P1.2 VERIFICATION OF TROPICAL CYCLONE GENESIS FORECASTS FROM THE TPC'S TROPICAL ANALYSIS AND FORECAST BRANCH (TAFB)

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1. INTRODUCTION

The Tropical Prediction Center (TPC) began formally issuing tropical cyclone (TC) genesis forecasts in graphical and textual marine forecasts during the 2001 hurricane season. These forecasts are intended to provide additional lead time to mariners in order to help them avoid the hazards posed by tropical cyclones. Pasch et al. (2001) noted that it would be a major advance to accurately predict a TCs formation point and subsequent track in operational forecasts.

Beginning in 2002, the "possible" TC forecasts were included on the Tropical Cyclone Danger Graphic (TCDG). This graphic depicts areas of possible danger surrounding tropical cyclones by adding 100, 200, and 300 n mi plus the 34-kt wind radii to the 24, 48 and 72 hour National Hurricane Center (NHC) forecast positions (NHOP 2003). This is commonly referred to by mariners as the "1-2-3 Rule" (Holweg, 2000).

To determine areas of "possible" TC genesis, TAFB forecasters routinely collaborate with the NHC duty hurricane specialist. If a weather system is determined to be a candidate for development within 36 hours, an area of "possible" genesis is depicted graphically on the TCDG. The region depicted typically encompasses a horizontal area of about 300,000 km^2 (about a 5° square). The "possible" TC forecasts were then verified based on the observed development of a TC (i.e., tropical depression or greater intensity) from the system.

2. DATA AND METHODOLOGY

The results of this study include verification of the "possible" TC forecasts from the 2002 and 2003 hurricane seasons. Both individual and event forecasts have been verified. For this study, a set of "possible" TC forecasts is an event when a genesis forecast was made for the same general area of interest on at least two consecutive TCDGs. In a few instances, a forecast was issued on one TCDG but not included on subsequent graphics. In these rare cases, the forecast was included in the individual forecast verification, but not included as an event forecast. Once a "possible" TC event began, if a forecast was not included on one TCDG but was included on the subsequent TCDG the event was considered to be continuous for the purpose of forecast lead time.

In the Atlantic, a few tropical cyclones actually weakened to open waves and then re-developed into tropical cyclones. In these cases, the individual forecasts during the time the system was an open wave was included in the individual forecast verification. However, the lead times were not computed for re-development. Only the lead before the initial development was considered. The lead time is defined as the time between the first TC genesis forecast and the time of the first NHC forecast/advisory.

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The probability of detection (POD) and false alarm rate (FAR) were computed for each basin. The POD is defined as the percentage of the number of predicted TCs versus the total number of TCs in each basin. A false alarm was considered to be an event in which the area of interest did not develop into a numbered tropical cyclone. The FAR is defined as the percentage of incorrect "possible" TC events out of the total number of events forecast.

The accuracy of individual forecasts was also explored. Unlike verifying the event forecasts, individual forecasts were verified based on the time criteria of development. The individual forecasts were verified based on tropical cyclone development within 36 h of the forecast. A category of "near miss" was used for verifying individual forecasts when a TC developed beyond the 36 h time frame. The largest lead time for each basin was about 120 h.

3. RESULTS

Table 1 includes the eastern North Pacific Basin (EPAC) "possible" TC event forecast verification results. The probability of detection in the EPAC has been outstanding during the past two hurricane seasons. Only one EPAC TC genesis (Christina in 2002) was not predicted during the 2002 and 2003 seasons. The EPAC average lead time has been above 24 h in both years, but decreased from 34.1 h in 2002 to 27.0 h in 2003.

East Pacific	2002	2003
Probability of Detection (POD)	94% (15/16)	100% (16/16)
False Alarm Rate (FAR)	21% (4/19)	43% (12/28)
Avg. Lead Time	34.1 h	27.0 h

Table 1. East Pacific Basin results of "possible" TC event forecasts during the 2002-03 tropical seasons.

In comparison to 2002, there was a large increase in the number of "possible" TC event forecasts in the EPAC during the 2003 season. The EPAC FAR increased from 21% in 2002 to 43% in 2003. The increase in false alarms may have been partially caused

by increased spatial resolution and a corresponding over-prediction of TC genesis in some of the global models. Beven (1999) documented the detrimental effect of these bogus TC genesis forecasts on hurricane and marine forecasts.

Table 2 includes the Atlantic basin "possible" TC event forecast verification results. It should be noted that three tropical cyclones developed outside of the June-November Atlantic hurricane season in 2003. Tropical Storms Ana (April), Odette (December), and Peter (December) developed either prior to or after the official hurricane season. There were no genesis forecasts available on the TCDG for these three TCs since that graphic is not routinely produced outside of the hurricane season. In the case of Odette, a "possible" tropical cyclone was indicated in TAFB text marine forecasts about 12 to 18 h prior to development. Prior to Peter's development into a Tropical Storm, TAFB had previously issued a non-tropical gale warning for the system. In the case of Ana, TAFB did not predict that the system would attain winds of 34 kt or greater.

Atlantic	2002	2003
Probability of Detection (POD)	79% (11/14)	83% (15/18)
False Alarm Rate (FAR)	32% (6/19)	32% (7/22)
Avg. Lead Time	13.7 h	28.1 h

Table 2. Atlantic Basin results of "possible" TC event forecasts during the 2002-03 tropical seasons. Note, the 2003 forecasts do not include "possible" TC forecasts for Tropical Storms Ana, Odette, and Peter, since they developed outside of the hurricane season.

The Atlantic POD and FAR rates were nearly identical between 2002 and 2003. However, the average lead time doubled from 13.7 h in 2002 to 28.1 h in 2003. During the last two years there has been an overall lower probability of detection in the Atlantic than in the Pacific. This is being attributed to the fact that some Atlantic TCs develop from non-tropical origins (i.e. frontal lows, subtropical cyclones). Even though numerical guidance indicated cyclogenesis in most of these cases, it was not clear that the system would acquire tropical characteristics. Hurricanes Kyle (2002) and Juan (2003), which developed originally as non-tropical lows, account for a third of the systems that TAFB did not detect early in the Atlantic basin during the past two years.

Combining the results for both basins gives a good overall indication of the fidelity of these TC genesis forecasts. The 2002-03 combined POD is 89% (57/64), the FAR is 33% (29/88), and the average lead time is 26.2 h (for the 64 genesis cases; a lead time of 0 h was assigned for the 7 undetected cases). The average lead time of the 57 detected genesis cases is 29.4 h.

Individual forecasts during the last two years were correct (a TC developed within 36 h) 46% (121/265) of the time for the EPAC and 47% (98/208) for the Atlantic. Since several systems had lead times in excess of 36 h, the percentage of correct forecasts increases dramatically when the "near miss" category (TC developed beyond 36 h) is included. Upon adding the "near misses", the individual forecast accuracy increases to 63% (156/247) for the EPAC and to 60% (124/208) for the Atlantic.

4. SUMMARY AND FUTURE GOALS

TPC has been able to provide users with additional lead time for developing TCs by issuing TC genesis forecasts in textual and graphical products. They have proven to be useful by providing mariners with an average of about one day of lead time to avoid the hazards posed by developing TCs. TPC/TAFB has provided these forecasts with a relatively low percentage of false alarms.

Objective techniques to determine TC genesis from numerical model output, i.e. a precise set of criteria such as number of closed surface isobars, low-level vorticity thresholds, etc. should be exploited to provide improved guidance to forecasters. These criteria should also include parameters to distinguish between tropical and non-tropical genesis. Such techniques would also enable systematic verification of genesis forecasts from various models. Another potentially useful numerical tool for predicting genesis could come from a multi-model ensemble. Using a combination of these objective methods and subjective forecaster input, along with further improvements in the models, it is hoped that false alarm rates will decrease while lead times increase. Future goals might include decreasing the FAR to 20% or lower while keeping the POD above 90%. By achieving these goals, TPC will be able to provide an even higher quality of public and marine forecasts for developing tropical cyclones.

5. REFERENCES

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