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USE OF THE NCEP GLOBAL ENSEMBLE FOR TROPICAL CYCLONE TRACK FORECASTING

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1. **INTRODUCTION**

Over the past decade, the use of ensemble forecasts at operational forecasting centers has taken an increasingly prominent role. Through application of the ensemble mean and spread information and through the use of ensemble-based probabilistic techniques, ensemble forecasting has already proven to be a useful tool in the extratropics (Toth et al., 2001). In the tropics, recent work has been done to run an ensemble of VICBAR forecasts (Aberson, 1995) and to use information from the NCEP global ensemble to target real-time observations in the hurricane environment (Aberson, 1997).

Given the remarkable increase in the track forecasting skill of the NCEP global model (MRF/AVN) over the last two hurricane seasons (Pan et al., 2002) and that the NCEP ensemble forecasting system derives its initial perturbed conditions from the global model, NCEP has begun to evaluate the performance of the ensemble in track forecasting. This paper will discuss the use of the NCEP global ensemble for track forecasting, including examples, track error statistics and a discussion of an ensemble-based strike probability product.

2. **OVERVIEW OF THE NCEP ENSEMBLE**

During the 2001 hurricane season, the NCEP ensemble used an operational configuration in which 10 perturbed forecasts were run at 00z and 12z. The forecasts were run at T126 resolution out to 84h and then truncated to T62 for the remainder of the forecast, out to 384h. The storm-tracking algorithm was only run for the high resolution, T126 portion of the forecast. Therefore, all ensemble tracks in this study from 2001 go out to only 84h, and track verifications are done to only 72h.

3. **TRACK RESULTS**

Individual tracks were obtained for all 10 ensemble member forecasts and then the track data points at each forecast hour were averaged together to get the ensemble mean track. This method is clearly favored over the alternate method of first creating an ensemble mean field for each variable and then running a tracking algorithm on those mean fields. Given the sometimes large spread of storm center positions and the probability that some member forecasts will dissipate a storm before other members will, attempting to track a storm using such smooth and relatively weaker mean fields would yield inconsistent results.

Figure 1 shows a single 84-hour forecast for Hurricane Gabrielle. While there is a great deal of spread among the ensemble perturbation tracks, the mean track forecast was a skillful one, very close to the observed track. Note that for this forecast, only six ensemble member tracks comprise the mean at 84h. In the remaining four members, the storm either dissipated prior to 84h or was otherwise unable to be tracked.

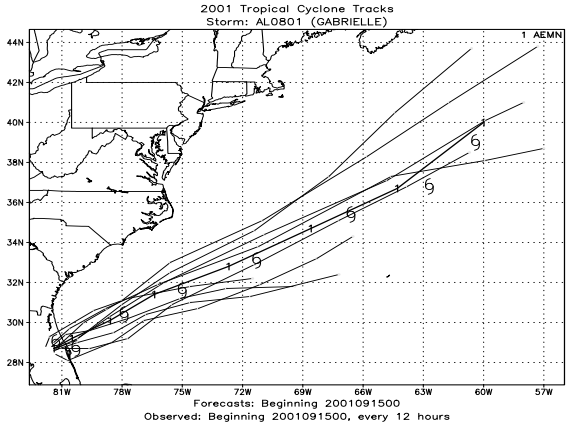

Fig. 1: NCEP Ensemble member tracks (unlabeled), ensemble mean track (1), and observed positions for Hurricane Gabrielle, initialized 00 UTC 15 Sep 2001.

Figure 2 shows that the ensemble mean track forecasts maintained a steady and consistent performance throughout the lifecycle of Gabrielle. Likewise, Figure 3 indicates the same consistency for Hurricane Felix in the period of its lifecycle after it regenerated.

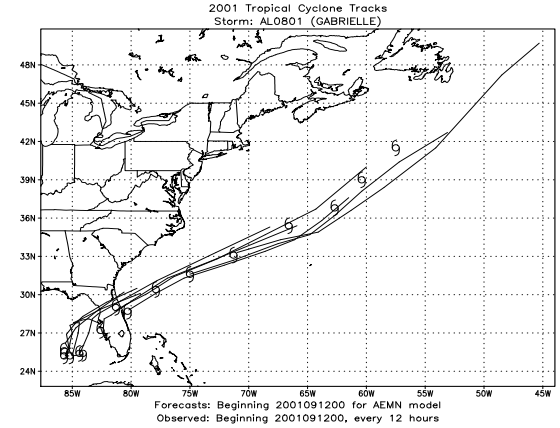

Fig. 2: NCEP Ensemble mean track forecasts over the lifecycle of Hurricane Gabrielle, issued every 12h, beginning 00 UTC 12 Sep 2001

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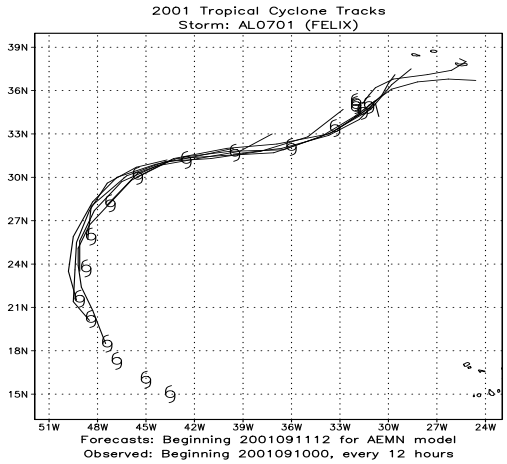

Fig. 3) Same as Fig. 2, but for Hurricane Felix, and beginning 12 UTC 11 Sep 2001.

4. **TRACK FORECAST VERIFICATION**

A homogeneous verification (Fig. 4) using TPC best track data (Atlantic, eastern Pacific) and JTWC operational position data (western Pacific) indicates that in 2001, the NCEP Ensemble mean (AEMN) was comparable to the other dynamical models in the eastern Pacific, though not as good as the AVN or UKMET. The ensemble had the lowest 72h error in the Atlantic, but the AVN was better at all earlier times. In the western Pacific, the ensemble had the lowest error at all times beyond 36h.

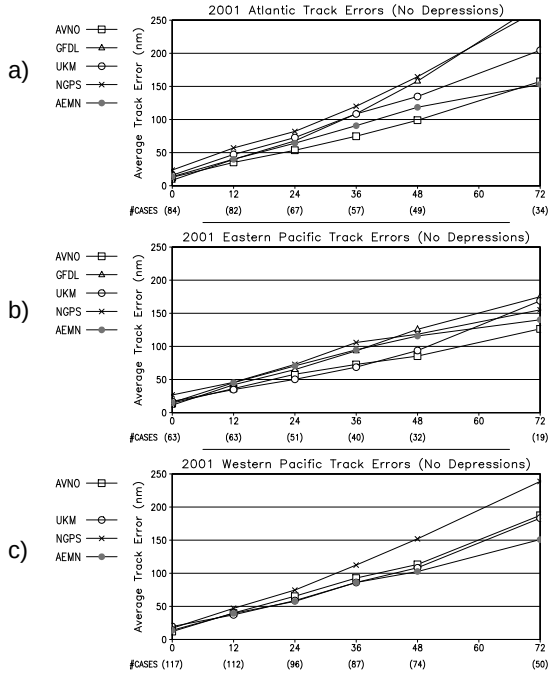

Fig. 4) Homogeneous track verification statistics for the 2001 season for a) Atlantic basin, b) eastern Pacific basin and c) western Pacific basin

A separate homogeneous verification (not shown) of the ensemble mean and the perturbation tracks showed that, as expected, the mean track outperformed any one of the perturbation tracks that make up the mean.

5. **STRIKE PROBABILITIES**

As part of its routine forecast package, NHC issues a product that lists the probabilities of nearby passage of a storm. Using the ensemble, we can develop a similar product (Fig. 5). At each grid point, we simply add up the number of forecast track points that come within X nautical miles of the grid point (X can be arbitrarily chosen) and divide that by the total number of members. Verification of such a field of probabilities will involve detailed analysis of climatological track information, and work on this is only just now beginning at NCEP.

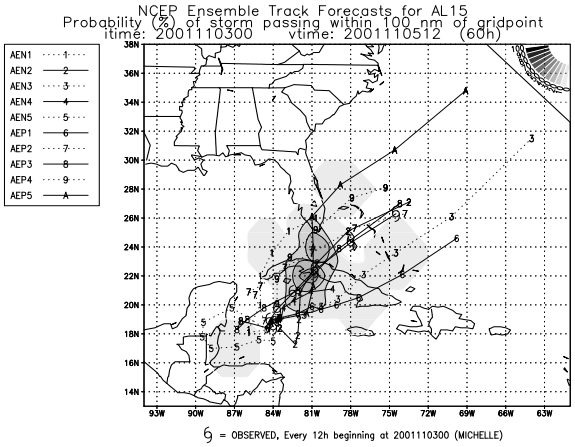

Fig. 5) Ensemble perturbation tracks and probability of storm passing within 100 nm of any grid point, for Hurricane Michelle at 60h, from 00 UTC 03 Nov 2001.

6. **REMARKS**

For the 2002 hurricane season, NCEP plans to run its ensemble at high resolution (T126) out to 180 hours every 6 hours. In addition, 6-hour cycling will be used instead of 24-hour cycling, which has shown a modest improvement in track errors during testing. Also, we plan to use the vortex relocation system (Liu et al., 2000) for the ensemble perturbation generation system, which has proven so effective in the NCEP AVN model.

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