P6.8 A REALTIME ENSEMBLE FOR THE PREDICTION OF HURRICANE TRACKS IN THE ATLANTIC BASIN

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The atmosphere has long been recognized as a chaotic system, e.g. very small perturbations to initial conditions result in increasingly large differences in the evolution of atmospheric models with time. Since the exact state of the atmosphere can never be measured, and the data cannot be perfectly assimilated into numerical models, all analyses contain errors whose magnitudes can only be estimated. An indeterminate number of initial conditions consistent with the observational data can therefore be used in numerical weather prediction, and single model runs at any synoptic time only give one possible solution to the evolution of the atmosphere. Ensemble forecasting is an efficient way to quantify the uncertainty in the evolution of the atmospheric system, and to provide numerous forecast scenarios and probabilistic forecasts of certain events. A best, or control, state is perturbed, allowing for different integrations starting from various initial states, and the perturbations are designed to mimic the fastest growing modes of the system, thus creating an envelope of possibilities for the particular forecast.

Tropical cyclone track prediction is one of the simplest methods with which to test ensemble forecasting, since only one parameter, the location, is being forecast. Since operational numerical track forecasting guidance at the National Hurricane Center (NHC) is dependent upon the National Centers for Environmental Predction Global Spectral Model, the basis for the global ensemble prediction system, some of the dynamical models with varying degrees of complexity have been tested (Aberson et al. 1995, 1998; Aberson 1999), as has the global ensemble prediction system itself.

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However, these tests were unsuccessful, due to the relatively low resolution of both the global ensembles and of the individual regional models, making representation of the tropical cyclone vortex problematic.

The current study is an attempt to create an operational ensemble forecasting system for tropical cyclone tracks that does not depend upon the operational global ensemble. VICBAR (Aberson and DeMaria 1994), a multiply-nested-mesh shallow-water model with time-dependent boundary conditions from the NCEP Global Spectral Model, is tested because of the low cost of running large numbers of ensemble members and because the forecasts are competitive with other models. During the 1998 - 2000 hurricane seasons, a 40-member ensemble forecasting system was run on over 150 cases in the North Atlantic basin. Individual perturbations are bred, and at each initial time (0000 UTC during 1998 and 1999, and 0000 and 1200 UTC during 2000), the perturbations are orthonormalized and added to the control. The synthetic vortex is only used in the control run, so that the perturbations are able to modify the location, intensity, size, and initial motion, of the tropical cyclone in a manner consistent within each individual case. The control and perturbed members all use the same version of the model.

The control analysis is considered the best representation of the initial conditions. As such, the control forecast should provide the best average forecasts of all the ensemble members, and this is the case in the current study. In a non-orthogonalized bred mode system, the perturbed ensemble members all are theoretically equally likely to perform best in each case, so that the average errors should be approximately the same. However, the ensemble perturbations here are orthonormalized and ordered in such a way that the high-numbered ensemble members have large perturbations close to the tropical cyclone vortex. The average errors tend to increase slightly with perturbation number, though the high-numbered perturbations have a high frequency of superior performance relative to the other members; member number 41 is the best 10-15% of the time, as opposed to an equally likely 2.5%.

The ensemble envelope should capture the actual evolution of the tropical cyclone track. Since track is a two-dimensional problem, the tracks are verified in both the cross- and along-track directions. The first tells where the storm is likely to go, and the second when it will get there. Tracks are interpolated with splines, and the location and time of the closest approach to the verifying location are found. The ensemble is then checked to see if the verifying location and time are within the ensemble spread. The ensemble is able to capture the track evolution more than 90% of the time through five days, and is therefore successful in capturing where the storm is likely to go. However, it is able to capture the timing between 65 and 80% of the time, suggesting that along-track errors may be large. These values are slightly larger than those of the operational suite of models available at NHC (Aberson 2001).

Because the ensemble is able to capture the track evolution, the spread of the ensemble may diagnose the potential reliability of the ensemble. In cases in which the ensemble spread is small, the error is likely to be small. When the ensemble spread is large, the error may still be small, since the mean or an individual ensemble member may accurately predict the track. However, in these cases, the errors may also be large, and so the reliability may be low. There should be no cases in which the ensemble spread is small and the error large. The VBAR ensemble obeys these general rules through five days.

Current work involves the development of a probabilistic landfall strike forecast from the ensemble, work on ensemble-based data assimilation techniques, and on targeting observations to improve tracks of hurricanes threatening landfall (Bishop and Toth 1999, Bishop et al. 2001).

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