8A.2 **Hurricane Initialization in HWRF Model**

Qingfu Liu*(1), Naomi Surgi(1), Stephen Lord(1)
Wan-Shu Wu(1), David Parrish(1), Sundararaman Gopalakrishnan(1)
John Waldrop(1) and John Gamache (2)

(1) NOAA/NCEP/EMC, (2) NOAA/AOML/HRD

1. Introduction

The GFDL Hurricane Prediction System has been the operational hurricane forecast model at the National Centers for Environmental Prediction (NCEP) since 1995. The initialization of hurricanes in the GFDL model uses a vortex replacement strategy, which consists of three major steps: 1) interpolate the global analysis fields from Global Forecast System (GFS) onto the operational GFDL hurricane model grid; 2) remove the GFS vortex from the global analysis; and 3) add a high resolution, model-consistent vortex (Kurihara, et al. 1995).

The GFDL model has been a star performer in terms of track forecast since its operational implementation. Even as a high resolution model, it still lacks forecast skill in intensity. As more observational data become available in the hurricane region, it is crucial to use those data in the hurricane initialization to improve the track and intensity forecasts. However, the GFDL model does not have its own data assimilation package and can’t use those data to generate a more realistic vortex structure in its hurricane initialization.

In order to utilize the observational data in the hurricane analysis, the Hurricane WRF (HWRF) project was created in 2000. The goal of this project is to replace the GFDL model as the operational hurricane model in 2007. The HWRF project takes advantage of WRF (Weather Research and Forecast) model development, and adds unique features (such as the moving nest and hurricane data assimilation) for hurricane prediction. Significant progress in the HWRF project has been made in the areas of model development and data assimilation during the last four years. This paper reviews only the progress in the HWRF data analysis.

2. HWRF Cycling System

The creation of the HWRF domain is based on the observed hurricane center position. So the model domain in the current cycle is different from the previous cycle for the same storm, as the storm is moving. Since the model domain from the previous cycle can’t fully coincide with the current model domain, we need to use some GFS data to fill in the grids near the HWRF outer nest boundaries. The HWRF cycling system can be summarized as follows:

Corresponding author address: Qingfu Liu, NCEP/EMC, 5200 Auth Road, Camp Springs, MD 20746. E-mail address: Qingfu.Liu@noaa.gov

a) Create a new HWRF domain based on the storm center position and fill in the outer and inner nest grids with guess data;
b) Run the GSI regional analysis for both the outer and inner nests and merge the two nested datasets together;
c) Run the HWRF model to obtain 03h, 06h and 09h forecast fields;
d) Go back to Step a).

The 3D-VAR data assimilation in (b) can be omitted if there are no 3D observational data. To run the GSI data analysis, an intermediate domain twice as large as that of the inner nest is created. The transition zone is added here to make a smooth transition at the inner nest boundaries in the merging process without changing the analysis field within the inner nest region.

2.1. Guess Fields Creation

To avoid large observational increments in the 3D-VAR data analysis, we modify the guess fields before the GSI uses them. Creation of the guess fields involves the following steps:

a) Create a new HWRF domain based on the new storm center position and interpolate 6h GFS forecast data onto the new HWRF grids (outer nest: 75^0x75^0, inner nest: 12^0x12^0);
b) Interpolate the 6h HWRF forecast data onto the new HWRF grids, replacing the GFS data with HWRF forecast data in the overlap region;
c) Separate the new data into the environmental flow and the hurricane component;
d) Correct the intensity of the hurricane component before inserting it back into the new HWRF grids at the observed position;
e) If there are no 6h HWRF forecast data, we will skip step (b) and replace the storm component with a bogus storm in step (d).

The details in the intensity correction in step (d) are as follows: first correct the storm wind based on the observed maximum surface wind (Liu, et al. 2004), then correct other fields using the NMC method (Parrish and Derber, 1992).

2.2. 3D-VAR Data Assimilation

The 3D-VAR data assimilation system used here is the newly developed Gridpoint Statistical Interpolation (GSI) analysis, which was developed by NCEP to replace the global Spectral Statistical Interpolation (SSI) analysis and the regional analysis. It has the capability to use many kinds of data, including ground based radar data and airborne radar data.

The airborne Doppler radar data used here are high resolution 3D data and are ideal for hurricane analysis. The data are preprocessed by John Gamache (HRD) for quality control and converted into superobs using the method developed by Purser et.al. (2000). The superobs are then used in the GSI data assimilation.

3. Analysis Results

We have done a series of tests using different sets of data and varying the structure function and background error covariance. Here we show one of the analyses at 750 mb using airborne Doppler radar data for Hurricane Ivan, on 2004090718. Fig.1 shows the streamlines and isotachs in the guess field. Fig.2 shows the streamlines and isotachs in the analysis field when using airborne Doppler radar data. The maximum wind shifted 90^0 to the west of the storm center. Fig. 3 shows the streamlines and isotachs of the analysis increment. The largest analysis increments are located in the hurricane core area where the data are concentrated.

4. Future work

We are currently using more airborne radar data from the 2004 hurricane season in the GSI analysis. We are also testing the impact of airborne Doppler radar data on hurricane track and intensity forecasts in the HWRF model. We will show more results at the conference.

Acknowledgements: We like to thank Russ Treadon and Shun Liu for their help and discussions during the development of the 3D-VAR data assimilation for hurricanes. We also like to thank Mary Hart for correcting typos and English usage for this paper.

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**, 2791-2801.

2). Liu, Q., S. Lord, N. Surgi, H.-L. Pan, T. Marchok, R. Tuleya and M. Bender: Hurricane Initialization in High Resolution Models, *Preprint for the 26th Conference on Hurricanes and Tropical Meteorology, 3-7 May, 2004. Miami, Florida*. Page 558-559.

3). Parrish, D.F., and J.C. Derber, 1992: The National Meteorology Center's spectral statistical-interpolation analysis system. *Mon. Wea. Rev.*, 115, 1479-1502.

4). Purser, J., D. Parrish and M. Masutani, 2000: Meteorological Observation Data Compression; An Alternative to Conventional "Super-Obbing". *Ncep Office note 430*.

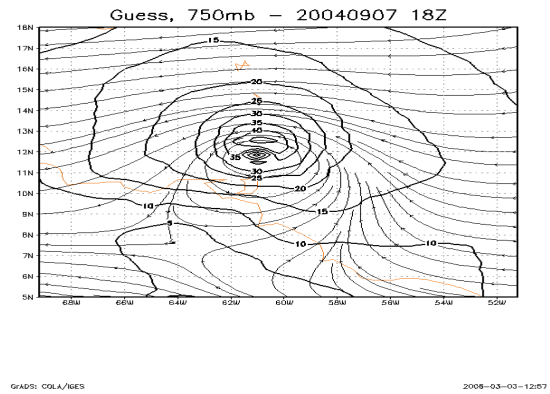

Fig. 1. Streamlines and isotachs (m/s) at 750 mb in the guess field for hurricane IVAN (20040718).

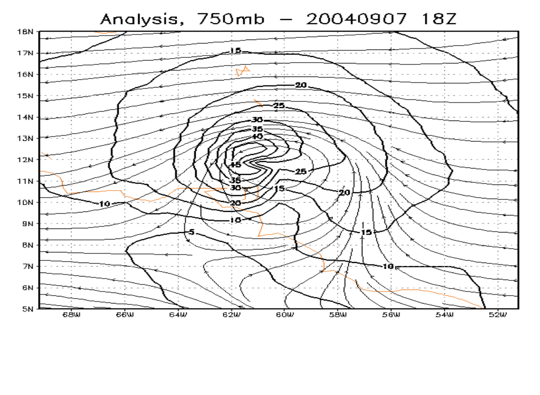

Fig. 2. Streamlines and isotachs (m/s) at 750 mb in the analysis field after using airborne Doppler radar data in the GSI for hurricane IVAN (20040718).

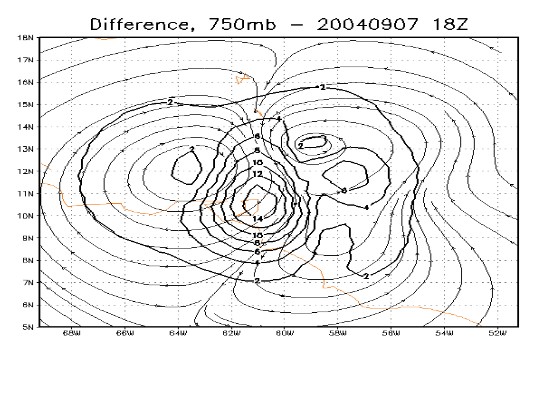

Fig. 3. Streamlines and isotachs (m/s) of the analysis increment at 750 mb for hurricane IVAN (20040718).