Enclosed is the JHT Annual Report for:

A PROPOSAL FOR TRANSITION OF RESEARCH TO OPERATIONS:

Upgrades to the Operational GFDL Hurricane Prediction System

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As reported in the semi-annual report, major upgrades to the GFDL Hurricane Prediction System, made possible through JHT funding in FY03, were successfully implemented into the operational version of the GFDL model before the start of the 2003 hurricane season. The upgraded hurricane model performed very well, particularly for track, and the GFDL model had the lowest track error of any other dynamical model guidance in the Atlantic, East and Central Pacific basins. However, one of the serious problems with the new model was a tendency to under-predict the intensity of weak systems, which in many cases were incorrectly dissipated by the model even when the actual storm developed. Considerable effort was made during the first year of the JHT funded period to remedy this problem. Careful testing of several of the proposed JHT funded physics changes played a major role in developing an improved version of the model which officially became operational at NCEP on May 11th, 2004.

Another problem with the 2004 model was a tendency to spin-down and spin-up the storm during the first 12 hours of the forecast. Although not part of the specific JHT WORK PLAN a major effort was made to improve the current axi-symetric model in the vortex initialization since it was recognized that a likely reason for this problem was inconsistent physics between the current axi-symmetric model used in the initialization, and the three-dimensional prediction model. A six-month effort was undertaken, starting in September 2003 to convert the current operational three dimensional hurricane model to a new axi-symmetric version. Testing of this new axi-symmetric model was begun in the early winter of 2003 and indicated that in some cases the spin-up/spin-down problem was dramatically reduced. However, after extensive evaluation and testing, degrading of the track occurred in several forecasts, and it was decided not to make this new version operational in 2004 but to continue running it in parallel during the 2004 season, with possible implementation at a later date.

OUTLINE OF SPECIFIC PHYSICS IMPROVEMENTS

One of the JHT proposed physics changes was to modify the downdraft formulation in the SAS scheme to enable penetration of the downdrafts to the surface. This was successfully accomplished and is one of the changes implemented on May 11th in the 2004 version of the model.

Another JHT proposed physics change implemented, was modification of the current momentum mixing. Although a new scheme was not adopted, a change was made in the current scheme to decrease the momentum tendency due to the effect of cumulus mixing, in the eyewall region. It was found that this helped in better intensification of the weak systems in most cases

and also helped to decrease the number of cases where the model incorrectly forecasted storm dissipation. The effect on track was minimal.

A third JHT proposed physics change, to include the effect of the evaporation of rain in large-scale condensation, was operationally implemented in summer of 2003 after parallel testing throughout July indicated a positive track improvement particularly in the 4-5 day period. It performed well for the remainder of the hurricane season and likely contributed to the GFDL model's superb track performance during the remainder of the 2003 season.

A fourth physics changed involved modification of the large-scale condensation threshold used in the GFDL model. This effort was accomplished in conjunction with NCEP scientists and was implemented in the May 11th upgrade.

Finally, in the separate JHT funded project with Isaac Ginis as the PI, ocean coupling was extended to the East and Central Pacific through the development of one-dimensional coupling in that basin. This code was successfully transferred and combined with the above-mentioned changes in March 2004. The new 2004 system was finalized in April 2004 and transferred to NCO in mid-April for operational implementation pending final approval by the NCEP director.

The final testing of the new version of the GFDL forecast system was made in March for the Atlantic and April for the East and Central Pacific. A test-bed of 114 cases from the 2002 and 2003 Atlantic hurricane season, and 60 cases from the 2002 and 2003 East Pacific season were selected after consultation with Richard Pasch, the TPC contact person for this JHT project. As was reported in the IHC meeting, the model's negative intensity bias for weak systems was greatly reduced in this new model (e.g., figure 1 and figure 2) as was the tendency to incorrectly dissipate weak systems. For example, in the early forecasts of Fabian (figure 1), the operational GFDL model either did not develop the storm (figure 1, black line) or dissipated the storm in the first 48h. At the same time the actual storm rapidly developed to a major hurricane. In the new system Fabian consistently developed, although too slowly. However, by day 5 the new model eventually developed a formidable hurricane of Category 2 status. The new model exhibited very little improvement in overall track error in the Atlantic, with a moderate improvement in the average intensity prediction in this basin.

In the East Pacific the improvement in both the track (figure 3) and intensity (figure 4) prediction was significantly larger then in the Atlantic. The average track error at 3, 4 and 5 days was reduced about 10%. In regards to the intensity prediction, the positive bias was reduced by nearly 50% at 1-2 days, and 30% at days 3-4. This resulted in an average decrease in the intensity error of about 17% and skillful forecasts relative to SHIFOR at all time levels beyond 12h (figure 4). In contrast, except for minimal skill at 4-5 days, the 2003 GFDL operational hurricane model showed no intensity skill in this basin. It is hoped that with the operational implementation of these improvements, the GFDL model will provide useful intensity guidance for forecasters at TPC in the upcoming hurricane season in the East Pacific with some improved intensity skill likely in the Atlantic as well.

CONTINUATION OF MODEL DEVELOPMENT WITH LIN MICROPHYSICS

As summarized in the semi-annual report, the new axi-symmetric model was coded with the capability to run with the same Lin microphysics that has been imported to both the current three dimensional hurricane model two-nest configuration and the high-resolution, three-nest version. This will enable the initial vortex to be initialized with consistent microphysics as in the three dimensional model. This will be an important model development once the further testing of the microphysics is resumed this summer. As already stated, the development of this new axi-symmetric model was a six month effort that involved over 1500 lines of computer model changes. As outlined in the original JHT proposal, testing of the high-resolution model with microphysics is planned for a limited number of real data cases later this summer with comparisons to be made with results from the Farrier microphysics packages. Depending on the results of these tests, parallel testing of the new high-resolution GFDL hurricane model which utilizes one of these microphysics packages will hopefully begin some time during the fall of 2004.

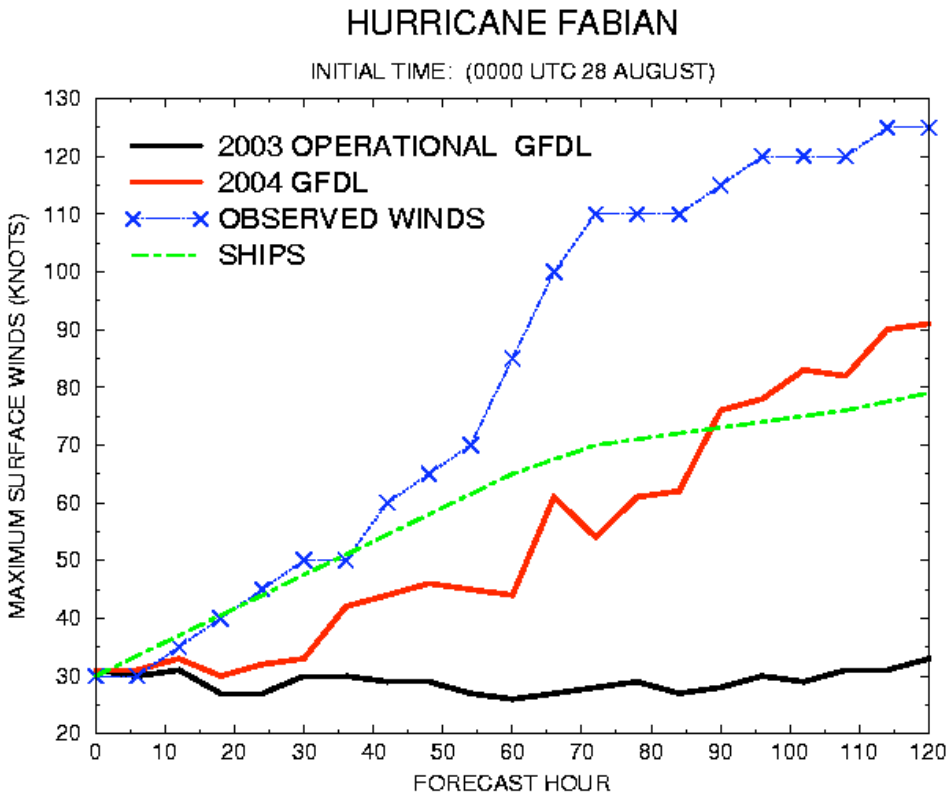

Figure 1 Predicted maximum surface winds (knots) for Hurricane Fabian (Initial time: 0000 UTC 28 August, 2003) for the current operational GFDL model (black line), the new 2004 model (red line), compared to the observed winds (blue dashed line, X) and the SHIPS model (green dashed-dotted line).

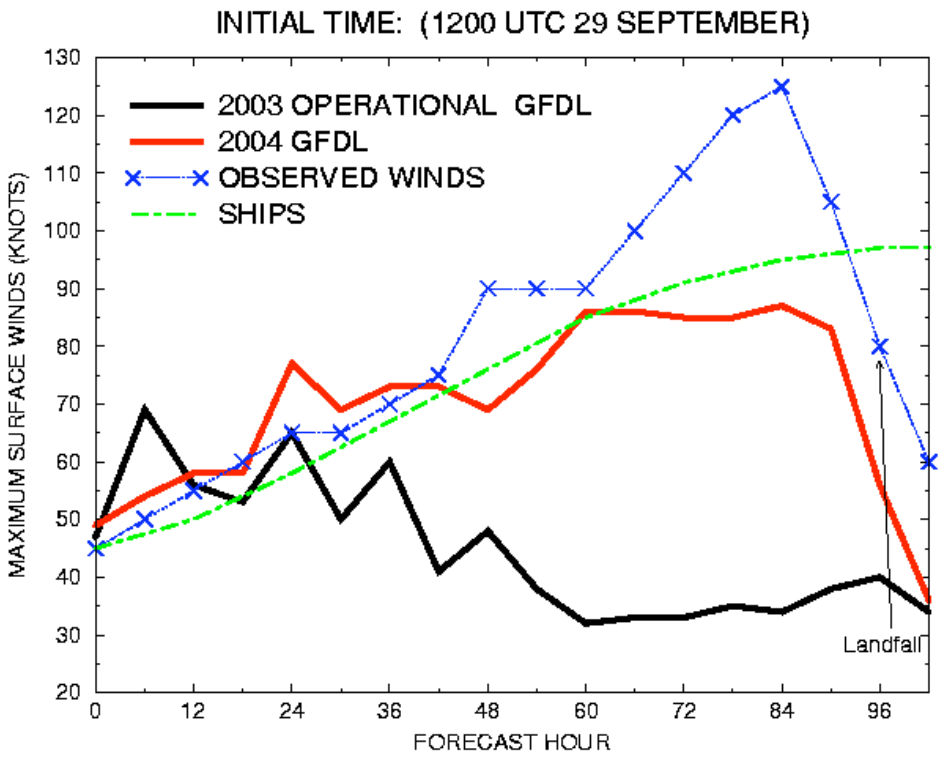

Figure 2 Predicted maximum surface winds (knots) for Hurricane Lili (Initial time: 1200 UTC 29 September, 2002) for the current operational GFDL model (black line), the new 2004 model (red line) compared to the observed winds (blue dashed line, X) and the SHIPS model (green dashed-dotted line).

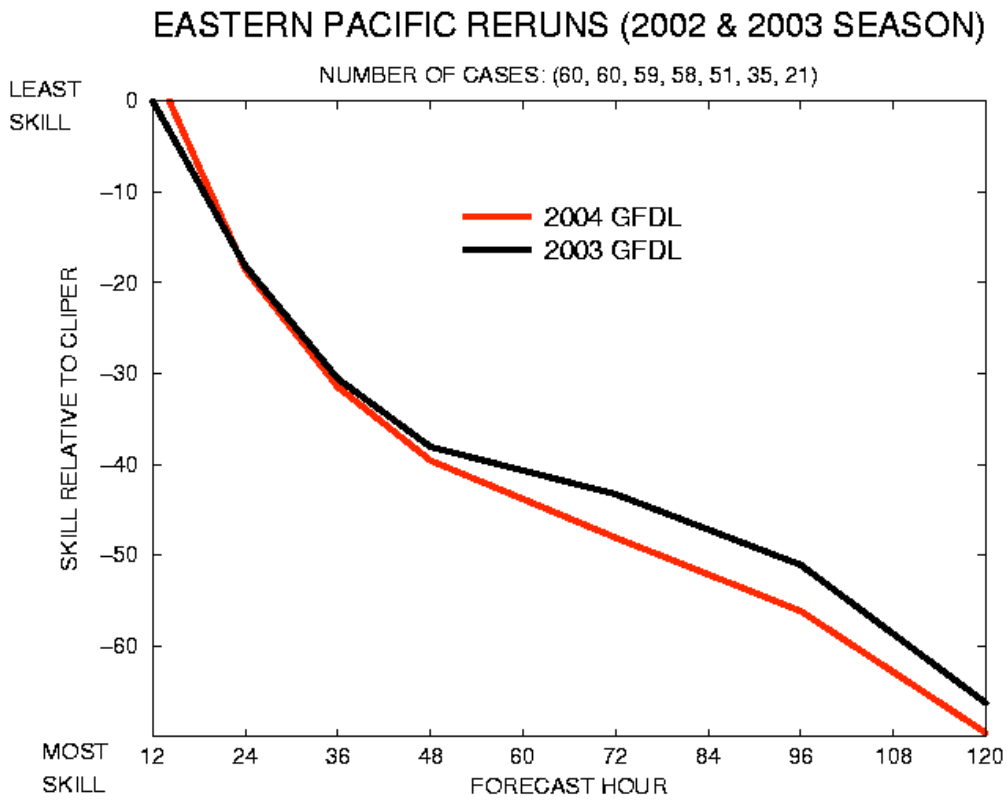

Figure 3 Average track errors normalized with respect to CLIPER for the current operational GFDL model (black line) compared to the new 2004 GFDL model (red line).

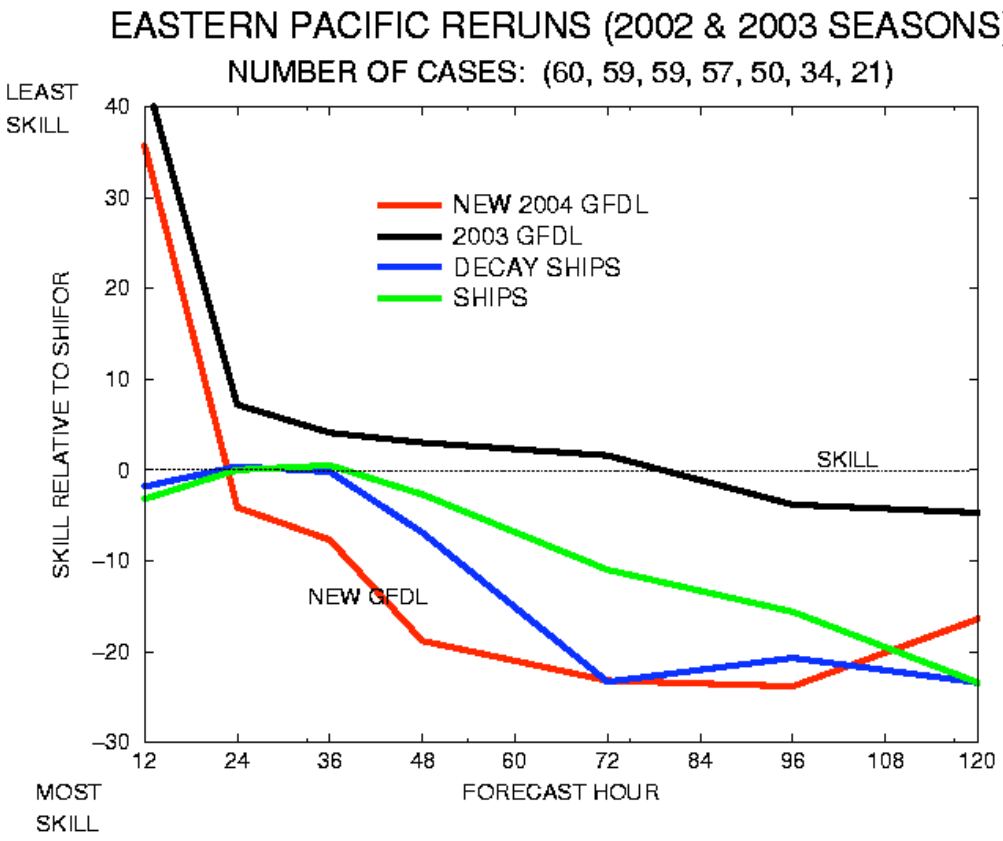

Figure 4 Average intensity errors normalized with respect to SHIFOR for the current operational GFDL model (black line) and the new 2004 GFDL model (red line), compared to SHIPS (green line) and the Decay SHIPS (blue line).