Enclosed is the Final JHT Report for:

A PROPOSAL FOR TRANSITION OF RESEARCH TO OPERATIONS: Transition of the GFDL Hurricane Prediction System to HWRF

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Major physics upgrades to the GFDL Hurricane Prediction System that were developed and tested during the past 2 years through JHT funding were made operational in time for the 2006 hurricane season. These physics changes were made in close collaboration with scientists at NCEP (National Centers for Environmental Prediction) and URI (University of Rhode Island). During the first 6 months of the funding period these changes were fully transitioned into the Hurricane WRF (HWRF) model that is being developed to run in parallel with the GFDL model in 2007.

As was anticipated, the new physics upgrades (i.e., NCEP's Ferrier microphysics and an improved momentum flux parameterization), significantly improved the GFDL model's skill in intensity prediction both in the Atlantic (Fig. 1) and eastern Pacific, accelerating the overall trend of reduced intensity errors with the GFDL model that has been evident during the past 4 years of JHT funding (Fig. 2). As seen in Figures 1 and 2, in 2006, for the first time the GFDL model exhibited superior performance compared to the statistical models in most forecast time periods, beating even the official forecast in the Atlantic and in the longer forecast time periods in the eastern Pacific (not shown).

In regards to overall track performance during the past 4 years of JHT funding, the GFDL model has provided the best overall track guidance in both the Atlantic and Eastern Pacific (Fig. 3), except at 5 days. In the Atlantic, the interpolated version of the GFDL model guidance exhibited skill relative to CLIPER of 40, 51, 47, 41 and 35% at forecast days 1, 2, 3, 4, and 5 (Fig. 3a) compared to 37, 48, 44, 39 and 36% skill relative to CLIPER for the GFS which was the next best model performer. The very small track errors at 12 and 24 hours represent a significant improvement over previous years and were primarily due to the changes to the model initialization as well as upgrades to the model physics, both of which were specific elements funded by the Joint Hurricane Testbed. In the eastern Pacific (Fig. 3b), the skill relative to CLIPER ranged from 29% at 2 days to 6% at 5 days.

Once the 2006 version of the GFDL forecast system became fully operational in June 2006, the emphasis at GFDL shifted toward assisting in the transition of the GFDL physics packages to the new HWRF model under development at NCEP. The strategy adopted by NCEP is to implement HWRF operationally with the same physics packages that were used in the 2006 version of the GFDL model. As outlined in last year's revised work plan, GFDL scientists imported the moist physics modules in Hurricane WRF into the GFDL model. Careful comparisons were then made of the diabatic heating and model tendencies using both the GFDL and HWRF physics modules. A number of differences between the two model packages were identified and appropriate changes were made to the HWRF code to make the moist physics

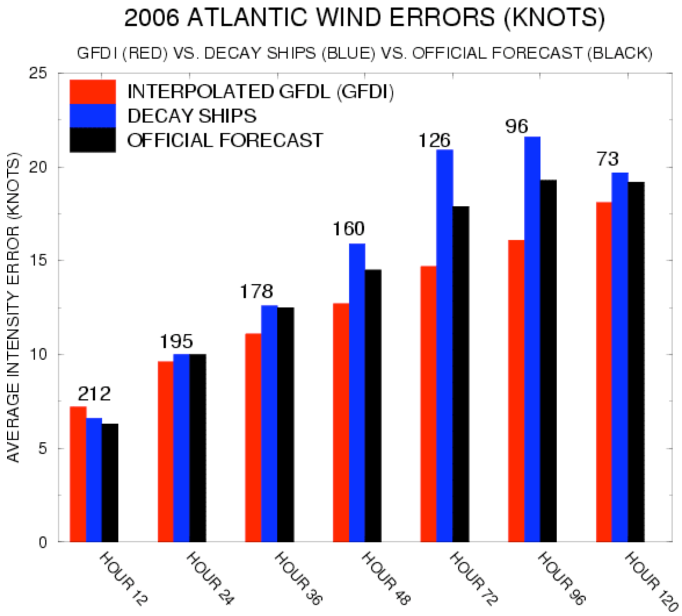


Figure 1 *Average forecast intensity error (knots) for the 2006 Atlantic hurricane seasons, for the interpolated GFDI model (red), decay SHIPS (blue) and the official forecast (black).*

packages as close as possible to the physics modules running in the 2006 operational GFDL model.

Once these changes were in place, a set of storms from the 2004 (Frances, Ivan, Jeanne, Lisa), 2005 (Dennis, Emily, Katrina, Philippe, Rita, Wilma) and 2006 hurricane season (Ernesto and Helene) was selected to serve as a suite of test cases to make a preliminary evaluation of the new HWRF model. These results, which were reported at the IHC meeting, indicated comparable skill in the track forecasts at day 3, with degradation in the HWRF track errors compared to the GFDL model, at days 4 and 5. However, continuing collaboration with GFDL and NCEP scientists during the past year has attempted to address some of the reasons for the degradation, and indeed the most recent version of the HWRF system indicates considerable track improvement at the longer times.

Several major upgrades to the Global Forecast System are scheduled to become operational in April 2007. These major upgrades include adoption of a hybrid sigma-pressure vertical coordinate system and replacement of the Spectral Interpolation (SSI) Analysis System with a Gridpoint Statistical Interpolation (GSI). Before operational implementation of this new modeling system, a major portion of both of the 2005 and 2006 hurricane seasons was rerun with this new hybrid Global Forecast System. Although not part of the original JHT work plan, it was necessary for the PI of this project to become involved in extensive evaluation of the impact of this new global model on tropical cyclone forecasts. To accomplish this, the 2006 version of the GFDL was also rerun with the new hybrid GFS for 2005 and 2006 storms in both the Atlantic and Eastern Pacific, which totaled 240 and 150 forecasts in both basins, respectively. Careful comparisons of both the track and intensity with both models were made and reported at this year's IHC meeting. In addition tracks comparisons from both models were made available to TPC forecasters for all of the storms rerun in the Atlantic and Eastern Pacific.

It was found that the new modeling system reduced the track error in the Atlantic by about 8% for both the GFDL and GFS models (Fig. 4) at 3, 4 and 5 days. In the eastern Pacific (figure not shown), little overall difference in the track performance was found except at day 5, where the GFDL errors were reduced about 10% and the GFS errors were increased about 3%. It is also encouraging that the GFDL intensity errors in the 3, 4 and especially 5 day period were significantly improved in the Atlantic when run off of the new GFS (Fig. 5).

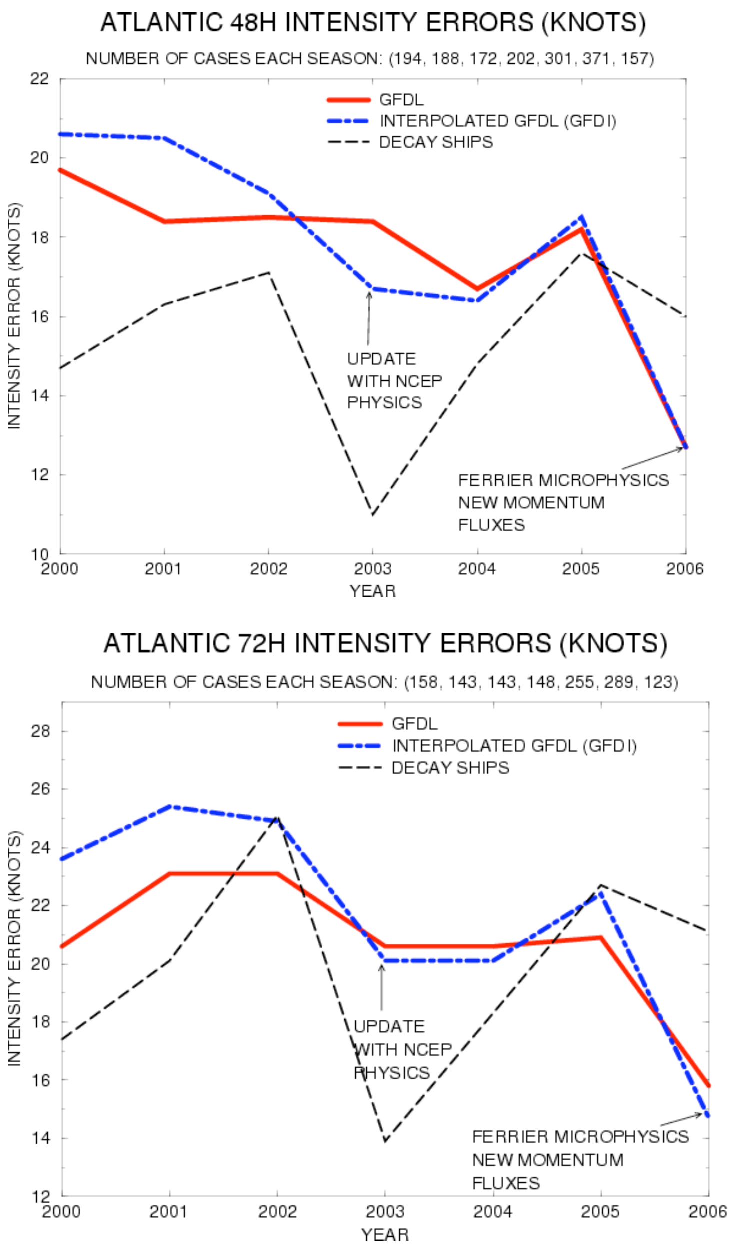
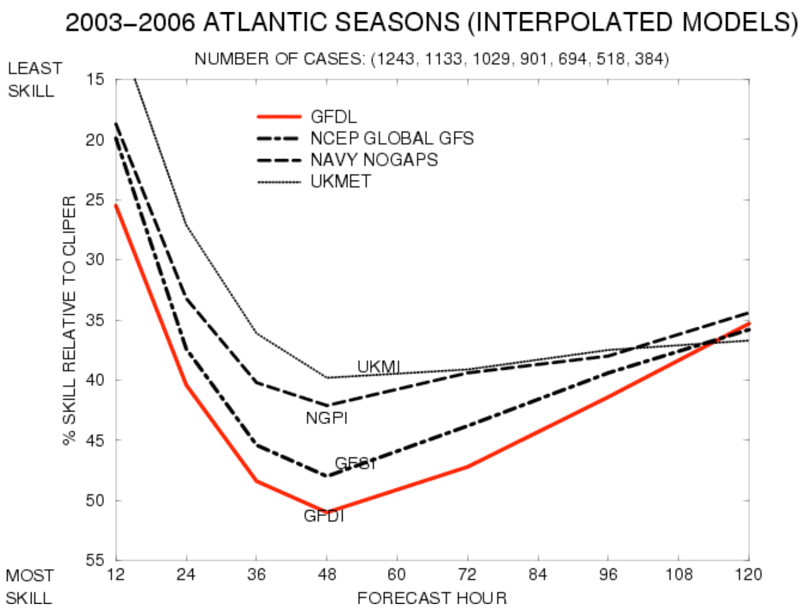


Figure 2 *Atlantic 48h (top) and 72h (bottom) hurricane season wind errors (knots) for the GFDL model (solid line), the interpolated GFDI model (dot-dashed line) and for Decay Ships (dashed line) for the years 2000 through 2006.*



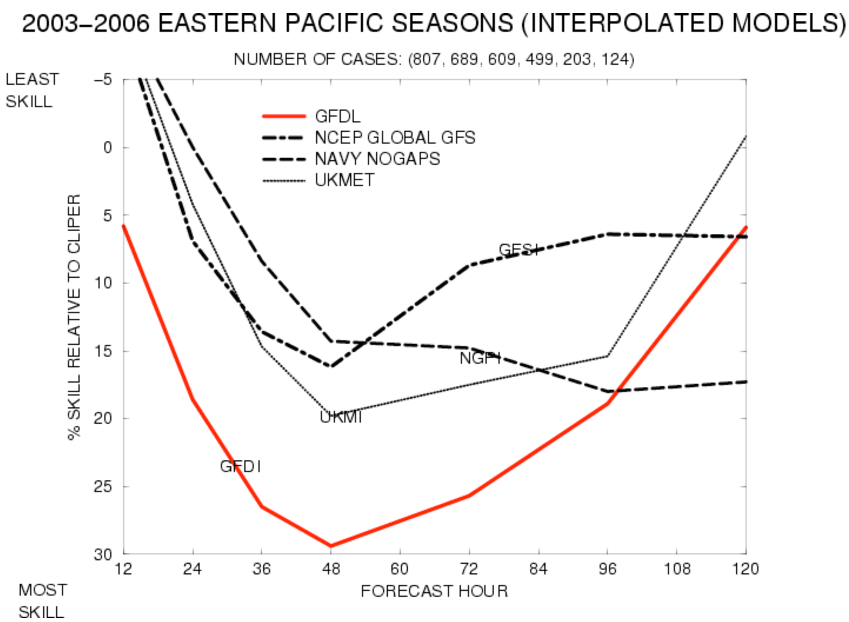


Figure 3 *Summary of the combined 2003, 2004, 2005 and 2006 Atlantic (top) and eastern Pacific (bottom) hurricane season track skill plotted relative to CLIPER, for the time-interpolated (GFDI) GFDL model (solid line), compared to NCEP's interpolated GFS model (dot-dashed line), the Navy's interpolated NOGAPS global model (dashed line) and the interpolated UK MET Office global model (dotted line).*

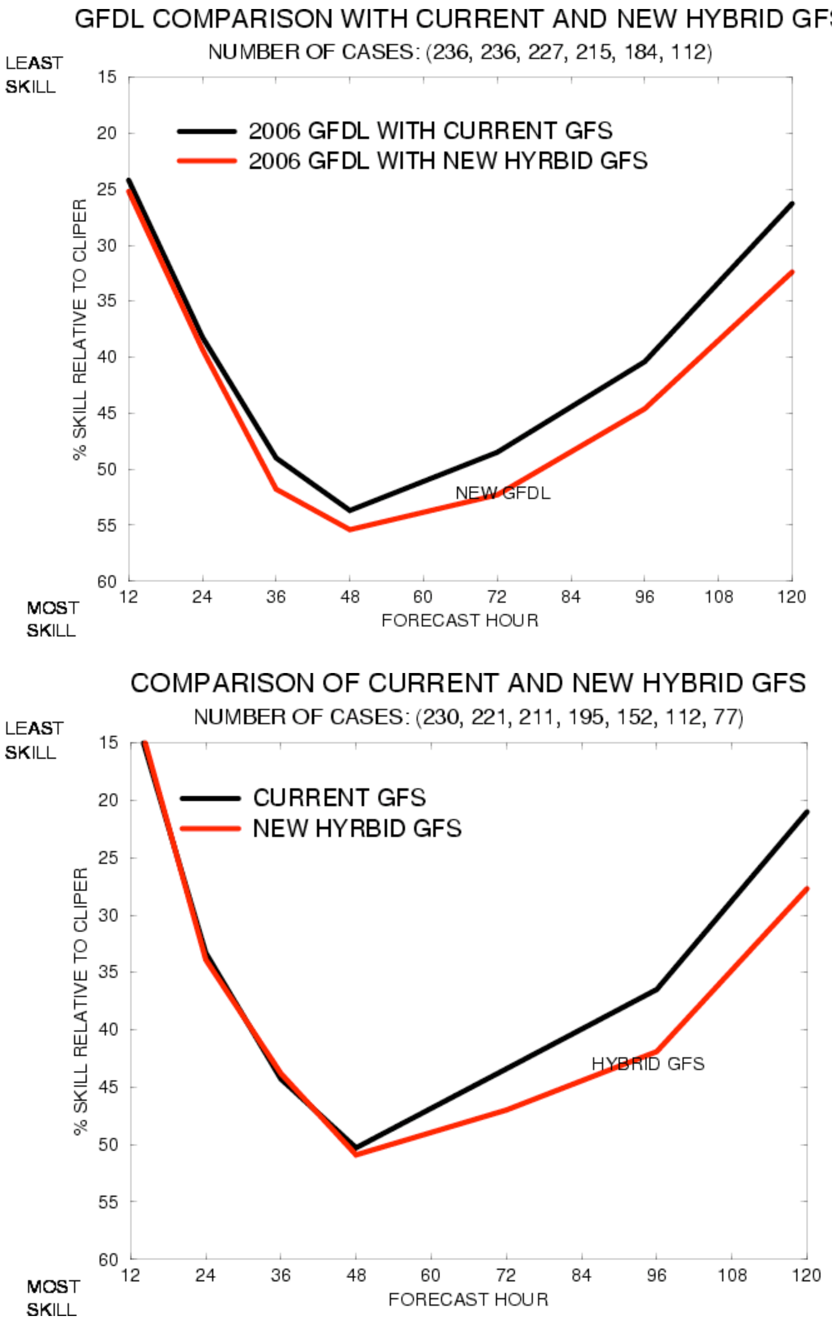


Figure 4 *Average track skill relative to CLIPER for 236 cases from the 2005 and 2006 Atlantic hurricane seasons comparing GFDL (top) and GFS (bottom) models run from the current operational GFS global model (black line) and the new hybrid global model (red). All of the GFDL forecasts shown were run with the 2006 version of the GFDL forecast system.*

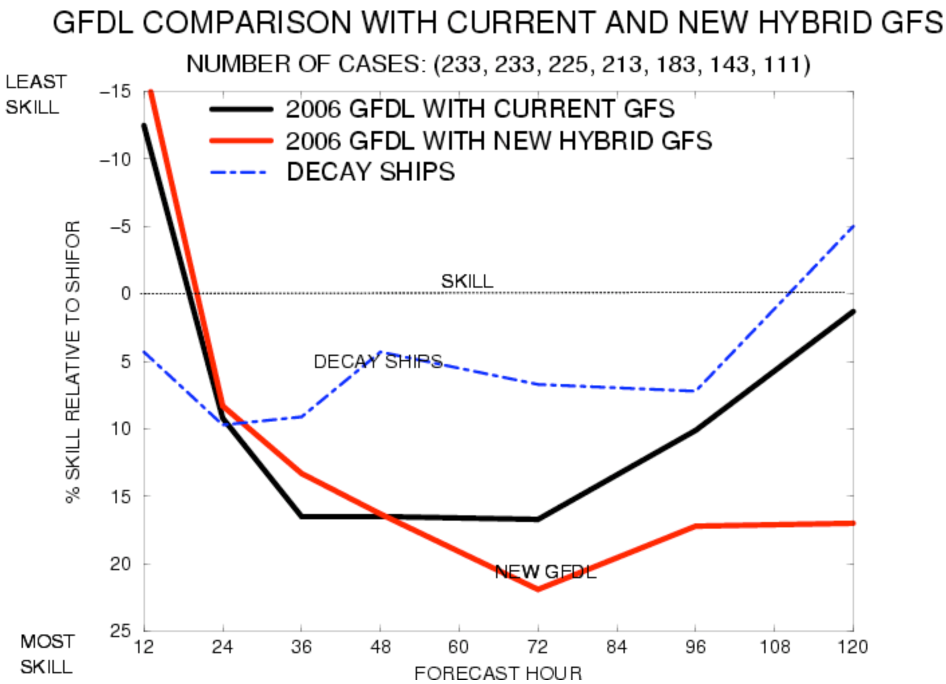


Figure 5 *Average intensity skill relative to SHIFOR for 233 cases from the 2005 and 2006 Atlantic hurricane seasons comparing the GFDL model run from the current operational GFS global model (black line), the new hybrid global model (red), and Decay SHIPS. All of the GFDL forecasts shown were run with the 2006 version of the GFDL forecast system.*

Finally, consultation with Navy personnel at FLEET continued. No new upgrades were made to the Navy's version of the GFDL model (GFDN) in 2006. However, evaluation of the degraded GFDN performance strongly suggested the existence of a bug in the GFDN forecast system. Through interaction with Navy personnel a bug in the generation of the vortex asymmetries was uncovered and fixed in October 2006. It is anticipated this will lead to improved reliability of GFDN in the coming year. In addition, collaboration with Navy personnel is continuing with the goal to upgrade GFDN some time in 2007 with all of the current physics packages running in NCEP's version of the GFDL model, addition of the third nest which has been operational at NCEP since 2005, and introduction of ocean coupling.

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