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FORECAST SKILL OF A SIMPLE COUPLED HURRICANE INTENSITY PREDICTION MODEL

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1. INTRODUCTION

During the past decade, deterministic models finally caught up with statistical methods of forecasting hurricane tracks. On the other hand, no deterministic model has yet systematically beat the best statistical forecasts of hurricane intensity, produced using the Statistical Hurricane Intensity Prediction System (SHIPS). At the last AMS hurricane conference, we presented results from the 1999 Atlantic season (Emanuel and Rappaport, 2000) using the very simple, coupled hurricane intensity model developed by the author (Emanuel, 1999). The skill of this deterministic model was comparable to and perhaps a little better than that of SHIPS. These encouraging preliminary results led to the adoption of the model, now called the Coupled Hurricane Intensity Prediction System (CHIPS), by the National Hurricane Center for use as an experimental product during the 2001 season. This paper provides an evaluation of the model's performance during this past season.

2. MODEL IMPROVEMENTS

The basic structure of the original model is described in the two papers cited in the Introduction. Several improvements were implemented for the 2001 season. In the original version of the model, the user had to manually specify both an initial intensity and an initial rate of intensification. Several runs of the model were made, varying the initial intensification rate, until the history of the storm to date was closely matched. For the 2001 season, an automatic algorithm was implemented to match as closely as possible the storm's intensity evolution to date, allowing the model to be run completely automatically. Thus, every six hour forecast was made. A second improvement was the incorporation of a proxy for environmental vertical wind shear in the model physics. Because the atmospheric model is axisymmetric, shear cannot be included directly. Instead, the 'ventilation' effect of shear is mimicked by advecting dry, environmental air at mid-levels into the storm core, in proportion to the predicted value of the bulk wind shear in the troposphere. (The shear forecasts were those used as input to SHIPS.)

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3. RESULTS

The forecast intensity error averaged over all the forecasts of all events whose initial intensity exceeded 30 kts is shown in Figure 1, as a function of forecast lead time. The improved initialization has yielded much better 12 hour intensity forecasts, with skill comparable to SHIPS and the official forecast. But by 24 hours, the intensity skill has degenerated and by 36 hours is worse than the GFDL model errors.

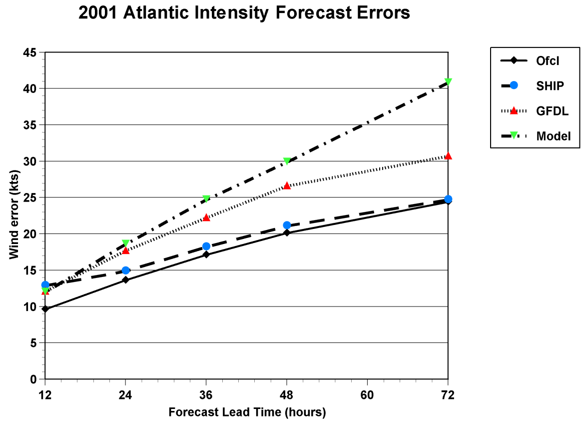

Figure 1: Wind intensity error (kts) as a function of lead time for the official NHC forecast, SHIPS, GFDL and CHIPS forecasts.

4. DISCUSSION

All or almost all of the 2001 storms were strongly affected by wind shear through most or all of their lives. This is similar to the 2000 season but quite different from the 1999 season. Although a proxy for shear is included in the 2001 version of CHIPS, it is not performing well. An indication of the problem can be seen in Figure 2, which shows a sequence of forecasts of Tropical Storm Chantal of 2001. This storm was affected by shear during all of its life. During the early part of the storm's history, the effect of shear on the modeled intensity is too large and the forecast intensity is too low. Later, when the actual storm begins to intensify, the model intensification proceeds at almost the same rate as simulations without shear (not shown). Thus the shear affects the model in a bimodal, almost switch-like manner, either preventing intensification altogether or having almost no effect.

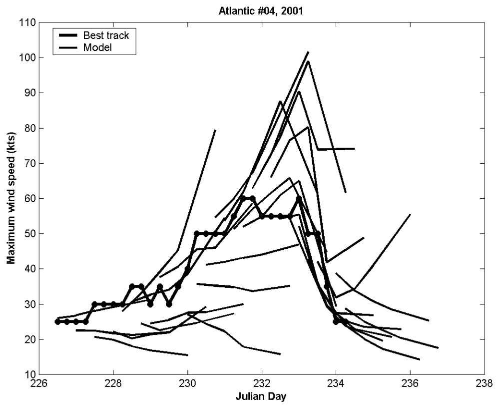

Figure 2: Observed (thick line) and predicted (thin lines) maximum wind speeds in Tropical Storm Chantal, 2001.

Another example showing problems with the model is provided in Figure 3. Here it can be seen that, owing to the use of the shear proxy, the first 8 forecasts fail to intensify Michelle, leading to very large forecast errors. The next series of forecasts intensified Michelle at about the right rate, but overestimated the peak intensity by about 20 kts. Notice that the forecasts initiated near the time of Michelle's peak intensity overforecast the rate of dissipation of the storm, while later forecasts were closer to the observed. In this instance, the earlier track forecasts had the storm moving over land, whereas the actual storm did not. Thus, in this case, the intensity errors are tied to the track errors.

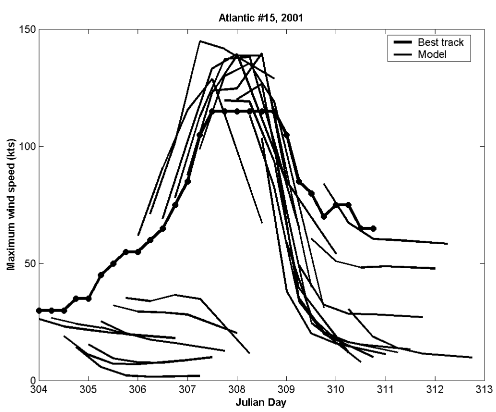

Figure 3: Observed (thick line) and predicted (thin lines) maximum wind speeds in Hurricane Michelle, 2001.

5. FUTURE PLANS

CHIPS appears to be a useful product for estimating "worse case" scenarios both for intensity and rate of change of intensity. The automatic matching algorithm works very well and greatly reduces initial and early lead time errors, but our first attempts to include a proxy for shear effects had decidedly mixed results.

The success of the automatic matching provides an avenue for systematic improvement. We can run the matching algorithm over the entire lives of past storms to determine the optimum (time-dependent) values of the shear proxy parameter that is used to do the matching. We can then use multivariate linear regression to determine optimum relations between these values and measures of environmental shear and model variables. Once such relations are determined, they can be used to predict the shear proxy parameter.

A preliminary result is shown in Figure 4, which uses a modification to the shear proxy that is proportional to the predicted cumulus mass flux. Comparing to Figure 2, it can be seen that both the underpredictions and the overpredictions are reduced. The modified CHIPS skill scores for this one event exceed those of the official guidance, GFDL and SHIPS, and exceed GFDL for the whole season. This encourages us to keep working on the model.

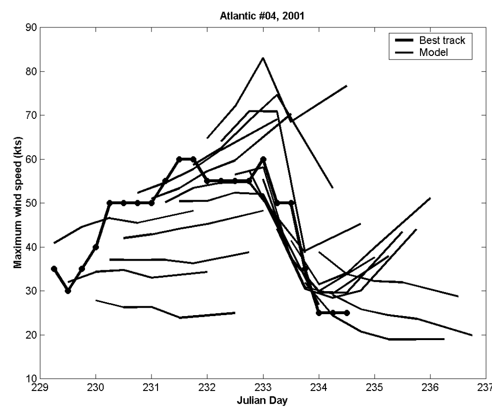

Figure 4: As in Figure 2, but using modified shear proxy.

5. REFERENCES

Emanuel, K. and E. Rappaport, 2000: Forecast skill of a simplified hurricane intensity prediction model. Preprints of the 24th Conf. Hurricanes and Trop. Meteor., Ft. Lauderdale, FL, Amer. Meteor. Soc., Boston

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