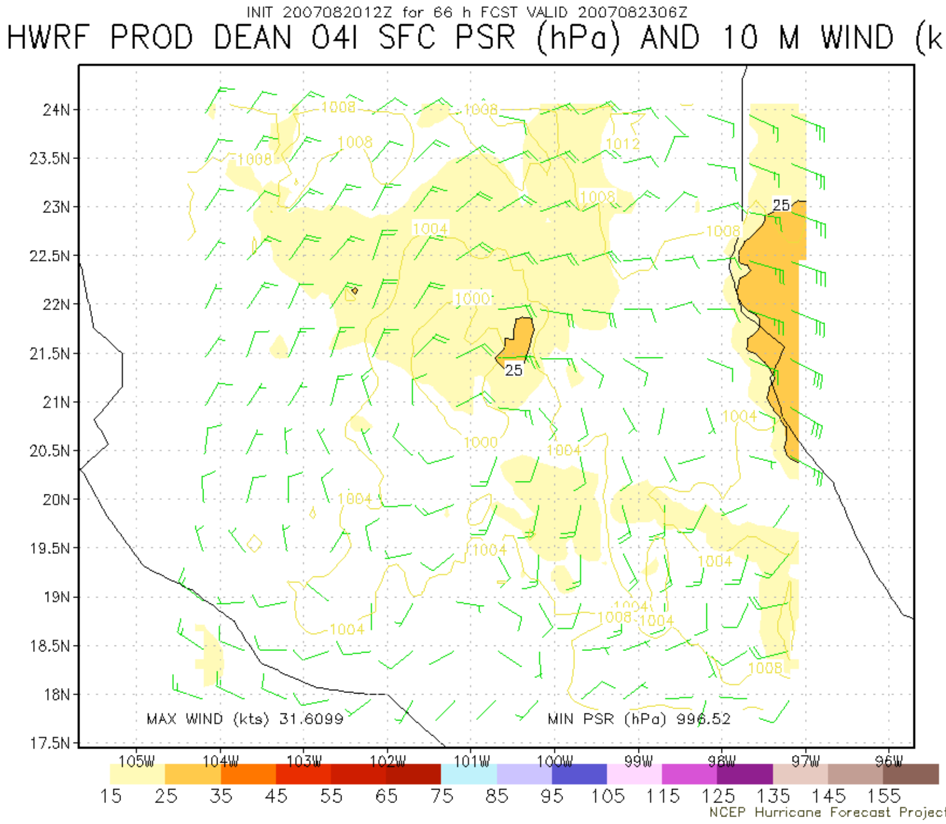

Fig: Test version of HWRF sea level pressure and 10m winds in case of Dean 082012 at 66h just after grid movement. Note lack of noise along east and west sides.

As mentioned, the "TPC post" component software was developed by SAIC and Tuleya to display swaths of wind and rainfall. The swath software was quite involved because of the complexities of the moving nested domain and the HWRF rotated E-grid. SAIC has carefully looked at these products which are routinely broadcast on the HWRF WEB site as well as produced side by side with the GFDL counterparts at the NHC. An example of the wind swath product for Felix is shown below. Notice that for this case, HWRF's track was quite good until Felix dissipated over land. HWRF was able to forecast the rapid dissipation of intensity as Felix made landfall.

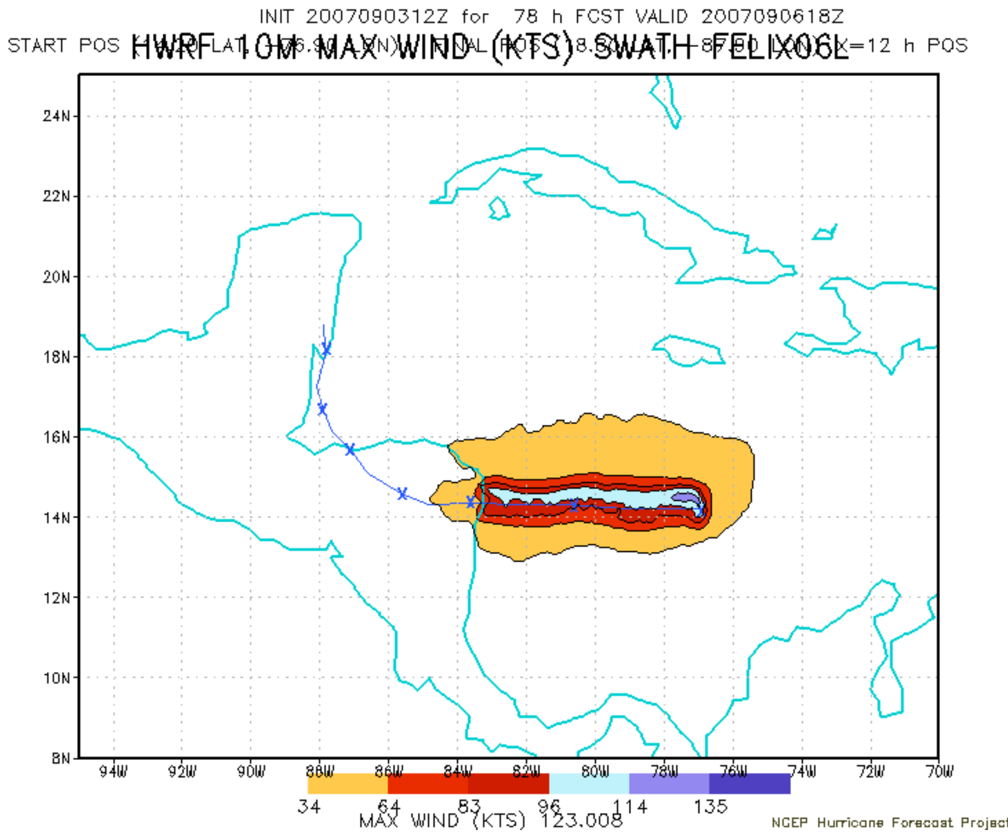

Fig: HWRF operational wind swath indicating rapid filling of Felix upon landfall.

A new grads-based tool was coded for model developers to compare various model intensity guidance. This was based on a standard track guidance using atcf-unix input and developed by SAIC with Tuleya monitoring its develpment. An example of its use is shown below for the intensity forecast of HWRF compared to other models for Felix making landfall.

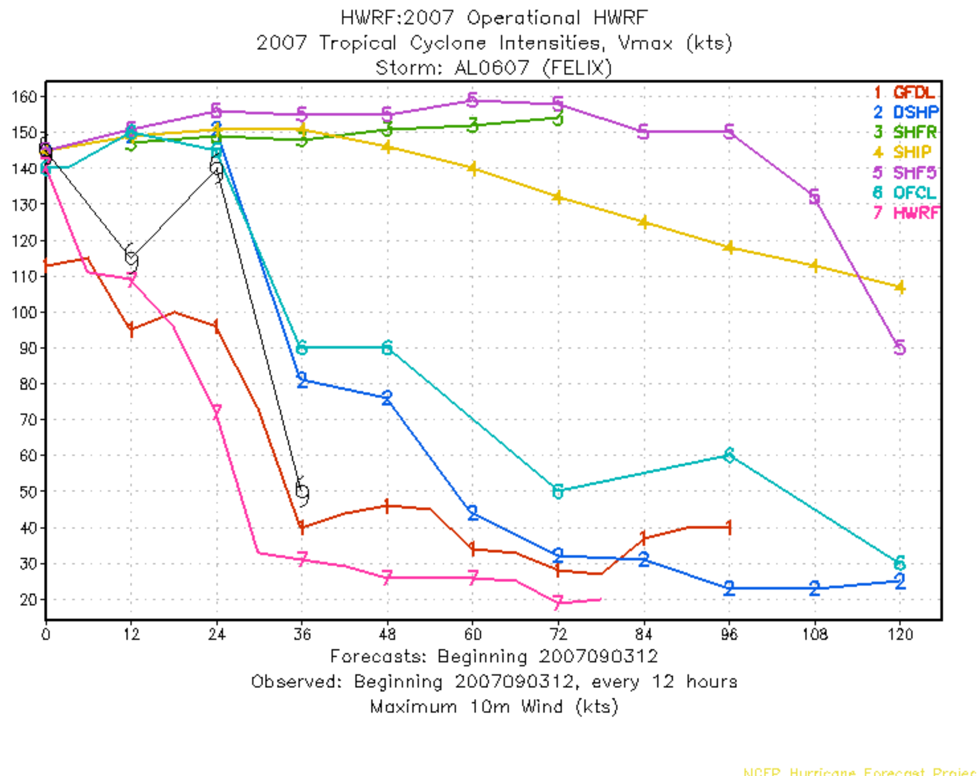

Fig: Operational intensity forecasts including HWRF for various models beginning on Sep03 12UTC produced by GRADS-based tool.

Besides track and intensity, SAIC and Tuleya are working with others in porting verification codes to evaluate the HWRF rainfall forecasts in a similar manner to the methods utilized in hurricane specific studies of the GFDL, NAM and the GFS models. These methods have been reported in two papers co-authored by Tuleya and colleagues at GFDL and HRD/NOAA which has been published in the Journal Weather and Forecasting. In addition, SAIC and Tuleya has worked with others at EMC on helping install a restart option for a high resolution HWRF and also in developing a new coupled ocean-atmospheric model.

SAIC and Tuleya have extensively studied the surface flux parameterization routines of HWRF and other models. Tuleya found a small inconsistency in the GFDL system and pointed it out to the GFDL caretakers. SAIC and Tuleya also found an inconsistency in the WRF GFS options of surface flux and vertical diffusion and has carried out sensitivity studies to test the impact(see below). SAIC and Tuleya have worked with others in evaluating the difference between the low-level wind distribution of HWRF and GFDL. HWRF horizontal diffusion will be reduced to give a wind distribution similar to GFDL. SAIC and Tuleya have pointed out the scientific basis of both the GFDL & HWRF horizontal diffusion and helped discover a minor HWRF bug in the operational version in that the operational HWRF; that is the diffusion coefficient is a function of turbulent eddy kinetic energy which is no longer calculated with the present HWRF options.

Finally, SAIC and Tuleya have worked with other EMC personnel in implementing and testing the NOAH LSM into HWRF for a series of tests. It appears that at least subjectively, experiments with the NOAH LSM are more realistic in that excessive rainfall is not predicted compared with the default(slab model) HWRF. On the other

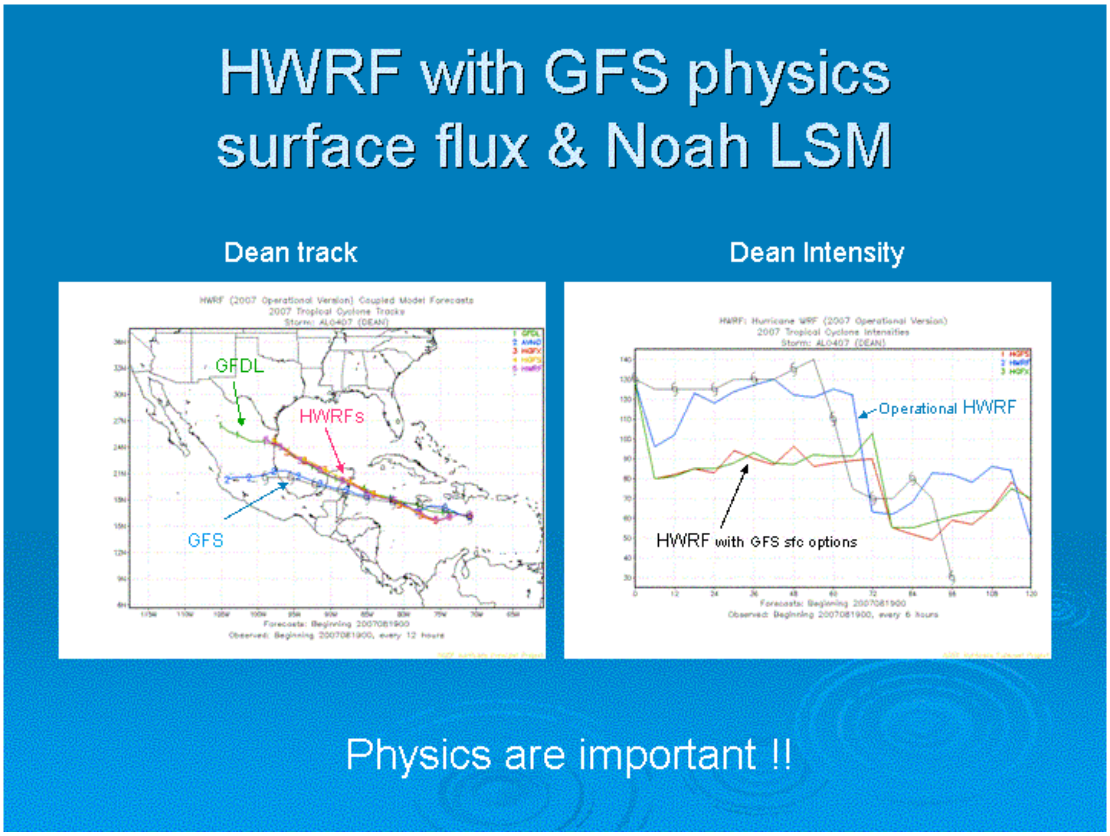

Fig: Comparison of HWRF tracks of DEAN (left) with GFDL and GFS. HWRF sensitivity experiments were performed wih GFS options of GFS surface layer and NOAH land surface model. Intensity comparison are on right.

hand if GFS options of surface flux are used together with the NOAH LSM option, storm intenisty is highly reduced (shown above). More sensitivity tests are planned.

The SAIC JHT project status, accomplishments and plans will be detailed at the upcoming 62nd IHC conference.