P1.19 THE ADVANCED OBJECTIVE DVORAK TECHNIQUE (AODT): LATEST UPGRADES AND FUTURE DIRECTIONS

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1. INTRODUCTION

The development of an advanced version of the Objective Dvorak Technique (ODT) continues at the University of Wisconsin-Madison/Cooperative Institute for Meteorological Satellite Studies (UW-CIMSS). This algorithm, the Advanced Objective Dvorak Technique (AODT), estimates tropical cyclone (TC) intensity from geostationary satellite IR imagery and builds upon the basic functionality and guidelines of the original ODT (Velden et. al., 1998). The first phase in the development of the AODT focused on expanding the range of applicability in order to provide TC intensity estimates over the entire lifecycle of storms. By employing computer-based techniques that approximate the quasi-subjective methods outlined in the original Dvorak Technique (DT, Dvorak 1984), the AODT performs with accuracy on par with subjective DT estimates obtained at various TC operational forecasting centers (OFC).

Recent additions to the AODT, such as improved scene identification, new DT rule handling, a latitude-dependent bias adjustment, and automated TC center determination, have resulted in more accurate results. Further improvement in the accuracy of the AODT intensity estimates is anticipated when other multispectral information is introduced and integrated into the algorithm (Velden et al., this volume).

2. RECENT IMPROVEMENTS

The latest version of the AODT includes a number of important upgrades. First, a new and improved “curved band” analysis technique has been implemented to better handle weaker storms. This method equates TC cloud patterns and banding curvature to intensity. The amount of cloud curvature is measured objectively using a 10° log-spiral analysis centered at a selected storm center location. Obviously, proper storm center location selection is very important to an accurate intensity estimate determination using this methodology. However, storm center location selection can be very subjective, especially in TC developmental stages. Therefore, the scheme also computes values from points surrounding the center in case the TC initial position is inaccurate. The maximum value found can then output along with the value at the expected TC center. The analyst then has this added piece of information to help deduce the TC position and intensity.

One of the remaining issues with prior versions of the AODT had to do with the necessity for an analyst to position a cursor over an image at the TC center location in order to activate the AODT analysis. To alleviate this, an automated TC center-determination scheme has been developed and implemented. It utilizes time-interpolated OFC short-term track forecasts as a first guess of the storm center location. It then employs a Laplacian Analysis scheme to search for sharp, spatially concentrated gradients in the IR brightness temperature fields to identify possible eye locations. More sophisticated methods are being developed (Wimmers and Velden, this volume)

The final major upgrade to the algorithm involves the inclusion of a bias adjustment to the AODT estimate of MSLP based upon storm latitude position (Kossin and Velden, 2004). This adjustment is in the form of a linear regression-based equation derived from a large set of homogeneous AODT and reconnaissance aircraft MSLP measurements. An incremental increase/decrease is applied to the AODT MSLP estimate when the storm is equatorward/poleward of approximately 23° latitude. The physical explanation for this adjustment is based upon the dependence of tropopause (and IR-measured cloud top) temperature and latitude. The adjustment is applied in all TC basins except the North Indian Ocean, where the decrease in tropopause height with increasing latitude is not as dramatic. The implementation of this adjustment has resulted in a statistical error reduction of approximately 10% in the AODT intensity estimates of MSLP. The adjustment was not found to apply to the maximum winds associated with the Dvorak T-number conversion table.

Other additional minor (but noteworthy) improvements to the AODT have been implemented. For example, the DT Rule 8 has been added to help reduce any unrealistic intensity estimate fluctuations by limiting the growth or decay rate of the estimates over set time periods (and from image to image). This addition has led to the reduction of the period over which the time-weighted averaged intensity estimate is calculated (from 12 hours to 6 hours). Statistical analysis has shown that the use of a 6-hour time-weighted average period now produces slightly more accurate results.

3. PERFORMANCE ANALYSIS

The latest version of the AODT with the above upgrades was subjected to a statistical analysis to assess performance. A large, homogeneous sample

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of 1630 cases with AODT and OFC DT intensity estimates matched in location/time with aircraft reconnaissance (ACR) measurements of MSLP. The homogeneous data set includes all AODT intensity estimates that are within one hour of an ACR measurement and 30 minutes from a DT intensity estimate from any one of three OFCs; the Tropical Analysis Forecast Branch (TAFB) at the Tropical Prediction Center (TPC) in Miami, FL, the Satellite Analysis Branch (SAB) of NOAA/NESDIS in Washington, DC, and the Air Force Weather Agency (AFWA) at Offutt AFB, Omaha, NE. The sample includes a total of 29 Atlantic Ocean TCs from the period 1995-2003, and is comprised of a wide variety of storm intensities and evolutions. As shown in Table 1, statistically, the AODT estimates obtained using either manually (man) or automatically (auto) determined storm center locations are on par or slightly better than those obtained by the OFC. The more positive bias associated with the auto-AODT estimates indicates a general underestimation in intensity as compared to the collocated ACR measurements. Underestimates of intensity typically arise from a failure to resolve the proper storm center location (i.e. eye not resolved by auto methods), resulting in an incorrect scene type identification and corresponding intensity estimate. This is the motivation for developing new, more sophisticated auto-center location methods such as those mentioned above. The user also has the option within the AODT to reanalyze any image(s) where a possible misanalysis may have occurred and override the storm location and/or scene type manually.

units in hPa	**Bias**	**RMSE**	**Abs.Err.**
AODT (man)	0.09	9.50	7.48
AODT (auto)	1.70	10.04	7.60
OFC	0.22	10.65	8.09

Table1: Performance of the latest version of the AODT. Sample includes 1630 AODT and OFC TC intensity estimate (MSLP) matches (homogeneous) validated against coincident aircraft reconnaissance MSLP measurements during 1995-2003 Atlantic TC seasons. AODT manual (man) and automated (auto) storm center determination methodologies are presented for comparison.

It should be noted that the AODT results in Table 1 do include the regression-based, latitude-bias adjustment, while the OFC estimates were not adjusted (currently not yet part of the operational procedure). If the same latitude bias adjustment is applied to the OFC estimates, the RMS error is reduced by about 10%.

4. FUTURE DIRECTIONS

The latest version of the AODT has been benchmarked, and is being implemented into several OFCs including TPC, SAB, AFWA and the Joint Typhoon Warning Center. It is also being tested in other TC basins around the globe. We feel that further gains in AODT performance will likely have to rely on the integration of information from other satellite platforms and spectral channels.

Beyond this, the development of an “integrated algorithm” designed to utilize a wide variety of currently available satellite information has begun at CIMSS (Velden et. al., this volume). The ultimate goal is to produce a unified, satellite-based algorithm combining the strengths of each component sensor and technique into a more powerful TC intensity analysis tool.

5. ACKNOWLEDGMENTS

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