The 2008 Mid-Year Report of the Project Entitled “Evaluation and Improvement of Spray-Modified Air-Sea Enthalpy and Momentum Flux Parameterizations for Operational Hurricane Prediction”

Prepared for:

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1. EXECUTIVE SUMMARY

This report summarizes the progress in the first half of the second year of the Joint Hurricane Testbed project, in which the parameterization scheme of sea-spray mediated fluxes developed at NOAA/ESRL is improved by taking into account the feedback effect of sea spray on the momentum flux. The improved scheme has been implemented and tested in the operational HWRF model. Testing of the scheme is conducted in the operational cycling mode for five benchmark historical hurricane cases. This is the first time the NOAA/ESRL sea-spray scheme has ever been evaluated in cycled operational forecasts. The preliminary results of the evaluation statistics for three of the five benchmark cases indicate that for strong storms (such as Katrina and Rita), the scheme tends to produce a greater positive bias of intensity during the first 48-72 hours than the control runs, while the impact on the track is small. For weak storms (such as Dennis), the scheme tends to produce an intensity bias that varies around that of the control runs, while the track is degraded slightly after 72 hours.

2. INTRODUCTION

During the past six months, the ESRL parameterization scheme of sea-spray mediated fluxes has been improved by taking into account the feedback effects on the momentum flux across the air-sea interface. The improvement is made based on an improved understanding of the dynamical aspects of the sea-spray feedback effects via the balance of TKE and enthalpy in the spray-laden surface layer and the extension of the Monin-Obukhov similarity assumption. In order to fully test the scheme in the HWRF model at NCEP/EMC, the NOAA/ESRL team visited NCEP in March 2008 to coordinate with Naomi Surgi's group for the purpose of testing the scheme in the operation setup of the HWRF model for the 2008 season. Collaborative effort has also been continued with Dr. Isaac Ginis' group at the University of Rhode Island to further the physical understanding of the impact of the spray-mediated thermal and momentum fluxes on the wave atmospheric boundary layer dynamics.

3. MODEL SETUP FOR EVALUATING THE IMPROVED SCHEME

The HWRF model is set up by Drs. Naomi Surgi, Vijay Tallapragada and Young Kwon at NCEP/EMC in the same way as the operational prediction experiment, in which a two-way nested grid included a moving inner grid which followed the storm center. The NOAA/ESRL sea-spray parameterization is added to the atmospheric boundary layer physics subroutine. A significant difference between the current round of evaluation and that carried out last year is that the current one is the first time the NOAA/ESRL sea-spray scheme has ever been evaluated in cycled operational forecasts for the HWRF benchmark cases: Dennis (2005), Katrina (2005), Rita (2005), Wilma (2005), Dean (2007). All the HWRF model forecasts presented in this report are run on the IBM supercomputer system at NCEP.

The improved NOAA/ESRL sea-spray scheme still contains two tunable parameters (the droplet source strength, *ss*, and the feedback strength, *ft*) associated with the functional formulas of the droplet source strength and the feedback strength. All the forecast cycles used for evaluating the improved scheme are carried out with $ss = 1$ and $ft = 1$. In general, the uncertainty of the first parameter is due to the lack of observational information on the connection of the spray generation and the wave breaking dynamics, while the uncertainty in the second parameter is associated with the lack of observations to quantify how sea-spray droplets modify the mean wind, temperature and moisture profiles in the surface layer. Although reliable laboratory and field-experiment data are required to calibrate these two parameters, tuning them in the HWRF model is necessary as the model evolves because error compensation exists in the model physics.

4. PRELIMINARY RESULTS OF EVALUATION STATISTICS

As planned with the NCEP/EMC team, a total of five benchmark historic hurricane events are chosen to run the cycled forecasts of HWRF to evaluate the improved scheme. Although all the runs have been completed, the diagnosis to obtain the evaluation statistics mandated at NCEP is still ongoing. Only some of the statistics for three of the five events are reported here: Dennis (2005), Katrina (2005), Rita (2005).

4.1 Dennis (2005)

Figure 1 shows the biases of the forecasted track and maximum surface winds from the runs with the sea-spray scheme for Dennis (2005), and compares the biases those from the forecast runs without the scheme. It is clear that the inclusion of the scheme tends to produce an intensity bias that varies around that of the runs without the scheme, while the track is degraded gradually after 72 hours.

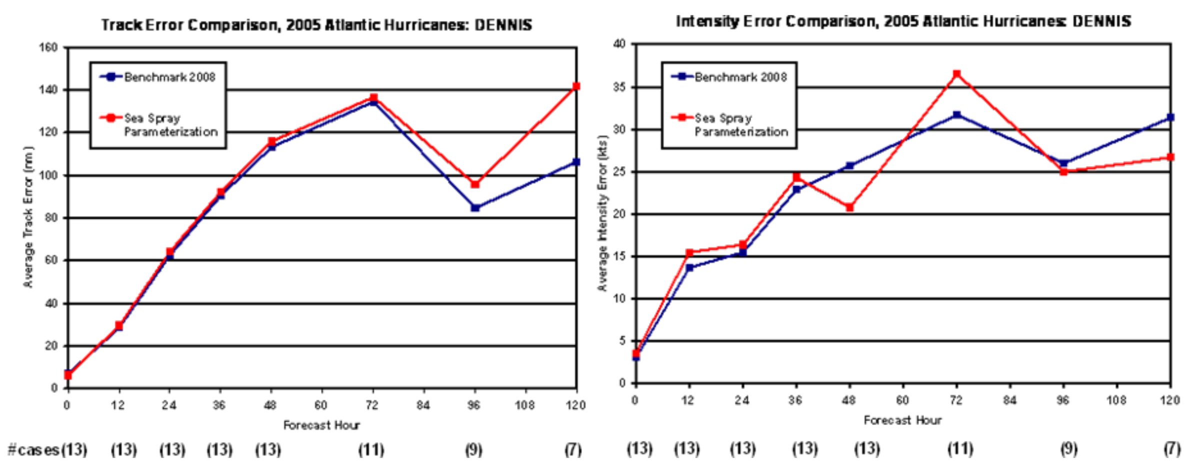

Figure 1: Biases of the forecasted track and maximum surface winds from the runs with (red) and without (blue) the sea-spray scheme for Dennis (2005). The number beneath each hour mark is the number of samples in the bias calculation for the hour.

4.2 Katrina (2005)

For this case, the accuracy of the track forecast from the runs with the sea-spray scheme is very close to that from the runs without the scheme during the first 72 hours of the forecast but becomes worse after 84 hours of the forecast. The intensity errors of the runs with the sea-spray scheme are larger than those without the scheme (see Fig. 2).

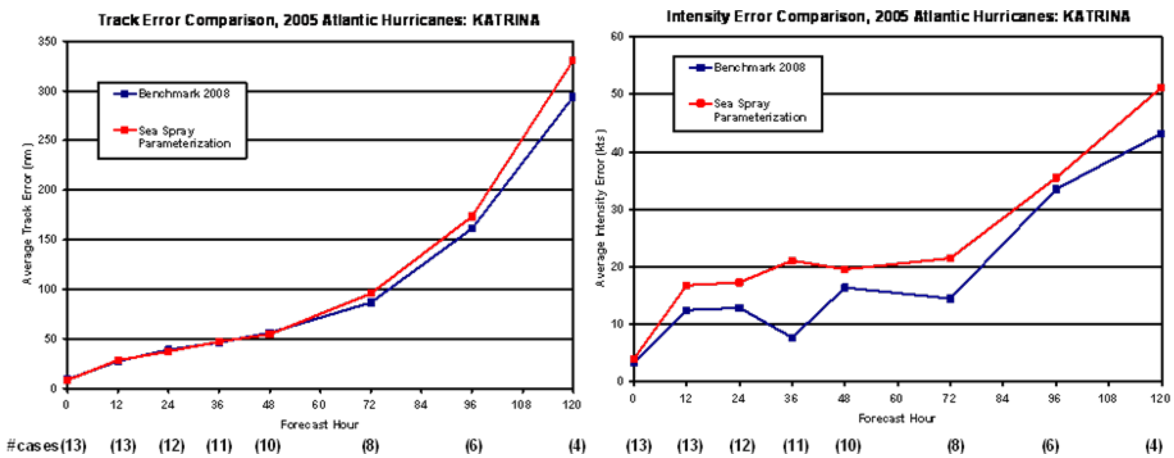

Figure 2: Biases of the forecasted track and the maximum surface winds from the runs with (red) and without (blue) the sea-spray scheme for Katrina (2005). The number beneath each hour mark is the number of samples in the bias calculation for the hour.

4.3 Rita (2005)

The biases of the forecasted track and the maximum surface winds from the runs with the sea-spray scheme for this case are shown and compared to those without the scheme in Fig. 3. It is interesting to note that for this case the impact of the sea-spray scheme on the track forecast is negligible. While the scheme overestimates the intensity during the first 72 hours of the forecast, there is an improvement at hour 96. Comparing this case with the Dennis and Katrina cases, it appears that the errors in the intensity forecast are not closely associated with those in the track forecast. It is also worth mentioning that the increase in the forecasted bias during the first 24 hours of the forecast appears to be intrinsic to the HWRF models spin-up, possibly associated with its vortex initialization. This result has two implications. The first is that the errors in the HWRF model forecast can only be partially attributed to the errors in the surface fluxes. The second implication is that the tuning of the two parameters in the sea-spray scheme should be performed in accordance with the tuning of the vortex initialization.

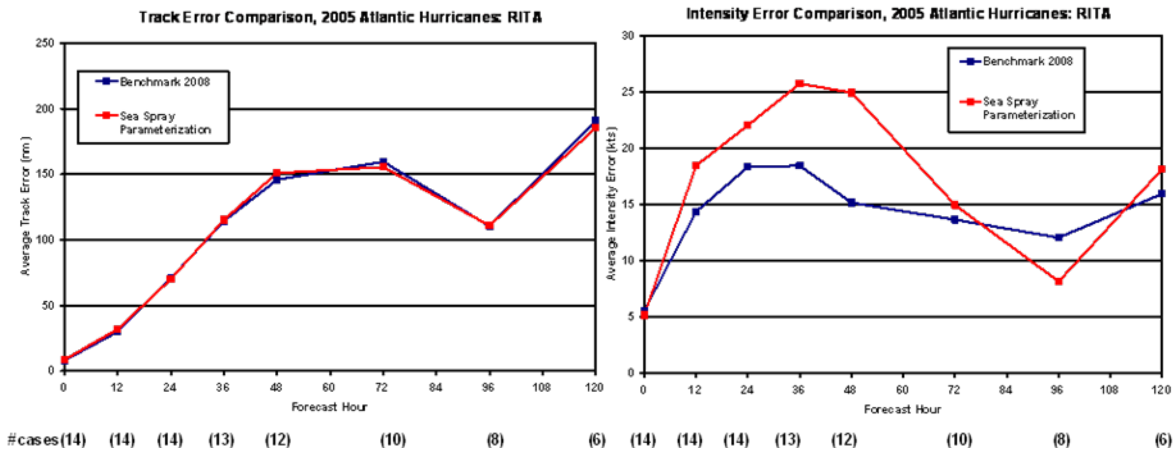

Figure 3: Biases of the forecasted track and the maximum surface winds from the runs with (red) and without (blue) the sea-spray scheme for Rita (2005). The number beneath each hour mark is the number of samples in the bias calculation for the hour.

5. SUMMARY AND CONCLUSIONS

This report presents preliminary results from the first half of the second year of the Joint Hurricane Testbed project at NOAA/ESRL in which an improved parameterization scheme of air-sea fluxes is implemented in the HWRF model and evaluated in operationally realistic cycled forecasts. Preliminary statistical results indicate more aspects of the scheme perform which did not emerge in last year’s evaluation of the scheme in single-cycle cold-start runs. The major findings from all the sensitivity runs so far are:

1. For strong storms (such as Katrina and Rita), the scheme tends to produce a greater positive bias of intensity during the first 48-72 hours than the control runs, while the impact on track is small.

2. For weak storms (such as Dennis), the scheme tends to produce an intensity bias that varies around that of the control runs, while the track is degraded slightly after 72 hours.

3. The errors in the intensity forecast are not closely associated with those in the track forecast.

4. The increase in the forecast bias during the first 24 hours appears to be intrinsic to the HWRF models spin-up, possibly associated with its vortex initialization.

The last finding has two implications. The first is that the errors in the HWRF model forecast can only be partially attributed to the errors in the surface fluxes. The second is that the tuning of the two parameters in the sea-spray scheme should be performed in accordance with the tuning of the vortex initialization.