5C.7 EVALUATION OF A KILO-MEMBER ENSEMBLE FOR TRACK FORECASTING

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1. INTRODUCTION

This preprint describes the evaluation of a semi-operational ensemble forecasting system with 1980 members. The ensemble utilizes a parameter-based perturbation scheme that is simple and fast enough to be used operationally with minimal computing resources, yet can provide information about the uncertainty of the forecast situation, allowing *a priori* estimates of forecast skill.

2. MODEL DESCRIPTION

A multigrid barotropic vorticity equation model (MBAR) is used to produce each of the forecast tracks (Fulton, 2001). MBAR was chosen because it reproduces the accuracy of the operational LBAR (a limited area shallow water spectral sine transform model) in approximately $\frac{1}{70}$ the computing time. Each 120-hour track forecast takes 1.4 seconds on a 1-GHz Pentium PC, allowing the entire ensemble to run in an hour. Them model uses three grid levels with the following resolutions: $h_1 = 188$ km, $h_2 = 94$ km, and $h_3 = 47$ km. (For a more complete description of the model setup, see Vigh et al., 2003.)

3. ENSEMBLE SYSTEM DESCRIPTION

Five classes of 'parameters' are perturbed (number of perturbations in each class indicated in parentheses): the background environmental flow provided by the NCEP Global Forecasting System (GFS) ensemble forecasts (11), the deep layer-mean averaging (4), the equivalent phase speed c_{eqv} (3), the vortex size/strength (3), and the storm motion vector (5). This study differs from previous studies with up to fifty members (Chan and Cheung, 1999a,b) in that each perturbation in a given class is cross-multiplied with all other perturbations of other classes to obtain an ensemble with 1980 members. One of the central questions addressed by this research is whether such cross-multiplication increases the degrees of freedom in the ensemble. (For a more complete description of ensemble design philosophy and perturbation classes, see Vigh, 2002.)

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4. EVALUATION

The ensemble is run for the Atlantic (2001-2003 seasons; 293 cases) and the Eastern North Pacific (2002-2003 seasons; 159 cases) basins using the operationally-estimated storm information available at forecast time. Due to the delay in receiving the GFS ensemble fields, the kilo-member ensemble forecasts are typically available 9-h after forecast time. In order to compare the usefulness of the kilo-member ensemble, two other ensembles are created from the available operational numerical guidance: an ensemble based on the 10+1 GFS ensemble forecast tracks, and a consensus ensemble calculated by averaging the interpolated track forecasts of the GFDL, NOGAPS, Aviation, and UK Met. models. Verification statistics include all available tropical and subtropical cases of tropical storm intensity or greater.

4.1 *Ensemble Mean and Subensembles*

The accuracy of the total kilo-member ensemble mean and 26 subensemble means (computed by averaging the forecasts of all members sharing a common perturbation: $11 + 4 + 3 + 3 + 5 = 26$) is determined by computing the Great-Circle distance between the respective ensemble mean forecast position and the official best-track verifying position. Besides the error, the ensemble mean spread, x-bias, and y-bias statistics are also calculated. The average errors of the ensemble mean are compared with those of a single ensemble control member, the GFS ensemble mean, the 5-day Climatology and Persistence (CLP5), the Aviation forecast (AVN0), and other models.

4.2 *Strike Probability Maps*

Probabilistic interpretations are possible with an ensemble of this size, so maps of strike probabilities (similar to the NHC's experimental product) are calculated for various forecast times. An example of a cumulative strike probability map through 120-h is shown in Fig. 1. To judge the skill of the kilo-ensemble strike probabilities, Brier Skill Scores will be computed (Jolliffe and Stephenson, 2003). In a related possibilistic interpretation, the ensemble can be looked upon as mapping out a subspace of all possible storm tracks. The reliability of this ensemble envelope will be examined.

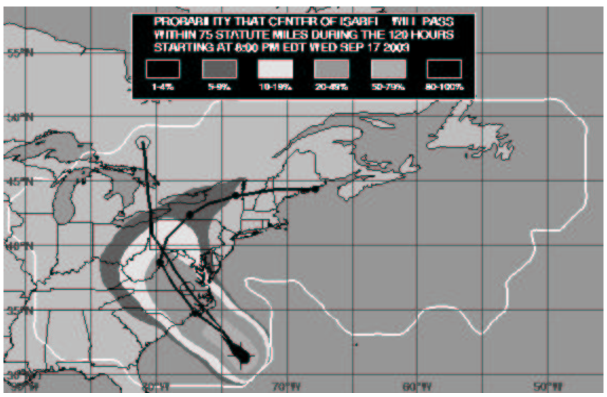

Figure 1: Cumulative strike probabilities through 120-h for Hurricane Isabel from 18 Sep 2003 at 0000 UTC. The ensemble mean forecast track is shown by the track with filled-circle markers (indicating the position at day 1, 2, 3, etc.), while the observed best-track is indicated by the open-circle markers.

4.3 Spread vs. Error Relationship

If the ensemble can accurately simulate the uncertainties in the dynamical system, then one would expect there to be a positive relationship between ensemble mean spread (the mean distance of the individual members from the ensemble mean) and the error of the ensemble mean forecast. A strong relationship could allow useful forecasts of forecast skill to be made at the time of the forecast. Figure 2 shows scatter plots of spread vs. error for various forecast times for the Atlantic basin. The relationship is quantified by calculating the regression and correlation coefficients from a linear regression best-fit of the spread vs. error of the ensemble mean forecasts. The relationship between spread and error is found to be strongest from forecast time 36-h to 96-h, peaking at 60-h. The correlation coefficient (and fraction of total variance explained) also peaks at 60-h.

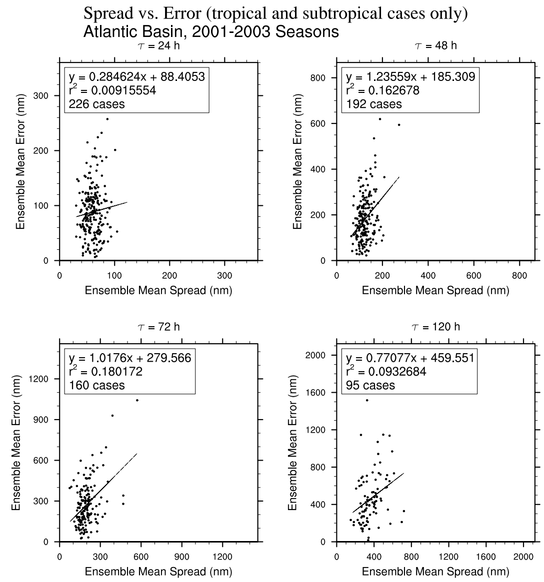

Figure 2: Scatter plot of ensemble mean spread vs. ensemble mean error for 2001-2003 Atlantic TCs (293 cases). Best-fit regression equation and r^2 are shown.

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