P5.13 # Hurricane Relocation in Global Ensemble Forecast System

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1. Introduction

A hurricane relocation system was implemented in Global Forecast System (GFS) at the National Centers for Environmental Prediction (NCEP) in 2000 (Liu, et al., 2000). The hurricane relocation system moves the hurricane vortex in the model guess to the observed location before the 3D-VAR updates the analysis. It contains the following major steps: a) locate the hurricane vortex center in the guess field, b) separate the hurricane model's vortex from its environment field (Kurihara et al., 1995), c) move the hurricane vortex to the observed position, and d) if the vortex is too weak in the guess field, add a bogus vortex to the 3D-VAR data analysis (Lord, 1991).

After the successful implementation of the hurricane relocation system in the GFS model, we tried to use it in the Global Ensemble Forecast System (GEFS). However, due to large differences in the hurricane structure among individual ensemble members, the relocation system does not have much effect on the statistics of the forecast tracks. In 2004 we modified the hurricane relocation system and added it to the GEFS. Test results show that the track spread from individual members was significantly reduced. The modified system was implemented in GEFS in July 2005 (Zhu et al., 2005).

This paper explains the hurricane relocation system in the GEFS and shows some of our test results with and without hurricane relocation.

2. Hurricane Relocation in GEFS

The hurricane relocation system from the GFS model was modified to be used in GEFS. The new system can be summarized as follows:

1) Split the forecast fields from ensemble members (including the control) into environmental fields and hurricane components;
2) Compute global ensemble perturbations without the hurricane component (breeding cycle);
3) Compute hurricane perturbations (after relocating the hurricane to the observed location) for individual ensemble member P1 (hurricane perturbation for P1) =
$$C^*(X_{P1}- X_{n1})^*\| X_{c0}\|/\| X_{P1}- X_{n1}\| ;$$
4) Add the hurricane perturbation and global ensemble perturbation to the analysis fields to create the model initialization.

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C is the scaling factor and X_{P1} (X_{N1}) represents the 3D (or 2D) variables such as wind, temperature, mixing ratio and surface pressure for ensemble member P1 (N1). X_{c0} represents the same variable for the model control. $\|X\|$ is the square root of the summation of X^2 over the whole hurricane area. The hurricane perturbation is scaled to be 5% of the magnitude of the control (C=0.05).

3. Test Results

After the modified hurricane relocation system was added to the GEFS model, we ran a series of experiments from 20040824 to 20040930. The test results are summarized in Figs 1, 2 and 3. Fig. 1 shows the differences in hurricane track forecast with and without the hurricane relocation for hurricane Frances (2004082800). You can see that there is a significant reduction in the initial track spread.

Fig. 2 compares the statistical results of the track error and the track spread for all the forecasts with and without hurricane relocation. The initial reduction of the track spread is maintained throughout the 5 day forecast period.

Fig. 3 shows the improvement in track forecasts compared to the operational models in the Atlantic and East Pacific Basins. The average track errors are smaller compared to the operational ensemble track forecasts throughout the forecast period, and the forecast tracks from the GEFS model are also better than those from the GFS model (higher resolution).

4. Summary and Discussion

The modified hurricane relocation system significantly reduces the spread of the track forecast in the GEFS model. However, it only slightly reduces the mean track error. The values of the global scaling factor and constant C used here are empirical factors, and need lots of ensemble experiments to determine their values.

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5. References

1). Kurihara, Y., M. A. Bender, R.E. Tuleya and R. J. Ross, 1995: Improvements in the GFDL hurricane prediction system. *Mon. Wea. Rev.*, **123**, 2791-280.

2). Liu, Q., T. Marchok, H.-L. Pan, M. Bender and S. Lord: Improvements in Hurricane Initialization and Forecasting at NCEP with Global and Regional (GFDL) models. *NCEP Office Note* 472.

3) Lord, S.J., 1991: A bogussing system for vortex circulations in the National Meteorological Center global forecast model. *Preprints of the 19th Conference on Hurricane and Tropical Meteorology*, Miami, FL., 329-330

4). Zhu, Y., Z. Toth, R. Wobus, Q. Liu, 2005: July 2005 Upgrade of the NCEP Global Ensemble Forecast System. NCEP note.

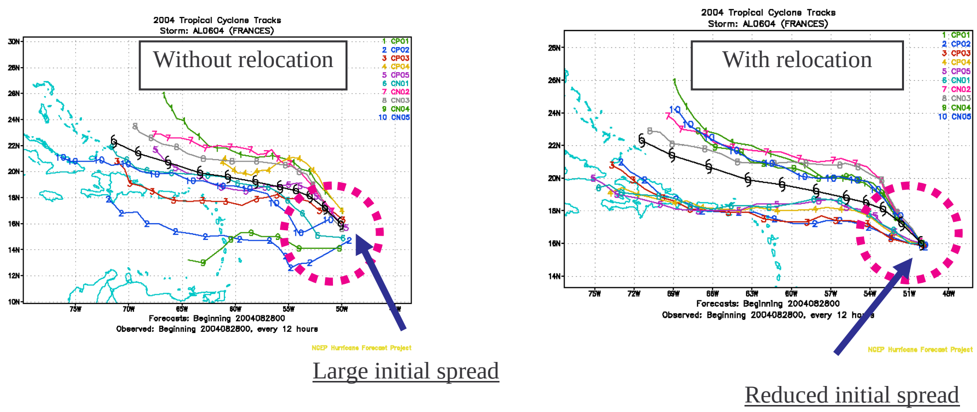


Fig. 1. Hurricane track forecast from GFS ensemble model individual members for Hurricane Frances (2004082800). The left panel shows the track forecast without hurricane relocation and the right panel shows the track forecast with the hurricane relocation. There is a significant reduction in the initial track spread.

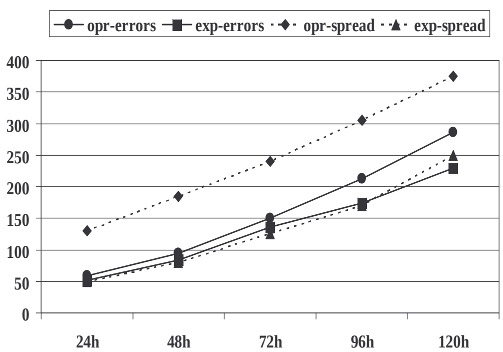
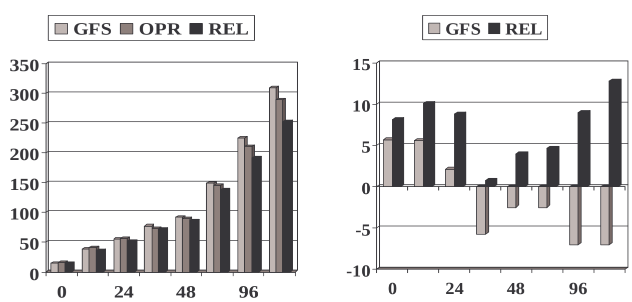


Fig. 2. Track errors and spreads without and with the hurricane relocation.



Track errors (miles)

Percentage improvement to operational ensemble

Fig. 3. Hurricane track errors and the percentage improvement compared to the operational ensemble model for the test period 20040824-20040930 (53-105 cases) for the Atlantic and East Pacific basins.