9C.5 EARLY DETECTION OF TROPICAL CYCLONES USING SEAWINDS-DERIVED VORTICITY FOR THE 2001 HURRICANE SEASON

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1. INTRODUCTION

The SeaWinds scatterometer aboard the Quikscat satellite provides routine surface wind vector observations roughly two times a day over the tropical oceans. These data have been useful in monitoring the intensity and location of tropical cyclones (TCs, Katsaros et al. 2001). Sharp et al. (2002, hereafter referred to as SBO) used these observations to create spatially averaged vorticity maps, which they used in an objective technique to determine regions that are favorable for tropical cyclogenesis. The current work uses the same technique, while taking advantage of newly available near-realtime (< 3 hour delay) data.

2. METHODOLOGY

SeaWinds observations of the 1999 Atlantic hurricane season were used by SBO to develop an objective technique for detection of potential tropical cyclones. The technique applies a mean vorticity threshold over a given spatial area. Vorticity is calculated directly within the SeaWinds observational swaths. Ideally, the existence of a TC (i.e., either a tropical depression, tropical storm, or hurricane) could then be confirmed by conventional tools such as satellite pictures of the area to look for persistent, organized convection.

The spatial scale for averaging vorticity is a 7-point (175 km) by 7-point box centered on the swath points. Individual vorticity values are calculated at the center of each 4-vector box of wind observations by determining the circulation around the box and then dividing by the area. A minimum of three wind vectors out of four in a square is required for the calculation. This approach allows the vorticity to be calculated at the same spatial density as the wind observations. All wind vector data are used in these calculations (i.e., the rain-flagged data are not removed). The inclusion of rain-flagged data likely modifies the vorticity calculation; however, the noise that results by including these data is small compared to the signal in the area of potential TCs. The average is then calculated from these individual vorticity values. For an average to be made, we choose to require that at least 44 (about 90%) of the 49 vorticity observations exist (i.e., not be missing). This limits the technique's ability in areas close to land and on the edge of the swaths. The test has three components:

1. The average vorticity in the 7-point by 7-point box must exceed the subjectively determined minimum threshold vorticity (10×10^{-5} s^{-1}).
2. The maximum rain-free wind speed within the box must exceed a certain minimum wind speed (10.0 m s^{-1}).
3. The above two criteria must be met at least 25 times (i.e., approximately an area of 15 000 km^2) within a 350 km by 350 km area.

If the above criteria are met, then a potential TC is identified. These threshold numbers are subjectively determined using the research-quality SeaWinds data for the 1999 Atlantic hurricane season (the near-realtime product was not available at that time). Storms from that season had to be directly 'hit' by the QuikSCAT swath (i.e., the storm center could not be within 150 km of the edge of the swath) and their central circulation pattern had to be clear of any landmasses to be considered in our determination of a threshold. Due to the small sample of swaths that fit these criteria (40 swaths), the thresholds might be too large, but are good for lowering the false alarm rate for 1999.

The domain used by SBO to develop this technique is the Gulf of Mexico, the Caribbean Sea, and the tropical Atlantic in the latitude band from 10°N to 25°N. Points north and south of this band were excluded because they are climatologically unfavorable origin points for TCs, and TCs did not develop there in the 1999 season. Test runs farther north are also susceptible to mis-identifying mid-latitude frontal systems in the latter months of the hurricane season. For this pilot project, we expand the domain to include the entire tropical Atlantic from 8°N to 30°N as well as the eastern tropical Pacific (east of 140°W).

3. EARLY RESULTS

3.1 *The Atlantic Basin*

For the 2000 Atlantic hurricane season, SBO showed moderate success at detecting potential TCs within the near-realtime Quikscat data. Their vorticity-based test found signals for 3 of 12 TCs an average of 20 hours before the NHC classified them as TCs. For the 2001 season, the results are a little better. 8 of the 17 TCs (Table 1) are identified an average of 43 hours before the NHC classified them as TCs. The earliest detection was for TC Felix, which was identified 62 hours before the NHC classified it as a TC (Fig. 1).

The probability of detection (POD, the number of times a system was detected early or during its existence divided by the total number of times QuikSCAT passed over an existing system) was 0.85. The false alarm rate (FAR, the number of times when the technique said a system would develop and none did divided by the total number of hits) was 0.36. The critical success index [CSI, the number of times systems were detected early or during their existence divided by the sum of the number of detected systems (N=88) and the number of times QuikSCAT passed over a developed system and the algorithm did not detect it (10)] was 0.57.

3.2 *The East Pacific Basin*

The technique and thresholds described above are extended into the East Pacific basin to determine their effectiveness in that region. The test found signals for 14 of 17 TCs (Table 2) an average of 42 hours before the NHC classified them as TCs. The earliest detection was for T. D. 6, which was identified 79 hours before the NHC classified it as a TC (Fig. 2).

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The POD for these systems was a successful 0.95; however, the FAR was a slightly higher 0.38 when compared to the Atlantic statistics. The CSI was 0.60. The degraded FAR statistic comes from the increase in the number of mis-identification of shear lines. This is likely because of the proximity of the Intertropical Convergence Zone to the domain of study. An increase in the minimum vorticity threshold could reduce the false alarms and still provide a successful POD.

Acknowledgments

Gene Legg and Paul Chang at NOAA/NESDIS provided the near-realtime data used in this report. Thanks to Jiraporn Whalley and Stacey Campbell for their help in automating the retrieval and processing of that data. NASA support came through funding for the Ocean Vector Wind Science Team. The Center for Ocean-Atmospheric Prediction Studies receives its base funding from ONR's Secretary of the Navy grant to James J. O'Brien.

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Table 1. Early detection times relative to the NHC's initial classification time (i.e., the time when the system first reached the criteria used by the NHC) for the 2001 Atlantic hurricane season. Nine TCs were not identified before the NHC's initial classification time.

Storm	Detection time prior to NHC (in hours, hindsight)
T. D. 2	31
Chantal	31
Erin	61
Felix	62
Gabrielle	10
Karen	47
Lorenzo	55
Olga	48

Table 2. Same as Table 1 but for the 2001 East Pacific hurricane season. Three TCs were not identified before the NHC's initial classification time.

Storm	Detection time prior to NHC (in hours, hindsight)
Adolph	9
Barbara	24
Cosme	45
Dalila	51
Erick	44
T. D. 6	79
Flossie	45
Gil	31
Henriette	26
Juliette	6
Kiko	62
Lorena	50
Narda	26
Octave	54

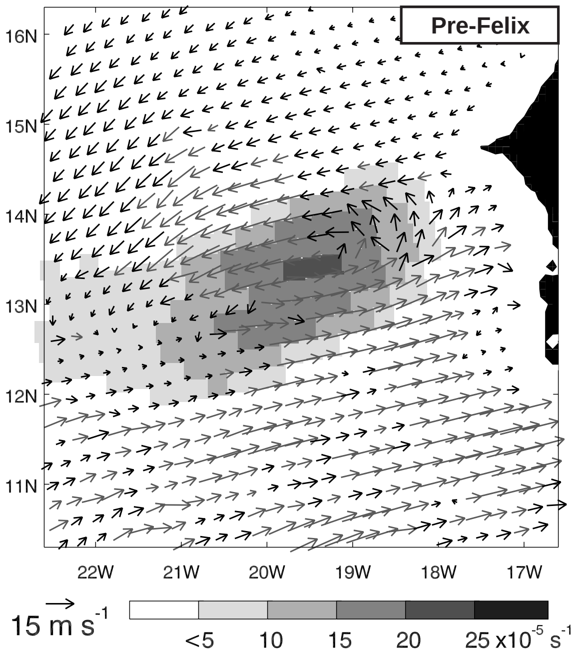

Fig. 1. Tropical Cyclone Felix 62 hours before the NHC classified it as a TC (0703 UTC 5 September 2001). The background grayscale represents spatially averaged vorticity. Wind speed is proportional to arrow length. Gray arrows indicate data flagged by the MUDH rain flag.

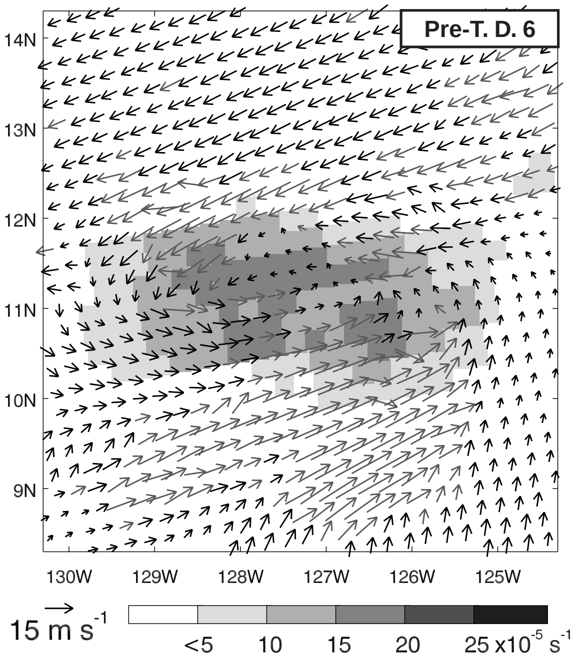

Fig. 2. As in Fig. 1, but for Tropical Depression Six 79 hours before the NHC classified it as a TC (1419 UTC 19 August 2001)