P1.3 STATUS OF THE UW-CIMSS OBJECTIVE DVORAK TECHNIQUE (ODT)

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1. INTRODUCTION

An algorithm has been developed at the University of Wisconsin-Madison, Cooperative Institute for Meteorological Satellite Studies (UW-CIMSS) to objectively determine tropical cyclone intensity utilizing geostationary infrared satellite data (Velden et. al., 1998). This algorithm is based upon the original subjective Dvorak Technique, utilizing many of the same rules and procedures outlined by this methodology (Dvorak, 1984) for determination of the current intensity estimate. The ODT is currently being used experimentally and operationally at many tropical cyclone forecast centers worldwide, with significant improvements in intensity estimations being realized at these locations.

2. BACKGROUND

ODT intensity estimations are based upon two temperature values (an eye and surrounding cloud temperatures) and recognition of the storm cloud pattern type. Cloud pattern types are determined utilizing Fourier Transform and histogram analyses of the cloud region within 136km of the center. The four valid cloud pattern types are eye, embedded center, central dense overcast (CDO), and shear. Adjustments to the intensity estimate for the eye pattern are dependent upon the temperature and clarity of the eye, as defined in the original subjective Dvorak rules (Dvorak, 1984).

A time averaged intensity estimate value (Final T-No.) is calculated utilizing a 12-hour, linearly-weighted averaging scheme, giving the most recent intensity estimates the most weight. A final current intensity value (CI number) is determined after implementation of a specific subjective Dvorak rule for weakening storms. This rule increases the final, time-averaged intensity estimate by a set value during the weakening stage of a storm life cycle until dissipation or restrengthening occurs.

3. RESULTS

Statistical comparisons between the ODT estimates, those obtained from operational center subjective techniques, and a previous objective Dvorak algorithm are presented in Tables 1 and 2.

Table 1 displays results from the developmental (dependent) test data set for 12 storms during the 1995-1997 Atlantic storm seasons. Table 2 shows results from an independent data set from the 1998 and 1999 Atlantic storm seasons. As can be seen, the ODT compares very favorably with the Tropical Analysis Centers (TAC) average bias and RMS error, displaying an overall reduction in the RMS error for the storms investigated. The ODT displays a marked improvement over a previous objective Dvorak algorithm (DD), reducing the RMS error by almost half.

MSLP estimate	Bias	RMSE	Matches
ODT	+1.69	7.34	407
ODT(Auto)	+2.84	8.59	407
DD	+3.63	14.33	407
TAC (any of 3)	+4.31	10.35	407

Table 1. Comparison of the ODT and DD estimates of 1995-1997 Atlantic TC intensities (MSLP) with operational estimates obtained from three Tropical Analysis Centers (TAC) which employed the standard Dvorak method (the Tropical Analysis and Forecast Branch of the Tropical Prediction Center, the Synoptic Analysis Branch of NOAA/NESDIS, and the Air Force Weather Agency). A match is considered whenever a ODT/DD estimate and any of the three TAC estimates were available with a coincident (within one hour) aircraft reconnaissance report of MSLP. Bias and RMSE are in hPa.

MSLP estimate	Bias	RMSE	Matches
ODT	-0.72	7.97	397
TAC (any of 3)	-0.05	10.38	397

Table 2. Same as Table 1, except only comparing the ODT with operational estimates from three TAC for Atlantic TC during 1998 and 1999 (MSLP). Bias and RMSE are in hPa.

4. ALGORITHM FUNCTIONALITY IMPROVEMENTS

During the past few years, modifications and additions have been implemented within the ODT algorithm at the request of the tropical cyclone forecast centers utilizing the ODT. These improvements have added functionality to the algorithm, allowing for a greater degree of objectivity and/or more control over the operation of the ODT.

A fully-automated, objective center finding routine has been developed to remove the final subjective element within the ODT algorithm, the storm center location determination. The routine relies on interpolation of tropical cyclone forecast positions, a 10° log spiral approximation scheme, and a Laplacian analysis scheme to automatically determine the storm center location. Comparisons with user selected storm center intensity estimate statistics are presented in Table 1 as ODT(Auto). A slight increase in bias and RMS error of the intensity estimates are noted over the user selected values for the same data set, however the

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results are still comparable to TAC subjective estimate statistics for the dependent data set.

The second major addition allows the user to change the ODT automatic scene identification result if it is felt it has misidentified the scene type. The addition of this functionality introduces a further subjective element to the ODT analysis, however if the operator is experienced with the ODT and the Dvorak Analysis schemes, statistical improvement can be achieved. Table 3 demonstrates the impact observed at the Satellite Analysis Branch of NOAA/NESDIS (SAB), between the 1998 and 1999 Atlantic hurricane seasons. The scene type override was implemented approximately 10% of the time in 1999 for the storms in this case study, with scene type modifications focusing on the embedded center and eye categories.

Year	No Difference	Within 1/2 T-No.	Matches
1998	19.4	75.6	160
1999	35.6	82.8	163

Table 3. Comparison between Synoptic Analysis Branch of NOAA/NESDIS ODT intensity estimates versus aircraft reconnaissance intensity values (pressure values converted from hPa to T-No.) for selected 1998 and 1999 Atlantic TC events. Values are given in percentages.

5. SUMMARY AND FUTURE DIRECTIONS

Numerous tropical cyclone forecasting centers have utilized the ODT operationally or experimentally since 1998. Operational users include the SAB, the NOAA Tropical Prediction Center/National Hurricane Center (TPC/NHC) in Miami, FL, the Joint Typhoon Warning Center (JTWC) at Pearl Harbor, HI, the Australian Bureau of Meteorology (Brisbane)-Severe Weather Section, and the Western Australian Regional Forecasting Center (Perth).

The original ODT algorithm was developed within the McIDAS architecture, however the code has recently been modified to allow for easier transition to site-specific satellite display and analysis systems. The JTWC is currently using this version operationally, while the Air Force Weather Agency (AFWA) at Offutt AFB, and will utilize this code in an experimental mode during the 2001 tropical cyclone season. A version has also been provided to NOAA for transition into AWIPS via TPC/NHC. An X-Windows based version of the ODT is currently being developed for other interested users. This version will be self-contained, requiring no existing satellite navigation/ calibration libraries or image display platforms, but use of the algorithm will require conversion of satellite imagery into McIDAS format.

Continued feedback from the tropical cyclone forecasting sites utilizing the ODT will be necessary to further tune the algorithm, especially in tropical cyclone basins outside of the North Atlantic Ocean and Caribbean Sea. The ODT was developed and tuned based primarily on Atlantic basin aircraft/ reconnaissance data. Tuning of the ODT for other regions will rely primarily on the significant experience of the tropical cyclone forecasters within these regions to help identify the strengths and weaknesses of the ODT.

Future research regarding the ODT will focus on the utilization of additional satellite information from geostationary and polar orbiting satellites, as well as the addition of new numerical techniques to analyze the current and future satellite data available. The use of a deep convection parameter (Velden and Olander, 1998), involving the differencing of collocated IRW and WV pixel values, has shown promise for the GOES geostationary satellites. The use of visible and other IR channels will also be explored for the GOES satellites. Microwave data from polar orbiting satellites will also be investigated, focusing on the analysis of convection patterns and the thermal structure of the tropical cyclones using SSM/I and AMSU instruments, respectively. Experimental quantitative analysis of the storm structure will be conducted using both geostationary and polar orbiting satellite data, focusing on the symmetry and extent of the convective regions as well as the structure of the eye/storm center region. Principle component analysis, empirical orthogonal functions, and/or neural networks will be explored.

6. ACKNOWLEDGMENTS

This study was coordinated with Jeff Hawkins of the satellite meteorology applications section of NRL-MRY. Funding through Space and Naval Warfare Systems Commands (PMW-185) under PE 0603207N.

7. REFERENCES

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