

**AODT – Advanced Objective Dvorak Technique**  
**USERS' GUIDE**  
**(X-Window Version 6.3)**

Prepared by

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on behalf of

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# AODT – Advanced Objective Dvorak Technique

## X Window System Version Users’ Guide

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## 1.) Description of the AODT Algorithm

The Advanced Objective Dvorak Technique (AODT) algorithm is a computer based technique, developed at the University of Wisconsin-Madison/Cooperative Institute for Meteorological Satellite Studies (UW/CIMSS), to objectively determine tropical cyclone intensity using geostationary satellite infrared imagery. The AODT can be used to classify storm intensity beginning from storm formation through development and dissipation. Previous versions of the ODT could only classify intensities once the storm being examined reached hurricane strength or greater (T# 3.5 or approximately 994/984mb in the Atlantic/Western Pacific).

The AODT is patterned after the Subjective Dvorak Enhanced Infrared 'EIR' Technique (SD) (Dvorak, 1975, 1984) which made use of various pattern identification schemes and rules to determine tropical cyclone intensity. The AODT has been developed to closely mimic the SD methodology in terms of intensity determination protocol and the incorporation of various rules and analysis methods.

The AODT was originally derived from previous objective satellite estimation algorithms developed at the University of Wisconsin/Space Science and Engineering Center and Colorado State University/Cooperative Institute for Research Applications. Significant modifications and additions have been made to the AODT, resulting in an algorithm that bears little if any resemblance to its forerunners in terms of methodology, functionality, and content. The primary modifications from previous digital Dvorak methods include the addition of a history file (containing previous intensity estimates obtained during a storm lifecycle), utilization of a time-weighted averaging scheme, new definitions and determinations of various environmental temperature values, and the use of various SD rules governing the variability of the intensity estimate values. These changes have led to more stable and statistically sound estimates of intensity.

For greater detail about the development process and statistical accuracy obtained with the current and previous ODT/AODT algorithm, please refer to Velden et al. (1998) and Olander et. al. (2002).

The X Window System version of the AODT (X-AODT) was developed to provide a user interface for the AODT algorithm only for those users who are unable to purchase McIDAS or access McIDAS image data. The X-AODT version will operate in the same manner as the McIDAS-based version of the AODT, but certain functionality will be lost due to limitations of the software/GUI interface. The ability to run the X-AODT outside of the GUI interface, primarily for use within scripts and system command schedulers, has been implemented, but certain functions will not be available as compared to the McIDAS-based version of the AODT. We strongly recommend obtaining McIDAS to make full use of the AODT algorithm and its functions.

## 2.) System Hardware and Software Requirements

The AODT was originally developed within the Man computer Interactive Data Access System (McIDAS) architecture. The algorithm utilizes McIDAS library functions and routines to ingest infrared satellite data, display textual and graphical results, read various input data files, and write various output files. The X-AODT GUI displays was developed using the X Window System, including Xt Intrinsic and the Motif user interface toolkit library. The most recent development within the LINUX architecture utilized X11R6.

Use of the GCC C-compiler is recommended, however the system C-compiler can be used if the *Makefile* files in the **navcal** directories are modified properly.

### 3.) X-AODT Acquisition and Installation

The current version of the X-AODT algorithm can be obtained via the UW-CIMSS AODT web page, along with the specific X-AODT Users' Guide. All files required for installation of the X-AODT are contained within a single compressed UNIX tar file. The X-AODT can be obtained from the following URL address:

**<http://cimss.ssec.wisc.edu/tropic/aodt/aodt.html>**

Once the X-AODT tar file has been downloaded, it can be uncompressed and unpacked using the following command:

```
gunzip XAODT-v6.3.tar.gz  
tar -xvf XAODT-v6.3.tar
```

The created **xaodt-v6.3** directory will contain the following files and directories:

- NOTES : X-AODT notes and instructions
- odt.c odtauto.c odtdata.c odftff.c odthistory.c odtintensity.c odtmcidas.c  
odtmcinput.c odtoutput.c odtsct.c odtssst.c : AODT C programs
- odtgui.c : X-AODT GUI interface programs
- odtnogui.c : X-AODT non-GUI interface programs
- odt.h,odtsst.h : X-AODT include files
- TOPOLRES : Low resolution topography file
- OUTLHRES : High-resolution world coastal outlines map file
- xaodt-compile : X-AODT compile script
- bin/ : directory containing binary files created during compilation
- enhancements/ : directory containing various image enhancements
- forecasts/ : directory containing auto-mode forecast files (suggested)
- history/ : directory containing output history files (suggested)
- lib/ : directory containing library files
- msat2area/ : directory containing image format conversion routine
- navcal/ : directory containing navigation/calibration files and F2C files
- pixmaps/ : directory containing various X-AODT GUI pixmap files
- resfile/ : directory containing X Window System application resource file
- sst/ : directory containing sea surface temperature files (suggested)
- samples/ : directory containing sample forecast files

The X-AODT algorithm can be compiled using the following syntax:

```
xaodt-compile <gcc/cc>  
<gcc/cc> - designates use of the system C-compiler (CC) or the GNU C  
compiler. GCC is recommended.
```

## 4.) Using the X-AODT

Prior to using the X-AODT for the first time, two files will need to be modified in order to properly define specific directory locations for various X-AODT inputs and parameters. The file *aodtenv* controls various UNIX environment variable definitions that identify the locations of specific directories containing various input and output datasets. Specifics on this file are explained below in Section 4A. The file *aodtdefs* in the **resfile** directory contains parameters controlling the layout and appearance of the X-AODT graphical user interface (GUI) within the X Window System. The specific modifications for this file are described in Section 4B below.

### A) UNIX Environment Variables

In order to provide more control regarding various X-AODT input/output file and directory definitions, the X-AODT utilizes UNIX environment variables to define specific variables used within the X-AODT algorithm. This provides the user greater ability to personalize the X-AODT to the local machine on which it is operating.

Eight environment variables are defined within the *aodtenv* file:

<u>Variable</u>	<u>Description</u>
ODTTOPO	Directory containing TOPOLRES topography file
ODTENH	Directory containing image enhancement files
ODTHISTORY	Directory for AODT history files storage
ODTDATA	Directory for satellite imagery data
ODTAUTO	Directory for forecast files for AODT auto-mode
ODTOUTPUT	Directory for LIST output
ODTSST	Directory for the external SST input file
XAPPLRESDIR	Directory for X Window application resource file

The first seven variable names are specific to the X-AODT, and will default to the \$HOME UNIX environment variable if not explicitly defined within the *aodtenv* file. The last variable is specific to the X Window System, and is explained further within the UNIX “X” manual page (“man X”). This variable is the full directory name where the X-AODT *aodtdefs* X Window application resource file is located (Section 4B).

To install these variables within the UNIX environment, use the following command on the UNIX command line:

```
. aodtenv
```

Once entered in the UNIX environment, the X-AODT session will utilize the eight AODT environment variables. The UNIX “env” command can be used to confirm the values assigned to each of the variables.

## B.) Application Resource File

The X-AODT X Window System application resource file *aodtdefs* is located in the **resfile** directory and contains all formatting information specific to the X-AODT GUI. *This file should not be modified under any circumstance except in the manner outlined in this section.* These modifications will explicitly define the directory location containing the pixmap files used by the X-AODT GUI. Unfortunately, use of additional methods to define this directory, such as a UNIX environment variable, were not readily available at the time of the X-AODT distribution, so direct modification of this file is needed until the proper method is learned and incorporated.

There are five entries within the *aodtdefs* file defining the directory and name of the pixmap files used by the X-AODT GUI. These files are located in the **pixmap** directory within the main **xaodt-v6.3** directory. The five specific entries to be modified have a form similar to the following (and can be searched for with the word “Pixmap”):

```
*position*<parameter>* labelPixmap: pixmaps/<file>.xpm
```

The <parameter> and <file> variables will differ between the five different entries. The full pathname should be inserted just prior to the “pixmaps/<file>.xpm” parameter. For example, if the **xaodt-v6.3** directory is located in the **/home/user/programs** directory, the following modification would be added to each line:

```
*position*<parameter>*labelPixmap: /home/user/programs/xaodt-v6.3/pixmaps/<file>.xpm
```

By inserting the full pathname for the pixmap files, the X-AODT can be executed from any directory, instead of only from the **xaodt-v6.3** directory, and the five pixmap files will be properly located and loaded when the X-AODT is executed.

### C.) Utilizing the X-AODT GUI

Once the specific X-AODT UNIX environment variables have been installed (Section 4A) and the *aodtdefs* application resource file has been properly modified (Section 4B), the X-AODT can be started with the command “**aodt**”. The main X-AODT GUI will appear as in Figure 1.

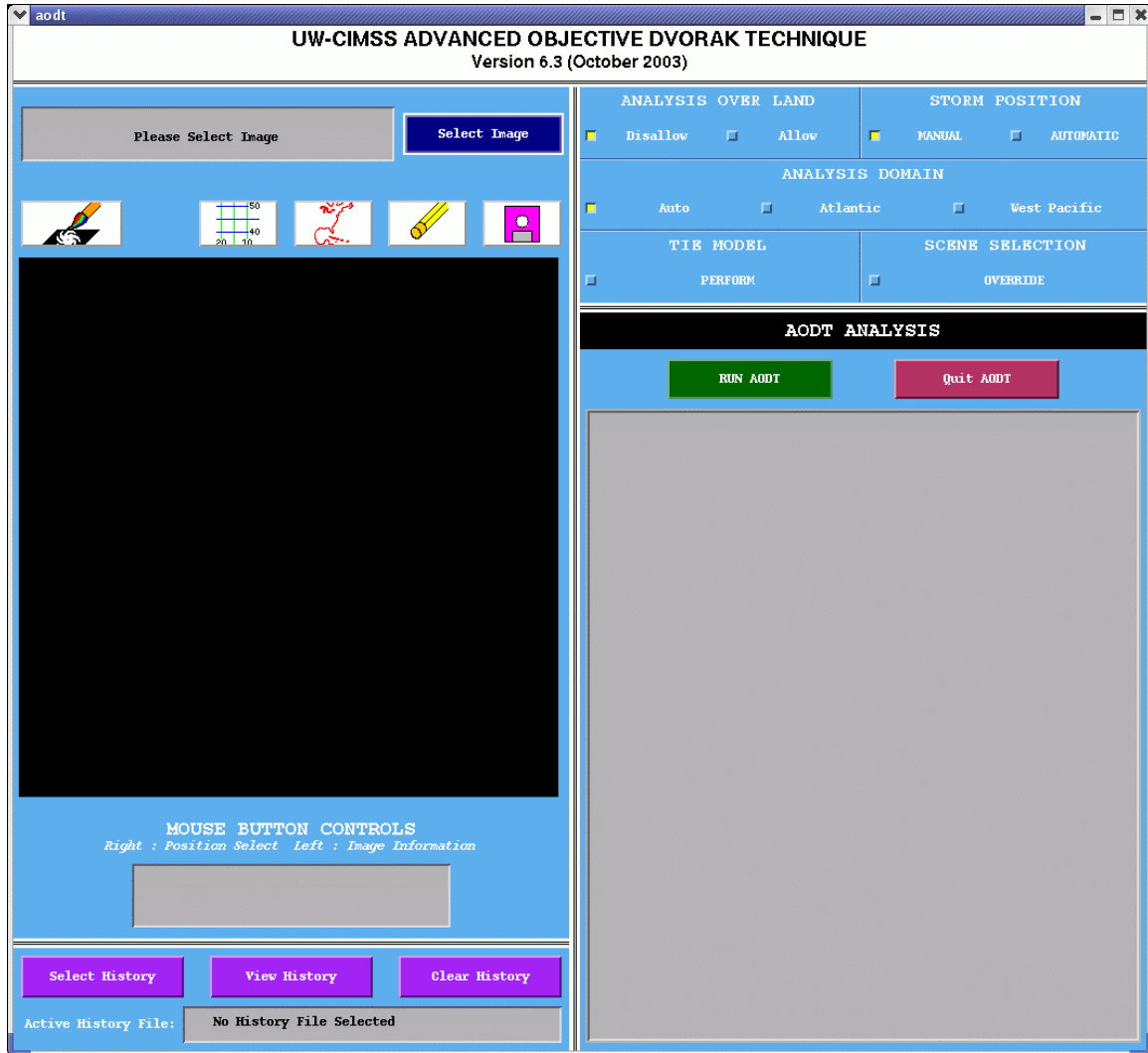


Figure 1: Initial X-AODT GUI appearance.

The main X-AODT GUI consists of four main “regions” below the title box at the top of the GUI (which displays the current version of the X-AODT). The upper left region is the Image Display and Analysis (IDA) region, which contains the image acquisition button, information region, image display area, and various image manipulation buttons, including image enhancements, map displays, and pixmap file output. The lower left region is the History File Control (HFC) region. This region contains various buttons controlling the selection and display of an AODT history file. The upper right region is the Analysis Control (AC) region, which contains various



toggle switches allowing the user to control various aspects of the AODT intensity estimate derivation algorithm, including automated storm center determination, TIE Model output, and scene override controls. Finally, the lower right section is the Analysis Output (AO) region, which contains two buttons and the text output window. Each region is described in greater detail in the four sections below.

### 1.) Image Display and Analysis (IDA) Region

The IDA region controls various aspects regarding the display and manipulation of the image to be analyzed by the AODT. The image is selected with the blue “Select Image” button. When this button is pressed, a popup window similar to the example displayed in Figure 2 will be displayed.

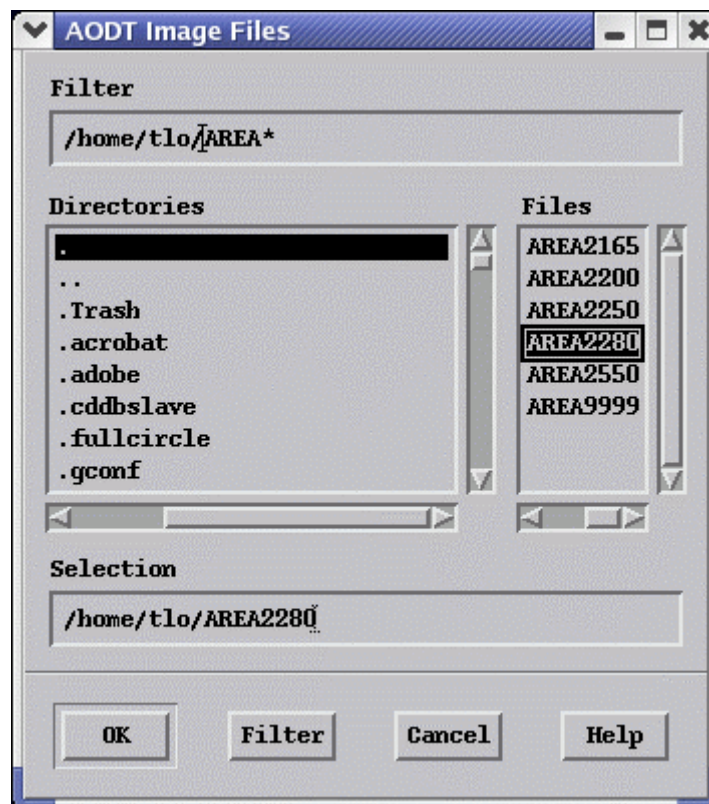


Figure 2: Sample Image Selection GUI popup window.

The file “Filter” will control the display of all image files in the “Files” list box. The filter has been fixed to display only image files with the “AREA” prefix, which is the McIDAS image prefix nomenclature. A four-digit number from 0000 to 9999 then follows the “AREA” prefix. The “Directories” box will default to the \$ODTDATA UNIX environment variable as defined in the *aodtenv* file discussed in Section 4A. The “Selection” box will list the full path name of the file selected (in this case, file “AREA2280” has been selected in the “home/tlo” directory).

Once the image has been selected, the popup window displayed in Figure 3 will be displayed. This window will prompt the user for the latitude and longitude center point location for the image as well as the line and element magnification factors. The magnification factors must be in whole numbers, and can be either positive or negative.

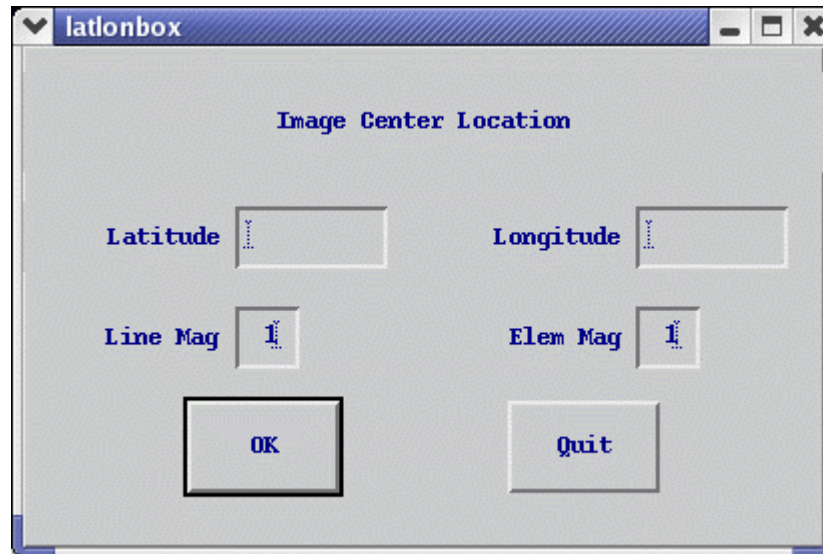


Figure 3: Image display control window.

Once the desired image center location and magnification have been entered, the image will be presented in the image display area in Figure 1, with information about the image, such as time, date, and resolution, provided in the image information region adjacent to the “Select Image” button. The image displayed will be in the native projection of the image, and will most likely be in “satellite projection”. At this time, the X-AODT does not allow for any remapping of the image into another projection, such as Mercator or Lambert Conformal. This option may be added in later X-AODT versions.

Five pushbuttons are located just above the image display area. From left to right the buttons are: Image Enhancements, Latitude/Longitude Lines, Map Display, Erase, and Pixmap Output. The Lat/Lon Lines button will display latitude and longitude lines on the image at a resolution derived by the routine. The Map Display button will display a high-resolution map of world coastal boundaries within the image display. User control of these two functions will be improved in later versions of the X-AODT. The Erase button will erase the map, Lat/Lon lines, and/or other annotations to the satellite image. The Pixmap Output will write a pixmap file of the contents of the image display area to the file “aodtdisplay.xpm”. The pixmap file can be useful for post-analysis of automated storm center location selection, for example.

The Image Enhancements button will display a popup window similar to Figure 2. The Filter will only list files with an “.ET” suffix. These files are located in the default enhancement directory defined by the \$ODTENH UNIX environment variable in the *aodtenv* file. This directory should be the enhancements directory within the **xaodt-v6.3** directory. Three enhancements are provided with the X-AODT : DEF.ET, BD.ET, and

NHC.ET. The BD.ET file is the standard Dvorak “BD” Hurricane Enhancement Curve, while the NHC.ET file is the colorized enhancement curve used at the Tropical Prediction Center/National Hurricane Center in Miami, FL. DEF.ET file is the default, “unenhanced” image display. Additional enhancement curves can be created and stored within this directory. The format of the enhancement files is:

```

Brightness  Blue      Green      Red
  min max    min max    min max    min max
  --- ---    --- ---    --- ---    --- ---
   lo  hi     lo  hi     lo  hi     lo  hi

```

- Brightness : Brightness temperature range <lo> <hi> (any value 0-255)
- Blue : Blue intensity value range <lo> <hi> (any value 0-255)
- Green : Green intensity value range <lo> <hi> (any value 0-255)
- Red : Red intensity value range <lo> <hi> (any value 0-255)

For example, the following line would produce the color “magenta” between the brightness temperature values 100 to 115:

```
100 115    255 255    0 0    255 255
```

The following example will produce a “rainbow” of colors from red and yellow between the brightness temperature values 120 to 180:

```
120 180    0 0    0 255    255 255
```

The final area within the IDA region allows the user to interrogate the displayed image with the mouse at the cursor location. If the right mouse button is pressed and held the location (latitude and longitude coordinates) at the cursor location will be displayed along with the temperature and brightness value.

## 2.) History File Control (HFC) Region

The HFC region of the X-AODT GUI controls the use of history files within the X-AODT GUI. Three pushbuttons allow the user to Select, View, or Clear the history file being used. When the Select History button is pressed, a popup window similar to the sample shown in Figure 2 will be displayed. The Filter allows only files with an “.ODT” suffix to be displayed. The Directories location will default to the \$ODTHISTORY UNIX environment variable, which will most likely be the **history** directory within the main **xaodt-v6.3** directory. Once a history file is selected, or a new history file is entered within the Selection region of the file selection popup window, the full name and path will be shown in the “Active History File” display area. If no active history file has been selected, the message “No History File Selected” will be displayed in this area.

Once a valid history file has been selected, the file will be used in all AODT analysis until it is cleared or another history file is selected. More information about the use of the history files during the AODT analysis is described in Section 4D.

The active history file can also be viewed in text and graphical mode by pressing the View History button. A popup window will be created to allow the user to specifically define the time and date boundaries over which they wish to investigate. A sample window is displayed in Figure 4.

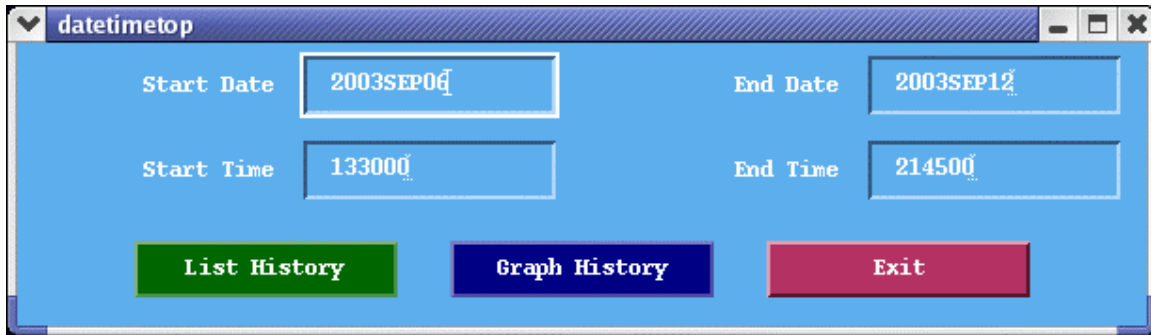


Figure 4: History file date/time boundary definition window.

By default, the first and last entries within the history file will be when the window is created, if available. The date and time values can be modified by the user if a smaller analysis timeframe is desired. Once the date and time values have been set, a text listing of the history file can be obtained by pressing the List History button. A sample History File List Window is provided in Figure 5.

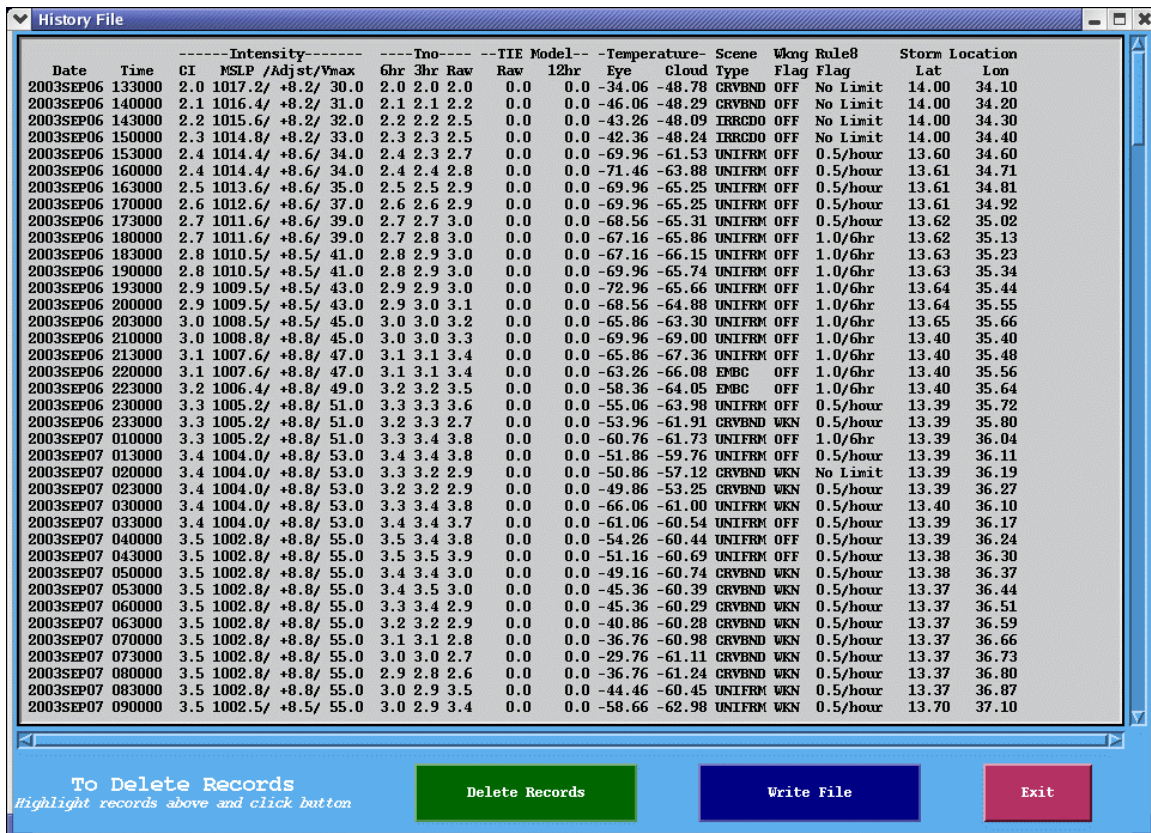


Figure 5: History File List Window.

An abbreviated listing of the history file contents is displayed within History File List Window. An example of the text listing is provided below for Hurricane Isabel:

Utilizing history file /home/aodtv6.3/history/ISABEL.ODT

Date	Time	CI	MSLP	Adjst/Vmax	6hr	3hr	Raw	TIE Model	Temperature	Scene	Wkng	Rule8	Storm Location		
									Eye	Cloud	Type	Flag	Lat	Lon	
2003SEP06	133000	2.0	1017.2/	+8.2/ 30.0	2.0	2.0	2.0	0.0	0.0	-34.06	-48.78	CRVBND OFF	No Limit	14.00	34.10
2003SEP06	140000	2.1	1016.4/	+8.2/ 31.0	2.1	2.1	2.2	0.0	0.0	-46.06	-48.29	CRVBND OFF	No Limit	14.00	34.20
2003SEP06	143000	2.2	1015.6/	+8.2/ 32.0	2.2	2.2	2.5	0.0	0.0	-43.26	-48.09	IRRCDO OFF	No Limit	14.00	34.30
2003SEP06	150000	2.3	1014.8/	+8.2/ 33.0	2.3	2.3	2.5	0.0	0.0	-42.36	-48.24	IRRCDO OFF	No Limit	14.00	34.40
2003SEP06	153000	2.4	1014.4/	+8.6/ 34.0	2.4	2.3	2.7	0.0	0.0	-69.96	-61.53	UNIFRM OFF	0.5/hour	13.60	34.60
2003SEP06	160000	2.4	1014.4/	+8.6/ 34.0	2.4	2.4	2.8	0.0	0.0	-71.46	-63.88	UNIFRM OFF	0.5/hour	13.61	34.71
2003SEP06	163000	2.5	1013.6/	+8.6/ 35.0	2.5	2.5	2.9	0.0	0.0	-69.96	-65.25	UNIFRM OFF	0.5/hour	13.61	34.81
2003SEP06	170000	2.6	1012.6/	+8.6/ 37.0	2.6	2.6	2.9	0.0	0.0	-69.96	-65.25	UNIFRM OFF	0.5/hour	13.61	34.92
2003SEP06	173000	2.7	1011.6/	+8.6/ 39.0	2.7	2.7	3.0	0.0	0.0	-68.56	-65.31	UNIFRM OFF	0.5/hour	13.62	35.02
<lines deleted from listing>															
2003SEP07	143000	3.7	999.7/	+8.5/ 59.0	3.7	3.7	4.0	0.0	0.0	-58.46	-58.88	UNIFRM OFF	1.0/6hr	13.69	37.91
2003SEP07	150000	3.7	999.0/	+7.8/ 59.0	3.7	3.7	4.0	0.0	0.0	-58.46	-63.06	UNIFRM OFF	1.0/6hr	14.50	37.70
2003SEP07	153000	3.8	997.5/	+7.8/ 61.0	3.8	3.7	4.1	978.0	983.2	-70.06	-64.70	UNIFRM OFF	1.0/6hr	14.54	37.78
2003SEP07	160000	3.8	996.9/	+7.1/ 61.0	3.8	3.9	4.1	970.8	982.7	-36.36	-65.60	EMBC OFF	1.0/6hr	15.24	38.19
2003SEP07	163000	3.9	996.1/	+7.7/ 63.0	3.9	3.9	4.3	975.4	982.3	-74.46	-67.50	UNIFRM OFF	0.5/hour	14.60	37.95
2003SEP07	170000	4.0	994.7/	+7.7/ 65.0	4.0	4.0	4.3	975.5	982.1	-74.46	-68.28	UNIFRM OFF	0.5/hour	14.64	38.03
2003SEP07	173000	4.0	993.8/	+6.8/ 65.0	4.0	4.1	4.4	965.5	981.4	-43.26	-67.41	EMBC OFF	0.5/hour	15.56	38.63
2003SEP07	180000	4.1	993.0/	+7.6/ 67.4	4.1	4.2	4.5	974.8	981.1	-71.46	-67.80	UNIFRM OFF	No Limit	14.71	38.19
2003SEP07	183000	4.2	991.4/	+7.6/ 69.8	4.2	4.3	4.4	976.3	980.8	-69.96	-65.67	UNIFRM OFF	1.0/6hr	14.74	38.28
2003SEP07	190000	4.2	991.3/	+7.5/ 69.8	4.2	4.3	4.5	977.4	980.5	-67.16	-63.97	UNIFRM OFF	No Limit	14.77	38.36
2003SEP07	201500	4.4	987.7/	+7.1/ 74.6	4.4	4.5	4.7	961.9	979.9	-13.66	-60.05	EYE/R OFF	1.0/6hr	15.24	39.04
2003SEP07	204500	4.4	987.7/	+7.1/ 74.6	4.3	4.4	3.9	961.4	979.0	-10.96	-61.52	CRVBND WKN	0.5/hour	15.32	39.10
2003SEP07	211500	4.4	987.5/	+7.0/ 74.6	4.2	4.2	3.9	957.6	977.8	-5.56	-63.80	CRVBND WKN	0.5/hour	15.44	39.21
2003SEP07	214500	4.4	987.5/	+6.9/ 74.6	4.3	4.3	4.8	953.5	976.2	-3.06	-64.25	EYE/R WKN	1.0/6hr	15.56	39.35
<lines deleted from listing>															
2003SEP08	161500	6.0	953.1/	+5.1/115.0	6.0	5.9	6.2	944.7	944.6	14.04	-66.46	EYE/C OFF	No Limit	17.53	42.87
2003SEP08	164500	6.0	953.1/	+5.1/115.0	6.0	6.0	6.1	944.8	944.6	15.54	-66.32	EYE/C OFF	No Limit	17.56	42.97
2003SEP08	171500	6.0	953.0/	+5.0/115.0	6.0	6.0	6.0	945.4	944.7	16.74	-64.83	EYE/C OFF	No Limit	17.62	43.01
2003SEP08	174500	6.0	953.0/	+5.0/115.0	6.0	6.0	6.0	945.7	944.7	16.74	-64.79	EYE/C ON	No Limit	17.65	43.12
2003SEP08	181500	6.0	952.9/	+4.9/115.0	6.0	6.0	6.0	945.9	944.9	15.94	-64.98	EYE/C ON	No Limit	17.76	43.12
2003SEP08	184500	6.0	952.8/	+4.8/115.0	6.0	6.0	6.1	945.8	944.9	15.94	-65.36	EYE/C ON	No Limit	17.81	43.18
2003SEP08	191500	6.0	952.8/	+4.8/115.0	6.0	6.0	6.0	945.4	945.0	15.94	-64.63	EYE/C ON	No Limit	17.86	43.26
2003SEP08	194500	6.0	952.8/	+4.8/115.0	6.0	6.0	6.0	944.2	945.0	14.74	-64.82	EYE/C ON	No Limit	17.85	43.36
2003SEP08	201500	6.0	952.8/	+4.8/115.0	6.0	6.0	6.0	943.7	945.0	14.34	-65.03	EYE/C ON	No Limit	17.88	43.44
2003SEP08	204500	6.0	952.7/	+4.7/115.0	6.0	6.0	6.1	945.1	944.9	14.34	-65.37	EYE/C ON	No Limit	18.01	43.50
2003SEP08	211500	6.0	952.6/	+4.6/115.0	6.0	6.0	6.0	946.6	944.7	15.84	-64.93	EYE/C ON	No Limit	18.14	43.60
2003SEP08	214500	6.0	952.6/	+4.6/115.0	6.0	6.0	6.1	941.8	944.6	15.44	-66.34	EYE/C ON	No Limit	18.12	43.63
<lines deleted from listing>															
2003SEP11	144500	6.7	931.0/	+1.6/132.2	6.7	6.7	6.9	936.1	941.1	18.84	-72.54	EYE/C ON	No Limit	21.44	54.45
2003SEP11	151500	6.7	931.1/	+1.7/132.2	6.7	6.7	6.9	936.1	939.8	19.64	-72.55	EYE/C ON	No Limit	21.37	54.52
2003SEP11	154500	6.8	928.3/	+1.7/134.8	6.8	6.7	7.0	935.8	939.6	19.04	-73.01	EYE/C ON	No Limit	21.37	54.61
2003SEP11	161500	6.8	928.3/	+1.7/134.8	6.8	6.8	6.9	935.2	939.0	19.54	-72.79	EYE/C ON	No Limit	21.40	54.70
2003SEP11	164500	6.8	928.2/	+1.7/134.8	6.8	6.8	7.0	935.1	938.8	18.54	-73.41	EYE/C ON	No Limit	21.43	54.74
2003SEP11	171500	6.8	928.3/	+1.7/134.8	6.8	6.9	7.0	935.3	938.6	19.54	-73.36	EYE/C ON	No Limit	21.42	54.81
2003SEP11	174500	6.9	925.4/	+1.6/137.4	6.9	6.9	7.1	935.1	938.5	19.14	-73.72	EYE/C ON	No Limit	21.44	54.89
2003SEP11	181500	6.9	925.4/	+1.6/137.4	6.9	6.9	7.0	935.0	938.1	18.94	-73.41	EYE/C ON	No Limit	21.46	54.97
2003SEP11	184500	6.9	925.5/	+1.7/137.4	6.9	7.0	7.0	935.4	938.0	18.94	-73.58	EYE/C ON	No Limit	21.43	54.99
2003SEP11	191500	6.9	925.5/	+1.7/137.4	6.9	7.0	7.0	935.0	937.8	19.94	-73.57	EYE/C ON	No Limit	21.44	55.05
2003SEP11	194500	6.9	925.4/	+1.6/137.4	6.9	7.0	7.0	935.3	937.3	19.14	-73.38	EYE/C ON	No Limit	21.46	55.11
2003SEP11	201500	7.0	922.6/	+1.6/140.0	7.0	7.0	7.1	936.0	937.3	18.64	-73.64	EYE/C ON	No Limit	21.46	55.17
2003SEP11	204500	7.0	922.6/	+1.6/140.0	7.0	7.0	7.0	935.6	937.0	19.74	-73.32	EYE/C ON	No Limit	21.48	55.26
2003SEP11	211500	7.0	922.6/	+1.6/140.0	6.9	6.9	6.8	936.3	936.6	19.54	-72.12	EYE/C ON	No Limit	21.46	55.33
2003SEP11	214500	7.0	922.6/	+1.6/140.0	6.9	6.9	6.8	936.6	936.6	19.14	-72.19	EYE/C ON	No Limit	21.49	55.37
2003SEP11	221500	7.0	922.6/	+1.6/140.0	6.9	6.9	6.7	936.5	936.4	19.04	-71.73	EYE/C ON	No Limit	21.49	55.43
2003SEP11	224500	7.0	922.6/	+1.6/140.0	6.8	6.8	6.8	937.8	936.3	18.44	-71.85	EYE/C ON	No Limit	21.47	55.51
<lines deleted from listing>															
2003SEP13	004500	7.0	922.3/	+1.3/140.0	6.1	6.1	6.0	945.0	941.3	15.94	-64.34	EYE/C ON	No Limit	21.78	59.13
2003SEP13	011500	7.0	922.3/	+1.3/140.0	6.1	6.0	6.1	944.9	941.5	15.74	-65.24	EYE/C ON	No Limit	21.77	59.24
2003SEP13	014500	7.0	922.3/	+1.3/140.0	6.0	6.0	5.9	946.5	941.7	14.94	-63.96	EYE/C ON	No Limit	21.78	59.34
2003SEP13	021500	7.0	922.3/	+1.3/140.0	6.0	6.0	6.0	946.8	942.0	15.54	-64.40	EYE/C ON	No Limit	21.79	59.41
2003SEP13	024500	7.0	922.2/	+1.2/140.0	6.0	5.9	5.9	950.0	942.5	15.44	-63.03	EYE/C ON	No Limit	21.96	59.41
2003SEP13	031500	6.9	925.0/	+1.2/137.4	5.9	5.9	5.8	951.9	942.9	14.54	-62.98	EYE/C ON	No Limit	21.95	59.59
2003SEP13	034500	6.9	925.0/	+1.2/137.4	5.9	5.9	5.8	949.3	943.2	13.94	-62.64	EYE/C ON	No Limit	21.93	59.65
2003SEP13	061500	6.9	924.8/	+1.0/137.4	6.0	5.9	6.3	944.8	943.9	12.34	-68.36	EYE/C ON	No Limit	22.14	60.03
2003SEP13	064500	6.9	924.9/	+1.1/137.4	6.0	6.1	6.3	945.3	944.1	9.64	-67.68	EYE/C ON	No Limit	22.10	60.19
2003SEP13	071500	6.9	924.9/	+1.1/137.4	6.1	6.3	6.4	945.7	944.6	9.74	-69.90	EYE/C ON	No Limit	22.04	60.29
2003SEP13	081500	6.9	925.0/	+1.2/137.4	6.2	6.3	6.4	942.6	944.7	12.64	-69.97	EYE/C ON	No Limit	21.99	60.37
2003SEP13	084500	6.9	924.9/	+1.1/137.4	6.4	6.4	6.7	941.6	945.1	12.14	-71.48	EYE/C ON	No Limit	22.10	60.44
2003SEP13	091500	6.9	924.8/	+1.0/137.4	6.4	6.4	6.7	941.8	944.9	12.24	-71.42	EYE/C ON	No Limit	22.16	60.58
2003SEP13	094500	6.9	924.8/	+1.0/137.4	6.5	6.5	6.7	942.4	945.0	10.54	-71.46	EYE/C ON	No Limit	22.16	60.65
<lines deleted from listing>															
2003SEP18	124500	4.6	967.8/	-9.4/ 79.6	4.6	4.6	4.4	972.1	971.6	-3.56	-52.15	EYE/R ON	No Limit		

The text output displays time, date, intensities (CI# with corresponding pressure/wind value, Final T#s (both 6 and 3 hour averaged values), and Raw T#), eye and cloud region temperatures, scene type, and the Dvorak Rule 9 and Rule 8 flag values. If the storm center is located over a land feature at the time listed, "LAND" will be listed prior for the scene type. The storm location is listed in the final two columns. See various sections in Section 7 for information about many of the parameters.

The user has two options within the List Window. The contents of the display can be output to an ASCII format file by pressing the Write File button. A file output popup window will appear, similar to Figure 2, to allow the user to define the name and location of the output file. The default directory for the output is defined by the \$ODTOUTPUT UNIX environment variable in the *aodtenv* file.

History file entries can also be deleted within this window. If a range of history file record is to be deleted, the left mouse button should be pressed and held while the cursor is moved over the records to be removed. When the left button is released and the Delete Records button is pressed, the highlighted records, as shown in Figure 6, will be removed from the history file. All records after the last deleted record will be recalculated as necessary. The total number of records removed and modified will be displayed in the AO Region output window.

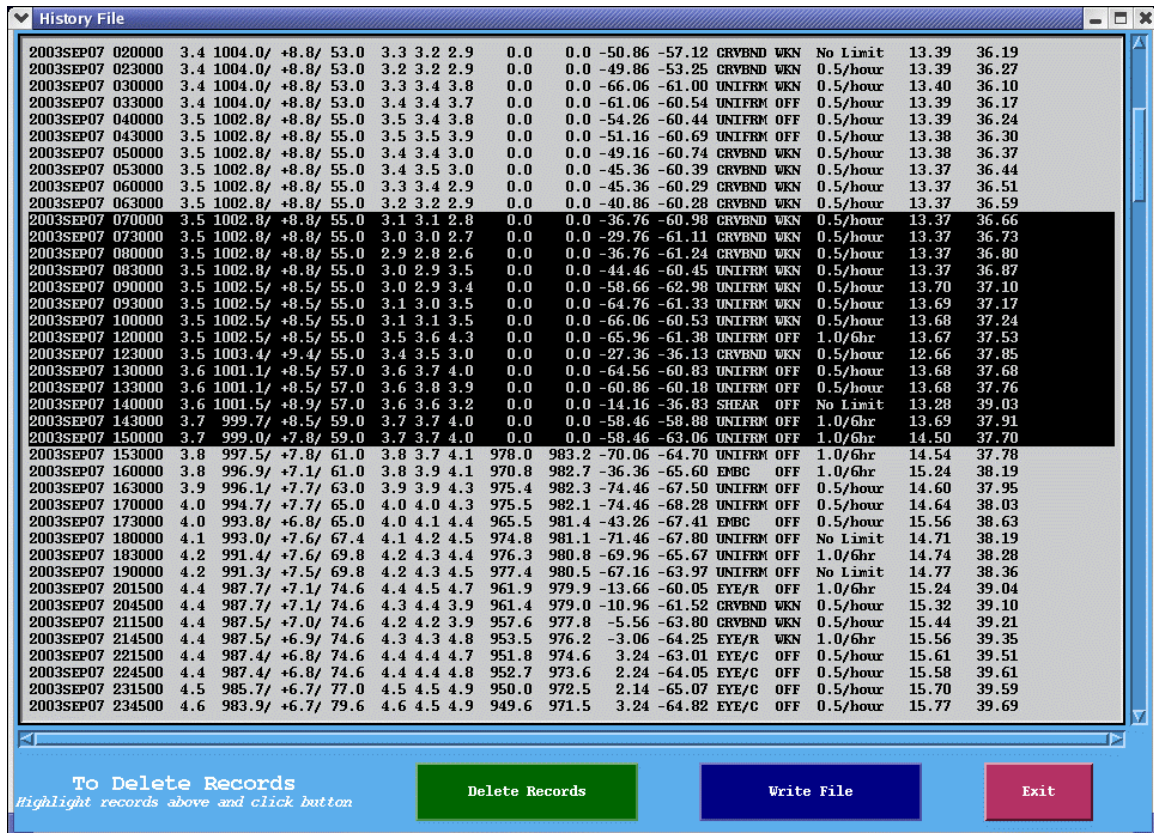


Figure 6: Highlighted records to be deleted in history file.

Pressing the Graph History button in the history file date/time boundary definition popup window in Figure 4 can create a graphical display of the history file. Once pressed, a window will appear showing various intensity parameters contained within the active history file being investigated. A sample graph for Hurricane Isabel is shown in Figure 7.



Figure 7: Graphical history file display window.

The graphical display window will initially show all available AODT intensity estimate parameters available within the history file. The Change Colors button allows the user to remove or change the color of any of the parameters displayed. The popup window presented in Figure 8 will be displayed. The first seven menu buttons are the various intensity estimate values available within the history file for the storm in question, while the final three menu buttons control the graph boundary color, graphic axis wording color, and the background color of the graph. Any intensity value can be removed by selecting “none” as the graphics color option for that parameter. The Set Colors button will exit the color selection window. An option to print the contents of the graphics screen to a pixmap file will be added to the next version of the X-AODT.

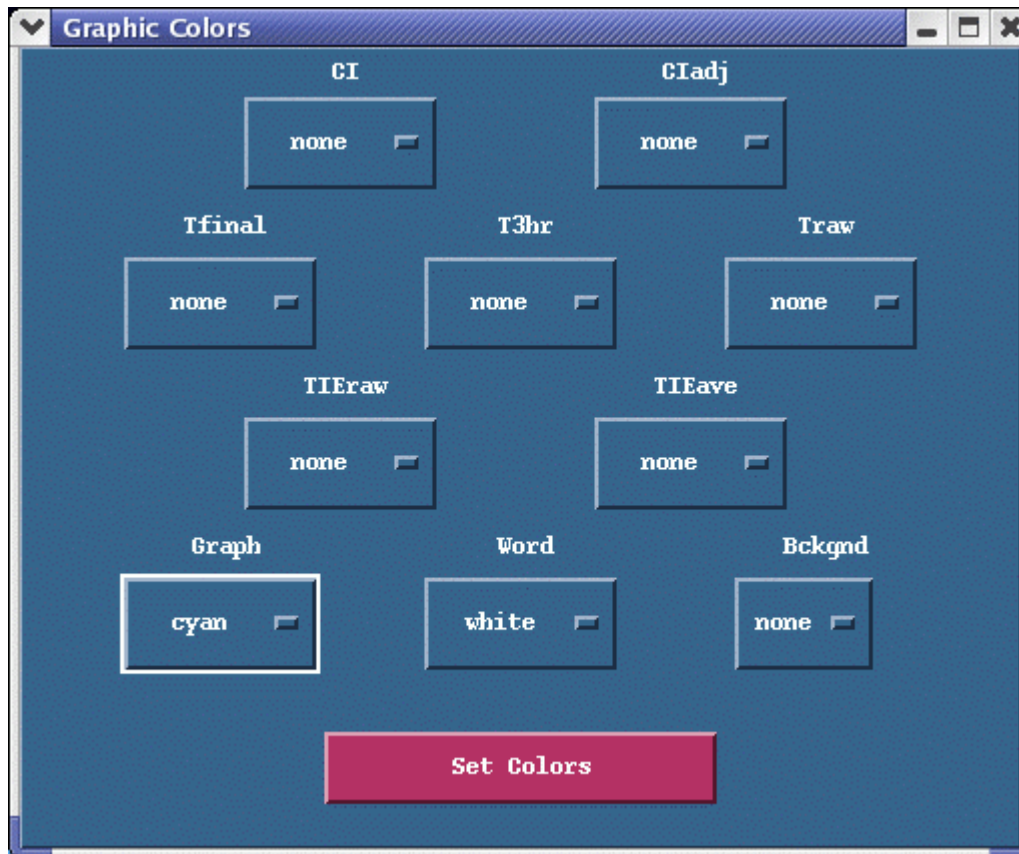


Figure 8: History file graphic color selection window.

### 3.) Analysis Control (AC) Region

Various aspects of the AODT algorithm can be controlled using the toggle buttons contained within the AC region of the X-AODT GUI. Five different selections control specific intensity analyses options of the AODT algorithm. Each option is discussed in greater detail below.

#### a.) Analysis Over Land

Two options are presented to allow or disallow AODT intensity estimates to be calculated over land regions. The default condition will be to disallow intensity estimations over land. If the user selects the Allow option, AODT intensity estimates will be provided for the image being investigated if the manually or automatically selected storm center is located over a land region. See Section 4C4c for more information on how the AODT handles the land interaction during the execution of the AODT algorithm and Section 7A for more information about the definition of a land region within the AODT topography file.



b.) Storm Position

Two options are displayed to allow for manual or automated selection of the storm center for the AODT analysis. Manual positioning is the default selection, which requires the user to select the storm center location within the image display window prior to execution of the AODT program. A manual storm center location is selected by pressing the left mouse button when the cursor is positioned at the user defined storm center location within the image display area of the IDA region. A red dot will appear in the image display area at the selected storm center position. The coordinates of the manually selected storm position will also appear in the output window of the AO region.

If the Automatic option is selected when the AODT analysis is started, a popup window similar to Figure 2 will be displayed prompting the user to select a forecast file from which to interpolate a storm position. The Filter will only allow a display of files with a “.txt” suffix. The files are located in the directory defined by the \$ODTAUTO UNIX environment variable as set in the *aodtenv* file.

Once the forecast file is selected, the window shown in Figure 9 will appear prompting the user to define the format type of the forecast file selected. Specific information about the different forecast file format types can be found in Section 7H.

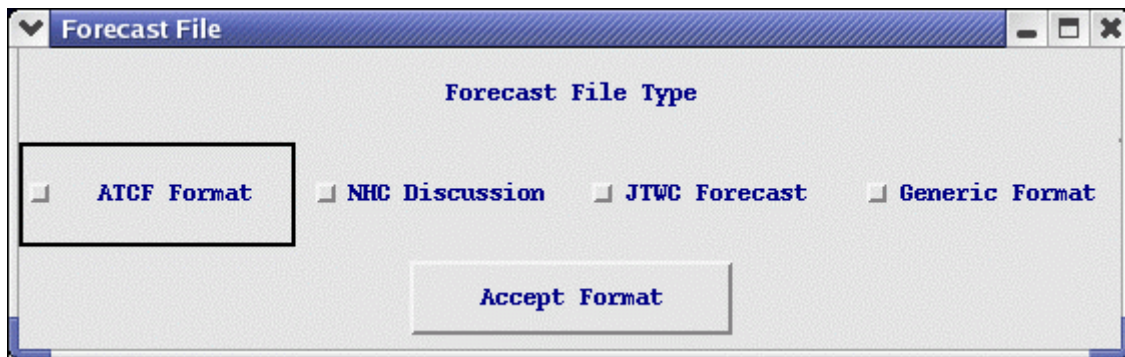


Figure 9: Forecast file format type selection window.

If the forecast file is valid, the AODT analysis will proceed. The interpolated forecast position will be displayed in the output window in the AO region (discussed in Section XX.D). In addition, a red dot will be plotted within the image display area at the interpolated forecast point along with a green dot locating the final storm center point determined by the AODT algorithm (see Sections 4C4d and 7H for more information on the automated storm center determination process). If the forecast is invalid, the user will be notified with an error message and the AODT analysis will be terminated

c.) Analysis Domain

Three options are displayed to allow the oceanic analysis domain to be automatically or manually selected for the AODT analysis. The Auto option is the default selection and will automatically determine the analysis domain as defined in Section 7G. If the user does not agree with the criteria the oceanic basin can be manually chosen with either the Atlantic or West Pacific buttons.

Please note that the criteria is not an actual selection of the ocean basin in which the storm resides, but instead it defines the correct ocean basin relationship between environmental intensity values, mean sea level pressure (MSLP), and T/CI# intensity values. A different intensity estimate may be produced for both analysis domain relationships since the cloud top temperature value will produce a different intensity estimate for certain scene types (eye scenes, CDO, and Embedded Center scenes). Also, the MSLP/T# relationships are different for the two analysis basins, as discussed in Section 7G.

d.) TIE Model

The TIE Model will not be executed unless the “Perform” button is activated prior to execution of the AODT. If activated, a popup window similar to Figure 2 will be displayed prompting the user to select a sea surface temperature (SST) file for the TIE Model analysis. The directory where the SST files are located in the popup window is named with the \$ODTSST UNIX environment variable defined in the *aodtenv* file (Section 4A). If the SST file is input correctly, the TIE Model intensity estimate will be displayed along with the AODT intensity estimate in the output window within the AO region of the X-AODT GUI. The format of the SST file is discussed in Section 7J.

e.) Scene Selection

The option to manually override the automated scene type classification determined by the AODT algorithm is achieved by selecting the Override option prior to starting the AODT analysis. If activated, the popup window in Figure 10 will present the automatically determined scene type along with the eleven different eye and cloud scene options the user can select from.

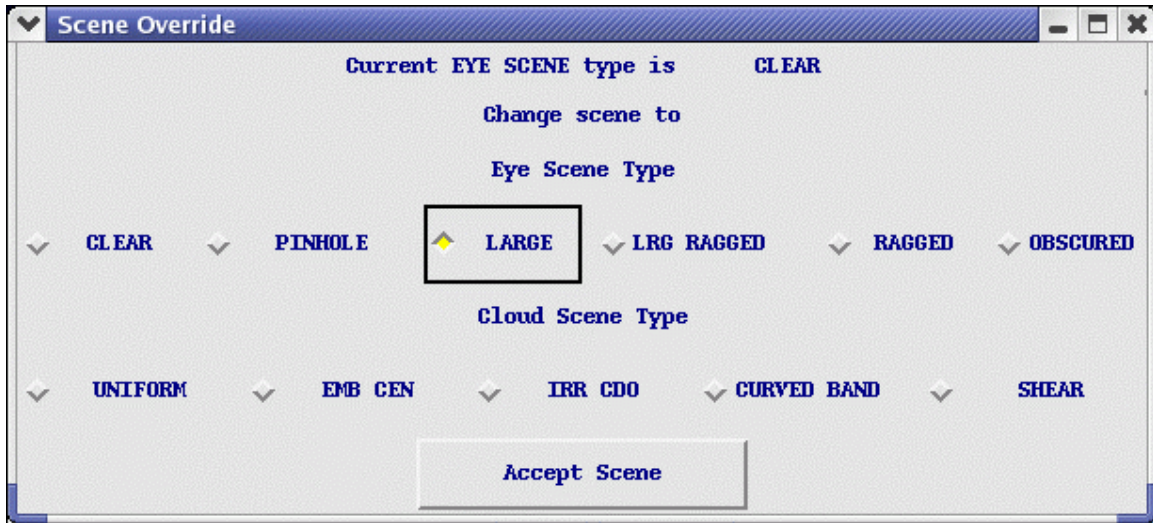


Figure 10: Manual scene change override window.

The current scene will be listed at the top of the window along with it being highlighted in the list of eleven scene types. If a different scene is selected, the new scene type button will be displayed once the Accept Scene button is pressed. The AODT intensity estimate analysis will then continue using the selected scene type and the intensity estimate will be displayed in the AO text output window.

#### 4.) Analysis Output (AO) Region

The Analysis Output (AO) window contains two buttons and the main text output display window. The “Run AODT” button initiates the AODT analysis of the image displayed in the IDA Region image display area, using any analysis control parameters defined in the AC region. The “Quit AODT” button will end the X-AODT GUI session.

During X-AODT operation, various text outputs will be displayed within the text output window, consisting of various runtime information and error messages and the final intensity estimate bulletin. Sample output messages are displayed in the two following sections.

a.) Full AODT Analysis

Full AODT analysis of an image requires the use of a history file and may use various combinations of parameters defined in the AC region. Below is sample output displayed in the AO output window during analysis of an image for Hurricane Floyd:

```
Utilizing history file /home/odt/xaodt-v6.3/history/FLOYD.ODT
Performing full AODT analysis
Utilizing image data file /home/odt/xaodt-v6.3/data/AREA2010
Using USER-SELECTED center position : LAT: 22.99 LON: 66.21
SST value of 18.6C at cursor location
Ocean basin automatically selected as ATLANTIC
Warmest pixel temperature of -0.1C at LAT: 23.99 LON: 66.21
ADDED RECORD TO END OF HISTORY FILE
WROTE 66 RECORDS TO HISTORY FILE /home/odt/xaodt-v6.3/history/FLOYD.ODT
*****
```

```
UW - CIMSS
ADVANCED OBJECTIVE DVORAK TECHNIQUE
AODT - Version 6.3
Tropical Cyclone Intensity Algorithm
```

```
----- Current Analysis -----
Date : 12 SEP 1999      Time : 124500 UTC
Lat  : 22:59:26 N      Lon  : 66:12:49 W
```

```
CI# /Pressure/ Vmax
6.5 / 934.8mb/127.0kt
```

Latitude bias adjustment to MSLP : -0.2mb

```
6hr-Avg T#      3hr-Avg T#      Raw T#
6.3              6.4              6.5
```

```
Eye Temp : -0.1C      Cloud Region Temp : -70.2C
Scene Type : CLEAR EYE
Ocean Basin : ATLANTIC
Flags : Rule 8 : NO LIMIT Weakening : OFF
```

-----

```
UW - CIMSS
TROPICAL CYCLONE INTENSITY ESTIMATE MODEL
TIE MODEL - Version 0.0A Beta
```

```
Sea Surface Temperature=18.6C
Current Pressure/Vmax : 920.0mb/140.4kt
12hr-Avg Pressure/Vmax : 923.8mb/137.4kt
```

```
*****
Successfully completed AODT analysis
```

The first section of the AODT output includes the runtime messages, which provide general information about the history file being used and various other parameters used in the derivation of the current intensity estimate. The history file utilized will be displayed first, and thus a full AODT analysis will be performed on the image. This will be indicated by the following message :

Performing full AODT analysis

The path and file name of the current image file being analyzed will be listed next. In this example the locally stored image file is named AREA2010.

The location of the storm center selected for the current intensity analysis will then be shown. The example above used a manually selected storm center location, indicated by the USER-SELECTED message containing the storm center coordinates. A discussion of an automatically selected storm center location will be provided in section 4D4. The ocean basin in which the storm is located will be displayed next. This value will either be ATLANTIC or PACIFIC, indicating the MSLP-T# relationship used for the output pressure value in the intensity bulletin and history file listing. The basin will automatically be determined unless manually overridden using the BASIN keyword. See Section 5G for more information on the ocean basin determination.

Once the intensity analysis has completed, the current analysis information will be written to the history file. In this example the current analysis was appended at the end of the history file, and was indicated by the message :

```
Added record to end of history file
```

The above message will appear most frequently since the AODT will usually be executed utilizing the latest available image for the storm being investigated. If analysis of a missed image or reanalysis of a previously examined image is performed, one of the following message groups will be displayed, respectively :

```
Overwrote record X in history file <history file>  
Modified X subsequent records in history file <history file>  
Wrote X record(s) to history file <history file>
```

or

```
Inserting record X in history file <history file>  
Modified X subsequent records in history file <history file>  
Wrote X record(s) to history file <history file>
```

When a record is overwritten or inserted into an existing history file, all records after the current analysis will be automatically recalculated, as needed, using the new records information.

Within the intensity estimate bulletin, all vital information relating to the current image analysis will be displayed. The date, time, and location are presented first, followed by the four intensity estimate values; the current Raw T#, Final T# (6-hour time-weighted average), Final T# (3-hour average), and CI#. The "Raw T#" value represents the current intensity of the storm, and is the value obtained after the Dvorak Rule 8 rules have been applied (see Section 7F). The "6hr-Avg T#" value is the 6-hour time-weighted averaged intensity of the storm. The time averaging scheme is explained

in greater detail in Section 5D. The “3hr-Avg T#” value is the average of the current and previous three hour analyses values. Finally, the “CI#” value represents the 6-hour time-weighted averaged value after various subjective Dvorak EIR rules governing its variability, Rule 8 and Rule 9 have been applied. For more details on these rules, see Sections 7E and 7F. Adjacent to the “CI#” value are the corresponding estimated mean sea level pressure (MSLP) and maximum wind (Vmax) values. These values are based upon specific relationships between T# and MSLP for different oceanic basins (see Section 7G)

The MSLP value displayed for the derived CI# intensity estimate has been modified by a latitude bias adjustment, which is a linear regression-based equation which adjusts the original CI# based upon the current storm latitude. The amount of the adjustment is listed under the CI#/MSLP/Vmax information in the intensity estimate bulletin. A positive/negative adjustment will increase/decrease the MSLP value obtained from the specific CI#/MSLP relationship for the scene being investigated. Please see Section 7K for more information on this adjustment.

The next section of the intensity estimate bulletin contains information about the scene being analyzed and various rule flag values affecting the current intensity estimate calculation. First, the eye and surrounding cloud region temperature values, described in Section 7C, are provided first. Beneath the eye temperature, the objectively determined scene type is listed. This classification can be manually defined by the user, if desired, using the OVER manual override keyword. Objective scene type determination is described in Section 7B. Next, the current oceanic basin is provided, and will be automatically determined unless explicitly defined by the user with the DOMAIN keyword, and is described in Section 7G. Finally, two Dvorak EIR Rule flag values are displayed. These flags, described in Sections 7E and 7F, notify the user whether these rules, which govern the determination of the Final T# and CI# values, have been applied during the current intensity estimation analysis.

The final section of the intensity estimate bulletin is the experimental Tropical Cyclone Intensity Estimate (TIE) Model output. An estimate will not appear if a valid sea surface temperature (SST) (Section 7K) cannot be obtained from an external data file. Also, the TIE Model estimate will not be displayed until the TIE Model estimate and AODT estimate difference is less than or equal to 0.5 T#. A message in the intensity estimate bulleting will be displayed indicating this condition has not been met. Once this condition has been met, all subsequent TIE Model estimates will be displayed within the intensity estimate bulletin and available for output with the LIST and GRAPH options. See the TIE Model Users’ Guide, available on the AODT homepage, for more specific information about the TIE Model.

b.) Abbreviated AODT Analysis

If a history file is not specified in the HFC region when utilizing the AODT, an abbreviated analysis will be performed. Much of the output will be the same, however a few modifications to the runtime messages and intensity bulletin will exist. First, the intensity bulletin will contain only one intensity estimate value. This estimate will be listed at the "CI#", representing the intensity estimate at the analysis time only. Second, the two "Rule Flags" values will not be listed since they are only utilized when a history file is present. A sample abbreviated output is presented below :

```
Performing abbreviated AODT analysis
Utilizing image data file /home/odt/xaodt-v6.3/data/AREA2010
Using USER-SELECTED center position : LAT: 22.99 LON: 66.21
SST value of 18.6C at cursor location
Ocean basin automatically selected as ATLANTIC
Warmest pixel temperature of -0.1C at LAT: 23.99 LON: 66.21
```

\*\*\*\*\*

```
                UW - CIMSS
      ADVANCED OBJECTIVE DVORAK TECHNIQUE
            AODT - Version 6.3
Tropical Cyclone Intensity Algorithm
```

```
      ----- Current Analysis -----
Date : 12 SEP 1999      Time : 124500 UTC
Lat  : 22:59:26 N      Lon  : 66:12:49 W
```

```
      CI# /Pressure/ Vmax
      6.5 / 934.8mb/127.0kt
```

```
Latitude bias adjustment to MSLP : -0.2mb
```

```
Eye Temp : -0.1C      Cloud Region Temp : -70.2C
Scene Type : CLEAR EYE
Ocean Basin : ATLANTIC
```

-----

```
                UW-CIMSS
TROPICAL CYCLONE INTENSITY ESTIMATE MODEL
      TIE MODEL - Version 0.0A Beta
```

```
      Sea Surface Temperature=18.6C
      Current Pressure/Vmax : 920.0mb/140.4kt
      12hr-Avg Pressure/Vmax : 923.8mb/137.4kt
```

\*\*\*\*\*

Successfully completed AODT analysis

c.) Land Interaction

If the storm center is over a land region (as defined in Section 7A), a warning will be presented in the runtime output and intensity bulletin. No intensity estimate will be calculated unless explicitly requested by the user with the LAND keyword. A sample output for a storm center over land is presented below :

```
Tropical cyclone is over land
*****
                UW - CIMSS
      ADVANCED OBJECTIVE DVORAK TECHNIQUE
            AODT - Version 6.3
Tropical Cyclone Intensity Algorithm

      ----- Current Analysis -----
Date : 12 SEP 1999      Time : 124500 UTC
Lat  : 22:56:18 N      Lon  : 66:02:56 W

      TROPICAL CYCLONE OVER LAND
      NO AODT ANALYSIS AVAILABLE
*****
```

d.) Automated Storm Center Determination

The AODT algorithm can be run in a completely automated mode, utilizing interpolated tropical cyclone forecasts and a Laplacian-based storm center determination routine to obtain a completely objective storm intensity estimate. See Section 7H for specific information on the formats allowed for the input forecast files.

The automated storm center location is determined using one of three techniques; polynomial interpolation of a forecast, Laplacian analysis of the current image, or linear extrapolation of previous history file positions. The polynomial interpolation scheme determines the current position of the storm using three positions (the current, 12 hour, and 24 hour forecast positions) from a TPC/NHC or JTWC forecast in conjunction with two previous positions from the history file (6 and 12 hour old positions), if available. If the forecast interpolation scheme fails, a linear extrapolation of the previous 12 hours of storm positions stored in the history is determined.

If either the interpolation or extrapolation methods are successful, a Laplacian analysis of the cloud top temperature field will be performed. This analysis scheme will search for large cloud top temperature gradients concentrated in small regions (e.g. eye regions). If the previous Final T# stored in the history file is greater or equal to 3.5, an examination of the Laplacian analysis will be performed to determine if the location chosen by this technique should be used. If this technique fails, but a definite “warm spot” location can be identified and is sufficiently close to the interpolated forecast position, the location of this feature will be utilized. For a more detailed discussion of the autolocation technique, please see Section 7H.



In the following examples, a TPC/NHC forecast was used in the polynomial interpolation scheme. The data points used in the polynomial interpolation scheme are displayed prior to the interpolated position. The Laplacian analysis is then performed using the interpolated position as the center point of the analysis region. Since an eye region was found, the Laplacian analysis position was used.

```
Accessing forecast file /home/xaodt-v6.3/forecasts/storm01-15.txt
CURRENT ANALYSIS TIME : 01/OCT/2000 0715UTC
      DATE      TIME      LAT      LON
T0 01/OCT/2000 0300UTC   18.10   87.10
T1 02/OCT/2000 1200UTC   18.30   87.40
T2 02/OCT/2000 0000UTC   19.00   87.50
FORECAST INTERPOLATION successful -- LAT: 18.16 LON: 87.27
Will utilize LAPLACIAN ANALYSIS position -- LAT: 17.96 LON: 87.28
```

If the polynomial interpolation scheme fails, and the linear extrapolation of the previous 12 hour storm center locations, stored within the history file, is used as the first guess for the Laplacian analysis.

```
Accessing forecast file /home/xaodt-v6.3/forecasts/storm01-15.txt
Error accessing forecast file /home/xaodt-v6.3/forecasts/storm01-15.txt
FORECAST INTERPOLATION failed
LINERAR EXTRAPOLATION successful - LAT: 18.09 LON: 87.22
Will utilize LAPLACIAN ANALYSIS position - LAT: 17.96 LON: 87.28
```

If both the polynomial interpolation and linear extrapolation schemes fail, the Laplacian analysis will not be performed and the AODT will quit and the user will be notified in the runtime message output section with the following message :

```
Error with autopositioning
Exiting AODT
```

A sample of what the X-AODT might look like after an automated AODT analysis has been successfully completed is shown in Figure 12.

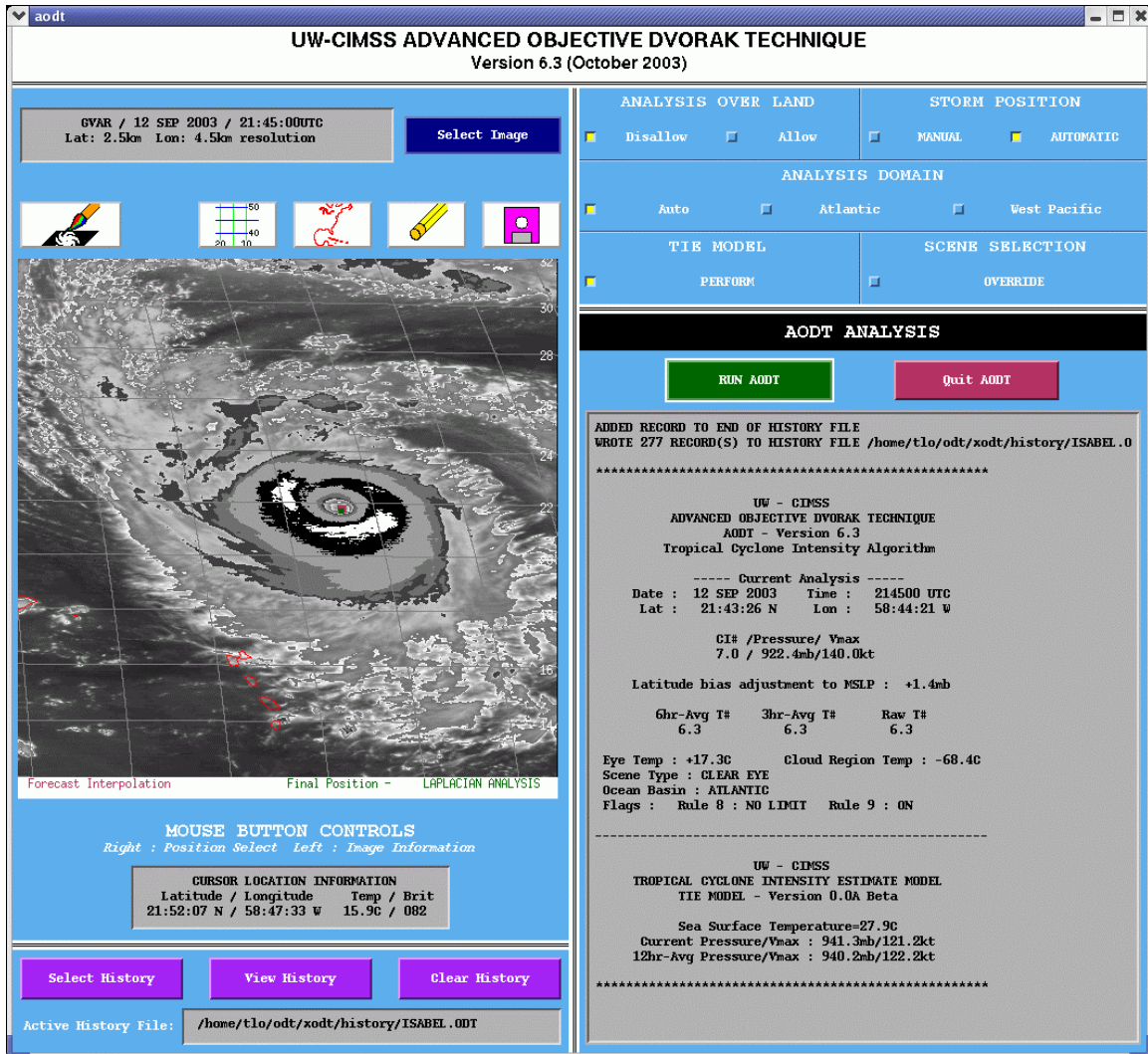


Figure 12: Sample X-AODT display at completion of automated AODT analysis.

## D.) History File

The AODT history file is an ASCII format file containing AODT intensity estimates, locations, and other specific information for each image analysis. The AODT algorithm utilizes records in the history file for the determination of the intensity estimate values as well as the application of various rules utilized within the intensity estimate routines. Each analysis stored in the history file will contain the following values :

Value 1	: date (YYYYMMDD format : YYYY=year, MM=month, DD=day)
Value 2	: time (hhmmss format)
Value 3	: Julian day and partial day
Value 4	: raw T# unadjusted
Value 5	: raw T# adjusted by Rule 8 rules
Value 6	: final T# value (6-hour time-weighted average)
Value 7	: final T# value (3-hour average)
Value 8	: final CI# value
Value 9	: eye region temperature (°C)
Value 10	: mean cloud region temperature (°C) – movable annulus
Value 11	: mean cloud region temperature (°C) – set region (old method)
Value 12	: “coldest-warmest” cloud region temperature (°C)
Value 13	: storm center latitude (+/- = North/South Hemisphere)
Value 14	: storm center longitude (+/- = West/East Hemisphere)
Value 15	: eye diameter or shear distance (in km)
Value 16	: eye region temperature standard deviation value
Value 17	: cloud region symmetry value
Value 18	: eye region scene type (original value)
Value 19	: cloud region scene type (original value)
Value 20	: eye region scene type (user override value)
Value 21	: cloud region scene type (user override value)
Value 22	: Dvorak Weakening flag
Value 23	: Dvorak Rule 8 flag
Value 24	: land/ocean flag
Value 25	: eye region FFT value
Value 26	: cloud region FFT value
Value 27	: curved band analysis – BD curve gray scale value
Value 28	: curved band analysis – convection curvature amount (out of 25)
Value 29	: distance from center to “coldest-warmest” temperature value
Value 30	: automated center determination flag
Value 31	: MSLP pressure value using latitude bias adjustment
Value 32	: TIE Model output flag
Value 33	: TIE Model current pressure value – if SST value available
Value 34	: TIE Model 12-hour averaged pressure value – if SST value available
Value 35	: sea surface temperature value (°C) – if available

History files should not be modified directly. Any modifications, such as reanalysis or removal of individual records, should only be done using the X-AODT History List Window shown in Figure 5 in order to assure correct modification to the remaining history file entries.

Due to constraints with the original McIDAS command line entry source code used by the AODT (with origins dating back to the initial DOS-based systems) history file names are limited to 12 characters in total length, including the “.ODT” suffix. History file names provided in the history file selection popup window, as shown in Figure 2, without the “.ODT” suffix will have it appended automatically, with the prefix name truncated to eight characters if necessary. For example, the command line entered history file name of JOSEPHINE will result in a file name of “JOSEPHIN.ODT”, while “OPAL.ODT” or “OPAL” will result in “OPAL.ODT”. The directory location of the history files is defined with the \$ODTHISTORY UNIX environment variable.

## 5.) Using the X-AODT in non-GUI mode

The AODT algorithm can operate independent of the GUI. This capability allows for use of the AODT within scripts and command schedulers, such as the UNIX “crontab” scheduler. Runtime status and final analysis text output are displayed within the text window. Graphical output is not supported except for an output pixmap file containing a display of the satellite image, image enhancements, and any annotations to the image, such as the manually or automatically defined storm center position.

Use of the AODT algorithm is initiated from the UNIX command line using a selection of keywords to control various functions of the AODT algorithm. All AODT keywords are defined in Section 5A, with examples provided in Section 5C.

The AODT is initiated and controlled with the following command line structure :

**aodt nogui/NOGUI <keywords>**

The keywords control various aspects of the AODT algorithm, many of which can be used in combination with other keywords to perform specific tasks. A short description of use for each keyword, along with several examples, will be presented in the following sections.

### A.) Keyword Description of Use

**NOGUI** (default=none)

Initiate the X-AODT in non-GUI mode. Label can be entered in all lower or upper case. Must be entered as second parameter on command line when X-AODT is started.

**HISTORY=filename** (default=none)

History file used for the AODT analysis. If no history file is specified, no history file will be created/appended. History file names can be up to twelve total characters in length, including the suffix “.ODT”, which will be added to the end of all history file names. The directory where the history file is written is defined with the \$ODTHISTORY environment variable. See Special Keyword Notes in Section 5B and Section 4D for additional information about the AODT history file.

**AREA=filename** (default=AREA9999)

Input McIDAS format image file for analysis. Directory location defined using \$ODTDATA UNIX environmental variable.



number values using empirical relationships defined in Dvorak (1984) and (Shewchuck and Weir, 1980).

**DOMAIN=ATL/PAC** (default=auto determination)

Define oceanic domain where tropical cyclone resides. ATL should be used for storms within North Atlantic basin, while PAC should be used for storms within Western Pacific basin. If the oceanic basin is not explicitly defined with this keyword, a basin will be selected automatically (see Section 7G). Domain selection will affect Raw T# intensity estimate determination and corresponding CI number pressure value (empirical CI number/pressure relationship).

**AUTO=YES/NO type filename atctype** (defaults=NO 0 AUTOFIX OFCL)

Allow for completely automated operation of AODT, utilizing NHC/JTWC forecasts and Laplacian Analysis to objectively determine storm center position. *Cannot be used with OVER keyword.*

type = 0 : ATCF Tropical Cyclone Forecast Record files.  
type = 1 : TPC WTNT4? (North Atlantic) or WTPZ3? (East Pacific) storm specific DISCUSSION files.  
type = 2 : JTWC WTPN3? (Western North Pacific) TROPICAL CYCLONE WARNING file.  
type = 3 : Generic format (see Section 7H for format/example)  
filename : Name of input file. The directory where the input files is located is defined with the \$ODTAUTO environment variable.  
atctype : ATCF objective technique acronym (default is official forecast)

**IC=value** (default=1.0)

Allow user to override the initial Raw T# intensity classification value, as defined in the Subjective Dvorak Rules. The initial Raw T# classification value will be set to 1.0 unless explicitly defined by the user as another value. This keyword should only be used when analysis of a tropical cyclone is initiated at a time later than initial formation (storm has a Raw T# value greater than 1.0). If value is set to 0.0, this function will be turned off for the analysis, allowing for the AODT derived value to be displayed as the Raw T#.

**LAND=YES/NO** (default=YES)

Apply AODT land interaction rule. See Sections 4C5c and 7A for more information.

**SST=filename** (default=SST.DAT)

Name of file containing SST information for TIE Model. Directory where SST file is located is defined using ODTSSST environmental variable. See Section 7K for more information.

**SEARCH=YES/NO**

(default=YES)

Perform search for maximum curved band location if Curved Band scene type was automatically determined or manually selected. See Section 7I for more information.

**B.) Special Keyword Notes**

If no history file is provided, the AODT intensity bulletin and runtime output (see Section 4C4b) will be abbreviated, providing the user with only the intensity estimate value at the current time. No analysis flag values will be listed, and no history file will be created or modified.

If the LIST or DELETE keywords are used, an AODT intensity analysis will not be performed. These functions are used to only investigate and modify the contents of the history file.

The AUTO and OVER keywords cannot be used in the command line at the same time. No user interaction is allowed during the automated operation of the AODT. If these keywords are used in the same command line entry, the override capability will be disabled, and an error message will alert the user of this fact.

**C.) Examples*****aodt***

Perform AODT analysis on current image using the X Window System GUI.

***aodt nogui HISTORY=OPAL.ODT***

Perform AODT analysis and add record to history file OPAL.ODT. All rules will be applied as necessary. If this is the first analysis in the OPAL.ODT history file, the initial Raw T# value classification will be set to 1.0.

***aodt NOGUI AREA=4567 LATLON=20.5 55.3 HISTORY=OPAL.ODT***

Perform AODT analysis in non-GUI mode on the image file AREA4567 with storm center point at 20.5N latitude and 55.3W longitude using the history file OPAL.ODT.

***aodt NOGUI AREA=AREA4567 LATLON=20.5 55.3 HISTORY=OPAL.ODT IC=2.5***

Perform AODT analysis as previous example, however the initial intensity estimate (first record in history file) within the history file will be set to 2.5.

***aodt NOGUI HISTORY=OPAL.ODT LIST=YES***

List contents of history file OPAL.ODT. No intensity analysis is performed.

***aodt NOGUI HISTORY=OPAL.ODT LIST=YES OUTPUT=FILE OPAL.TXT***

Do NOT perform AODT analysis; provide listing of history file OPAL.ODT to output file OPAL.TXT within directory defined with the \$ODTOUTPUT environment variable.

***aodt NOGUI HISTORY=OPAL DELETE=YES DATE=1995OCT03 151500***

Delete only the 1995OCT03/151500UTC record from the history file OPAL.ODT. No intensity analysis is performed, but all subsequent records in the history file are modified following the deleted record.

***aodt NOGUI HISTORY=OPAL DELETE=YES DATE=1995OCT03 151500 1995OCT03 191500***



Delete all records between 1995OCT03/151500UTC and 1995OCT03/191500 UTC from the history file OPAL.ODT, inclusive. No intensity analysis is performed, but all subsequent records in the history file are modified following the deleted records.

***aodt NOGUI HISTORY=OPAL LIST=YES DATE=X X 1995OCT03 31500***

List all records between the beginning of the history file OPAL.ODT and 1995OCT03/31500UTC. No intensity analysis is performed.

***aodt NOGUI AREA=AREA8888 HISTORY=OPAL.ODT AUTO=YES 2 wp2698.txt***

Perform automated AODT analysis in non-GUI mode on image file AREA8888 and add record to history file OPAL.ODT. AODT will read JTWC Tropical Cyclone Warning file wp2698.txt for forecast information, and is located in the directory defined by the \$ODTAUTO environment variable.

***aodt NOGUI AREA=AREA9999 LATLON=14.5 -145.4 PIX=YES NHC PURPLE***

Perform AODT analysis in non-GUI mode on image file AREA9999 centered at latitude 14.5N latitude and 145.4E longitude, and create an output pixmap file aodtdisplay.xpm with the NHC.ET enhancement and a purple dot at the storm center location defined with the LATLON keyword.

## 6.) Image Format Conversion Routine

A program has been included with the X-AODT package to convert Meteosat High Resolution Image (HRI) satellite imagery into McIDAS AREA format imagery. The program will convert Meteosat A-Format data, specifically the AIVH (A-Scan Infrared Visual Half mode) data into the McIDAS AREA file that the X-AODT requires.

The program is contained within the **msat2area** directory in the main **xaodt-v6.3** directory, and is named `readsat.c`. This program can be compiled using either the GNU C compiler “gcc”, or the standard UNIX C compiler “cc”. The command to compile the routine is:

```
gcc -o readsat readsat.c
```

The *readsat* program can be used on big or little endian machines, and will automatically read the input file and format the output file in the correct manner for the machine where the program is installed. To run the *readsat* program, use the following command structure on the UNIX command line:

```
readsat <input HRI file> <output AREA#>
```

The <input HRI file> is the file name of the input Meteosat HRI image, while the <output AREA#> is the number suffix for the output McIDAS AREA format image. For example, a value of 8888 would result in an output file named AREA8888.

## 7.) Background Information

### A.) Land Flag

Tropical cyclone land interaction is determined utilizing the low-resolution topography map TOPOLRES provided. The resolution of the map file is 1.0° X 1.0° latitude/longitude. If the storm center is positioned over a grid box with an average height greater than sea level (and more than 50% covered by land), the land flag will be triggered. If the land flag is triggered, no intensity estimate will be produced unless specifically requested by the user using the LAND keyword. The history file will still include an entry for any intensity estimate attempted while over land. The latitude, longitude, and land flag parameters will contain their assigned values, however the values for the intensity estimates and the remaining parameters will be assigned a “missing value” (mostly 0’s). Calculation of both Final T# values and the CI# value will exclude all “over land” entries once the storm resumes movement over open water (non-land grid points).

### B.) Scene Classification

Objective scene identification is performed using Fast Fourier Transform (FFT) analysis, 10° log spiral analysis, and/or other statistical analysis techniques. Scene classifications are performed separately for the eye (0-24km from storm center) and surround cloud (24-136km) regions. Determinations of certain scene types are dependent upon past intensity estimates stored in the history file of a particular storm, closely mirroring the thresholds defined in the subjective Dvorak EIR technique. The six eye region scene types and five cloud region scene types are described below :

#### Eye Region

<u>Scene Type</u>	<u>Description</u>
CLEAR	Clear, well-defined eye
PINHOLE	Very small eye/pronounced warm spot
LARGE CLEAR	Clear, well-defined eye greater than 40 km diameter
LARGE RAGGED	Ill-defined eye region greater than 40 km diameter
RAGGED	Ill-defined (cloudy or oblong) eye region
OBSCURED	Very cloudy/cloud covered warm region
NONE	No eye

#### Cloud Region

<u>Scene Type</u>	<u>Description</u>
UNIFORM CDO	Overcast cloud region with uniform temperature structure
EMBEDDED CENTER	Arc of convection within central overcast cloud region
IRREGULAR CDO	Cloud region over storm center, but large shift in coverage
CURVED BAND	Curved cloud region surrounding circulation center
SHEAR	Displaced convection and exposed circulation center

Eye scene types are derived by examining the eye region FFT harmonics, variability of temperature values in the eye region, and “BD enhancement curve” categorical differences between the eye and surrounding cloud region temperature values. Eye size is derived by measuring the distance across the eye between BD-curve “Dark Gray” temperature range edges. Distances are measured at 90° angles outward from the user or auto-selected storm center location, and are averaged to give an approximate eye size.

Cloud region scene types are determined by examination of the entire cloud region FFT harmonics, the average difference between opposing 15° arc average temperatures (convective symmetry value), and by differencing the average and “coldest-warmest” cloud region temperature values. If the cloud scene is thought to be a “Curved Band” type scene, a 10° Log Spiral analysis will be performed to determine the curvature extent of the convective cloud region around the selected center position. The algorithm will first target the BD-curve “Light Gray” temperature range to define the convective region of the curved band area. If this temperature region is devoid of significant activity/completely surrounds the selected storm center position, analysis of warmer/colder ranges BD-curve temperature levels will be performed. Once a Curved Band scene is determined, an additional search will be performed to look for a location that yields a greater amount of curvature in the cloud region, and thus a higher intensity estimate (Section 7I). If the scene is determined to be a “Shear” scene, the distance between the center position and the closest BD-curve “Dark Gray” temperature range pixel will be determined.

Once the scene type has been automatically or manually determined, the value is used in conjunction with the eye and surrounding cloud top temperatures, oceanic basin type, and other history file information to calculate the intensity estimate for the image being investigated.

### **C.) Eye and Surrounding Cloud Region Temperature Determination**

Proper determination of the storm center is paramount for an accurate storm intensity estimate since the eye and cloud region temperature value calculations are heavily dependent on this location.

Determination of the eye region temperature is straightforward. This temperature is assigned the value of the warmest pixel within a 24 km radius from the user or automated storm center location. Since an incorrect eye temperature can lead to an incorrect intensity estimate, proper selection of the storm center location is essential.

Calculations of the two surrounding cloud region temperature values are a bit more complicated than for the eye temperature. The first cloud region temperature value computed is centered at the storm center location and lies between 24 and 136 km from the center location. Individual analysis rings are selected, and are dependent upon the resolution of the satellite imagery. Thus for a 4 km resolution infrared image, there will

be  $(136 - 24)/4 = 28$  rings. On each ring the warmest temperature will be found. The coldest of these values will be used as the cloud top temperature value. This value is referred to as the “coldest-warmest” temperature, and it is used only in the determination process for the cloud region scene type. The ring number (CWRN) distance (in km from the storm center location) on which the “coldest-warmest” temperature value is located is used in the determination of the “mean” cloud region temperature discussed below. For more information about this value, see Velden et al. (1998) and Zehr (1989).

The second cloud region temperature computed is the “mean” cloud region temperature value, and is the actual value that is assigned as the cloud region temperature. First, an annulus region is determined around the storm center location. The annulus will be a total of 80 km wide and is centered on the CWRN distance explained above. The minimum inner/maximum outer radius of the annulus will be the CWRN distance minus/plus 40 km. The minimum inner radius cannot be less than 24 km from the storm center location, but there is no maximum limit on the outer radius distance. For example, if the CWRN distance is 48 km, the inner distance will be a minimum of 24 km (not 8 km), and the outer distance will be 104km. Once the annulus is defined, it is divided into 24 arc regions ( $15^\circ$  each) and the average temperature of each arc is calculated. The average of the 24 average arc temperature values is computed and assigned to the “mean” cloud region temperature value.

The “coldest-warmest” temperature value was replaced with the “mean” temperature value after close examination of both values, and their respective Raw T# intensity values, in relation to aircraft reconnaissance intensity measurements. The “coldest-warmest” temperature value varied significantly more than the “mean” values, and their corresponding intensity estimates. The intensity estimate values computed using the coldest-warmest temperature values were found to be inferior to the intensity estimates using the mean temperature values, thus the change was implemented.

#### **D.) Time Averaging Scheme**

The Final T# (6-hour average) value is calculated using a linear-weighted time averaging scheme, which places greater weight on the current intensity estimate value and less weight upon each preceding intensity estimate. The time averaging scheme uses the current Raw T# value and all available Raw T# values obtained within the last 6 hours. The current value is given a weight of 6.0, with all other values given weights directly proportional to their time difference from the current analysis time.

Determination of the time-weighted Final T# value previously utilized a 12-hour time period, but it was found that by changing the analysis period to 6 hours coupled with the use of the Dvorak EIR Rule 8 (see Section 7F) provided a statistically superior intensity estimate. In addition, utilizing a 6-hour time averaging period eliminates the need for the Rapid Deepening flag and corresponding time-averaging period change (from 12 hours to 3 hours). The rapid deepening flag had been a documented source of error in the analysis of some tropical cyclones where it had been (incorrectly?) triggered.

### **E.) Dvorak EIR Rule 9/Weakening Rule**

The Dvorak EIR Rule 9/Weakening Rule (Dvorak, 1984) is used in the determination of the CI# after a storm has reached its maximum intensity and is weakening. This rule holds the CI# values 0.5 to 1.0 T# higher in value than the current Final T#. Subjective application of this rule (e.g. how and when to apply it) varies from forecaster to forecaster and is the focal point of much debate. The value of 1.0 is utilized in the AODT algorithm since it provides the most statistically accurate estimates of storm intensity when compared with reconnaissance pressure measurements.

In the AODT algorithm, application of this rule is performed when the storm has undergone a “significant strengthening event”. This event is identified by computing a least squares fit to the current and all Final T# values during the past 24. If the slope of this fit is greater than or equal to 1.0 (increasing 1.0 T# in the last 24 hours), a significant strengthening event is said to be occurring. Once the Final T# (6-hour average) begins to decrease, the Rule 9 guidelines are applied to calculate the CI#.

An additional criteria check can modify the Rule 9 “additive” constant of 1.0 if the storm CI# values becomes “constant” (does not vary by more than 0.5) for a continuous 24-hour period. If this condition is met, the additive value will be reduced to 0.5 while the storm maintains its steady state condition. Once this steady-state condition has ended, the additive constant will return to the maximum value of 1.0.

An additional rule within the AODT affects the calculation of the Final T# and CI# prior to weakening after a “significant strengthening event” (e.g. during the formation stages). This rule is as follows: “Always hold the CI# to the highest Final T# in the last 12 hours (but never greater than 1.0 for the CI#) in all cases”. This rule will hold the CI# equal to the highest Final T# (6-hour averaged) obtained during the previous 12 hours. For example, if the Final T# value increased to 5.2 then decreases in intensity, the CI# value will be held at 5.2 for 12 hours unless the T# exceeds 5.2 during that time period. If this rule is invoked, the “Weakening” flag indicator in intensity estimate bulletin (Section 4D1) will display “WEAK” (as opposed to “OFF” or “ON” when the Dvorak EIR Rule 9 discussed above is being applied).

### **F.) Dvorak EIR Rule 8**

The Dvorak EIR Rule 8 constrains the rate of increase or decrease of the Raw T# intensity estimate value based upon specified rates of change over specific time periods. The rate of change comparisons are performed against the Final T# (6-hour average) values stored in the history file at various times prior to the current analysis time, with the rate of change constraints being dependent upon the “current” intensity of the storm, as defined in the Dvorak EIR technique. The Final T# (6-hour average) value of the record immediately prior to the current analysis time is used as a proxy for the “current” intensity estimate. When “current” intensity of the storm is less than 4.0, the current Raw T# rate of change cannot exceed  $\pm 0.5$  T# over 6 hours. If the “current” intensity estimate

value is greater or equal to 4.0, the rate of change of the Raw T# value cannot exceed the following rates : 1.0 over 6 hours, 1.5 over 12 hours, 2.0 over 18 hours, and/or 2.5 over 24 hours. If one of the criteria is/are exceeded, the Raw T# will be assigned the maximum/minimum value that does not exceed the criteria in question.

As a final “gross error check” for the Raw T# values derived by the AODT, a supplementary Rule 8 rule has been added to the Dvorak Rule 8 rules listed above. This additional rule will limit the growth of the Raw T# value by 0.5 over 1 hour. Implementation of this rule was found to be necessary due to the inherent variability of the AODT during “scene type transitions”, especially between eye and non-eye cases. Due to the completely objective nature of the scene determination scheme, and the threshold values that are used to define the different scene types, changes between scene types can result in unrealistic jumps in Raw T# values from one intensity estimate to another. The addition of this rule will produce estimates that are reasonable when these types of scene changes occur, but still will allow the Raw T# values to change at a rate greater than observed in nature. The largest MSLP change we found in our test data set was with Hurricane Opal, which had a decrease in observed MSLP (from reconnaissance aircraft) of 17mb (933mb to 916mb) over about two and a half hours (07:20UTC to 09:45UTC). This corresponds to a change of about 0.6 T# (933mb  $\approx$  6.6 T#; 916mb  $\approx$  7.2 T#) in 2.5 hours, or approximately 0.25 T#/hour.

Implementation of this rule has allowed for a modification of the time-weighted Final T# calculation from 12 hours to 6 hours, with the 6-hour weighted average proving to be slightly more accurate statistically than the previous 12-hour methodology. By utilizing the 6-hour scheme, the rate of change of the time-weighted Final T# value is typically more than with the 12-hour scheme, allowing for greater rapid increases in intensity over time than previously found. Introduction of the Dvorak EIR Rule 8 limits this growth realistically, and has allowed for the rapid flag determination scheme to be removed from the AODT. The rapid flag was found to work in certain cases, but often led to significant overestimates of intensity in other cases, due to the time-weighted averaging scheme changing from 12 hours to 3 hours. The integration of the Dvorak EIR Rule 8 in conjunction with the new 6-hour time-weighted average Final T# scheme has resulted in more realistic intensity estimates and changes over time.

#### **G.) Oceanic Domain Auto Determination**

The AODT intensity estimates are dependent upon the ocean basin in which the storm being examined is located. This is a result of using separate empirical relationships between CI# and minimum sea level pressure (MSLP) for the North Atlantic (Dvorak, 1984) and Northwest Pacific (Shewchuck and Weir, 1980) basins. Also, a different Raw T# may result for a particular eye and cloud region temperature pair, depending upon which basin is designated.

Previous versions of the ODT relied on the user to manually designate the ocean basin using the DOMAIN keyword. The AODT can automatically determine the ocean

basin based upon the longitude value of the selected storm center location. A storm west of the international dateline (180° E/W) and east of the Prime Meridian (0° E/W) is designated as a Northwest Pacific storm (regardless of N/S hemisphere), with all other storms (longitude-wise) designated as Atlantic. The user can override this determination process with the DOMAIN keyword, if desired.

The division point in the Pacific Ocean was chosen to match the “areas of responsibility” for the Joint Typhoon Warning Center and Central Pacific Hurricane Center. Use of either CI#/pressure relationship in the Eastern Pacific Ocean is a topic for debate, but no specific rules defining the use of one of the relationships for this or other regions, such as Indian Ocean or Southern Pacific Ocean, have been documented, so it is left to the user to decide which is the proper relationship in these regions.

## **H.) Automatic Storm Center Determination**

The automated storm center location algorithm approximates tropical storm position using four methods : polynomial interpolation of NHC/JTWC forecasts, warmest pixel search, Laplacian Analysis of the cloud region temperature values, and linear extrapolation of the history file positions.

As a first guess, the forecast positions from NHC or JTWC are used in conjunction with previous storm locations in the polynomial interpolation routine. This routine interpolates the position at the time desired using three forecast positions (current, 12 hour, and 24 hour positions). The four types of input file formats are :

- ATCF Forecast Record file (“OFCL” forecast is default)
- NHC Tropical Storm/Hurricane Discussion files (WTNT4? or WTPZ4?)
- JTWC Tropical Cyclone Warning files (WTPN3?)
- Generic Entry file (see below for format)

If the forecast interpolation fails, a linear extrapolation of storm positions for the previous 12 hours (stored in the history file) is attempted. Once a valid interpolated forecast or extrapolated history file position is obtained, the Final T# intensity estimate of the record immediately preceding the current analysis time in the history file found. If this value is less than 3.5, the interpolated/extrapolated point is used as the final automated storm position. However, if this value is greater or equal to 3.5, a more thorough analysis of the image is conducted to determine a better storm center location.

The analysis begins by searching for the warmest satellite image pixel within 75km of the forecast interpolated/history file extrapolated point. A Laplacian Analysis is then performed over a 90km radius analysis region, which identifies temperature gradients exceeding various threshold values. The gradient threshold fields are then statistically analyzed, with an empirically defined “confidence factor” derived based upon the scatter and cohesiveness of the gradient points for each of the thresholds.



If this confidence factor is greater than an empirically defined threshold “A”, a well-defined and spatially confined cloud feature with strong temperature gradients has been located (e.g. an eye). The average position of the Laplacian Analysis gradient threshold field points determined for the storm center location will be used as the center point position in this case unless this distance is greater than 80km from the initial warmest pixel location. This last check will assure that a non-eye cloud feature at the edge of the Laplacian Analysis region is not incorrectly analyzed as an eye feature due to the small number of points being examined at this distance.

If the confidence factor is below “A” but above “B”, a less well-defined feature has been identified. This type of feature may be a large but clear eye (less spatially confined), a forming, obscured, or ragged eye (spatially confined, but less of a temperature gradient to examine), a strong, centralized feature in the cloud top temperature field, but without an eye feature (e.g. embedded center cloud pattern), or even an organized curved band-type pattern. As with the “A” case above, the average position of the Laplacian Analysis gradient field points will proxy as the storm center point position.

If the confidence factor is below “B” but above “C”, a feature has been located, but it is a broadly defined spatial feature without a strong, centralized gradient to identify (e.g. a warm spot/forming eye feature). The location of the warm spot is provided as the storm center location if this location is within 40km of the initial interpolated/extrapolated position and is significantly warmer than the cloud top temperature at the interpolated/extrapolated position.

Any feature with a confidence factor below “C” will use the forecast interpolated /extrapolated history file position as the storm center location.

Each line in the Generic Entry file contains either the initial/current position of the storm or a forecast position at 12-hours or 24-hours, and are formatted as follows :

**dd mm yyyy tttt aa.a bbb.b**

<u>parameter</u>	<u>value</u>	<u>format</u>
dd	date	two digit integer
mm	month	two digit integer
yyyy	year	four digit integer
tttt	UTC time	HHMM format : HH-hour MM-minute
aa.a	latitude	floating point (+/- : north/south)
bbb.b	longitude	floating point (+/- : west/east)

An example file for Floyd using the 12 September 1999/03:00UTC forecast product :

```
12 09 1999 0300 22.7 64.5
12 09 1999 1200 22.9 66.0
13 09 1999 0000 23.2 68.3
```

The first line contains the “initial” position, with the second and third lines containing the 12-hour and 24-hour forecast positions. Use of a forecast file older than 24 hours will result in a failure with the auto-positioning routine.

#### **I.) Maximum Curved Band Location Search**

If a Curved Band scene type has been determined automatically, or was selected manually during a scene override, an additional search will be performed to locate a storm center position possessing a greater cloud curvature measurement than obtained at the original selected storm center location. The search will examine the same BD-curve temperature range as obtained with the automatic scene type determination scheme. A 2° latitude/longitude box, centered at the originally selected storm center location, will be examined at a 0.2° spacing between search points. At each search point, the 10° Log Spiral will be examined to determine the maximum arc length of the BD-curve temperature range being targeted. The spiral will then be rotated 15° and the measurement is performed again. Once the spiral has been rotated 360°, the spiral is moved to the next search point and the process is repeated. The search point possessing the maximum arc length measurement will then be shown in the intensity analysis output.

This feature was incorporated, in response to user feedback, due to the high degree of subjectivity inherent to the curved band analysis technique. It was added to provide an objectively determined location with the greatest curvature, however this location may or may not be the best location, due to limitations inherent to the technique. The storm center location produced by this method should be used as a suggestion, and should be examined closely to determine its applicability to the current scene analysis over the original storm center location.

#### **J.) Sea Surface Temperature Information**

The sea surface temperature (SST) information is used in conjunction with various parameters in the AODT history file in the determination of the TIE Model intensity estimate for the current scene being analyzed. Details on the usage of the SST values and the derivation of the TIE-Model intensity estimates are discussed in the TIE Model User’s Guide, obtained at the following website:

**<http://cimss.ssec.wisc.edu/tropic/aodt>**

The SST data used for the TIE Model intensity estimate within the AODT package can be obtained from various FTP sites listed on the following website :

**<http://polar.wwb.noaa.gov/sst/>**

The SST files obtained from the above website are real-time, global, one-degree resolution GRIB format files (RTG\_SST) distributed by the National Centers for Environmental Prediction/Marine Modeling and Analysis Branch (NCEP/MMAB). Significant detail on the derivation process for the RTG\_SST files can also be found at the above website.

Once obtained, the SST files should be placed in the directory defined in the “aodtenv” file with the \$ODTSST environmental variable. The X-AODT algorithm using the SST GUI or keyword, as described in Sections 4C3d and 5A, obtains the name of the file to be used. If the SST file is available, the TIE Model intensity estimate will be appended to the end of the AODT intensity estimate bulletin after the first clear eye scene has been identified. An example of the TIE Model intensity estimate is shown in Section 4C4a.

### **K.) Latitude Bias Adjustment**

The MSLP value displayed in the AODT intensity estimate bulletin is adjusted using a linear regression-based adjustment equation. This equation is designed to eliminate a pronounced intensity estimate bias noted in the derived CI# value of the AODT and underlying Dvorak Technique. The equation used for this adjustment is as follows :

$$CI\#_{adj} = CI\#_{orig} - (-20.60822 + (0.88463)*ABS(latitude))$$

This equation requires the CI#<sub>orig</sub> value to be entered in units of pressure (millibars). Since the AODT produces estimates in terms of T# values, the CI#<sub>orig</sub> value must be converted to millibars before the adjustment equation is applied. This pressure value is stored in a history file.

For more specific information about the derivation and reasoning behind this latitude bias adjustment, please refer to the following online document (Kossin and Velden, 2003) at :

**[http://www.ssec.wisc.edu/~kossin/articles/kossin\\_velden\\_MWR.pdf](http://www.ssec.wisc.edu/~kossin/articles/kossin_velden_MWR.pdf)**

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