P1.1 Hurricane Ensemble Prediction Using NCEP Operational HWRF System and GEFS Perturbations

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1. Introduction

This study illustrates the capability of the ensemble technique to improve hurricane track and intensity forecast using the operational Hurricane Weather Research and Forecasting (HWRF) system at National Centers for Environmental Prediction (NCEP).

The key to a successful hurricane ensemble forecast is to generate a set of initial states that represent real uncertainties in hurricane position and intensity errors, as well as in the large-scale flow environment. In general, hurricane movement is dictated by large-scale environment flows. Therefore, any uncertainties in the initial large scale flow will have great impact on the hurricane track forecasts.

As a first step to develop hurricane ensemble forecast system for HWRF, the impact of the large-scale flow initial uncertainties on hurricane track forecast is investigated by using the perturbations generated by Global Ensemble Forecast System (GEFS). The results show that the hurricane ensemble track forecasts are indeed sensitive to the initial large scale flow. The ensemble tracks are spread around the observed best track. The hurricane track forecasts are improved compared to the single deterministic prediction. The track position errors are largely reduced by the ensemble mean in total of 72 cases. The ensemble intensity forecasts remain the same forecast skills as the single deterministic forecast, because the uncertainties in initial hurricane intensity are not accounted for.

2. Methodology

In order to better understand how regional hurricane model responds to the large scale flow perturbations at the initial time, two experiments were designed. The experiment one uses the GEFS data (resolution T126L28) as input data to initialize HWRF domain, while the second experiment uses operational GFS (T382L64) to define all initial conditions for HWRF. Exp 1 has 21 ensemble members with its perturbations generated by Ensemble Transform (ET) method in the GEFS. Exp 2 is a single deterministic run and serves as benchmark. Both experiments follow the same procedures:

- Define initial domain using GEFS or GFS data;
- Perform storm relocation and storm initialization for each ensemble member and each cycle;
- Conduct 5 day forecast for each ensemble member.

3. Results

The methodology was tested in two hurricanes: hurricane Hanna 2008 and hurricane Bill 2009. Both hurricanes lasted about 10 days. Forecasts were performed four cycles per day. The experiments contain total 72 sample forecasts.

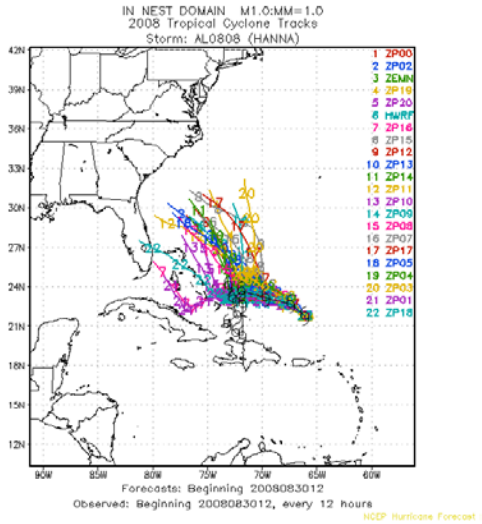


Figure 1: Ensemble track forecasts for Hurricane Hanna, starting at 12Z on Aug. 30, 2008.

Fig.1 shows an example of the ensemble track forecasts from each individual ensemble member for Hurricane Hanna 2008. Although all ensemble members started from the same initial positions with the same initial intensities, the predicted tracks are very different from each other. Some storms moved towards to north while others moved eastwards.

Fig. 2 and 3 show the comparison of forecast track errors between ensemble and control experiments. It shows clearly that the hurricane track forecast errors are reduced by ensemble technique. The ensemble forecasts have much more number of cases that outperformed track forecasts from control run.

4. Conclusions and Plan

- Use of GEFS perturbations leads to improved hurricane track forecasts
- Hurricane intensity forecast skills remain the same as that from control run because initial hurricane intensity and position were not perturbed

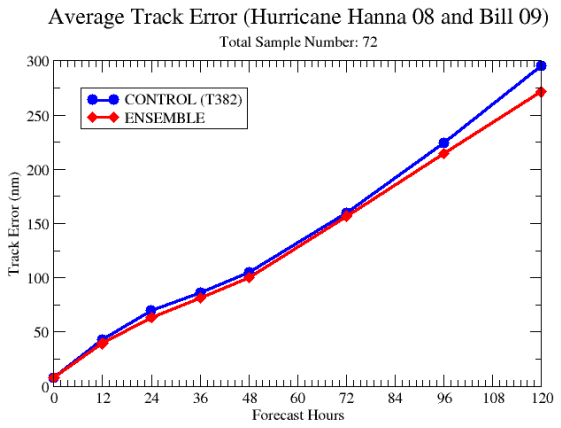
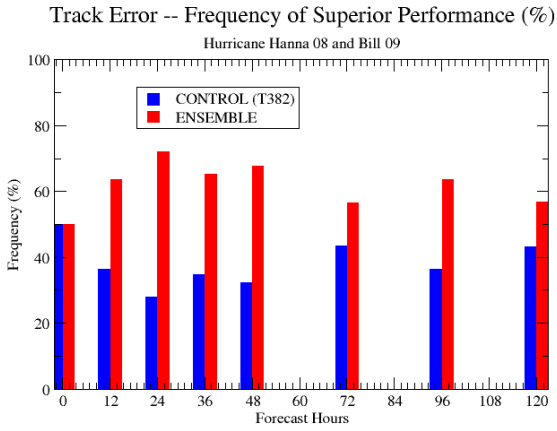


Figure 2: Average track forecast errors for Hurricane Hanna 2008 and Bill 2009, total of sample forecasts:72.



Future Plan:

- Develop ensemble perturbations using HWRF model for parent domain, 27Km resolution with 21 members; Make it available for HFIP multi-model ensembles;
- Develop a method to perturb hurricane initial position and intensity;
- Evaluate the impact of physics-based ensemble perturbations;
- Work closely with HFIP ensemble team on development of multi-model ensembles and determine optimal regression coefficients for participating models;
- Develop post-processing software, such as cluster analysis, for hurricane track and intensity forecasts.