Fog Monitor

User's Guide
AWIPS OB6 Release

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Table of Contents

1 Introduction

The Fog Monitor is an AWIPS application which applies various algorithms to visible and infrared satellite images in order to identify potential areas of fog. At night, the application primarily uses the well-known infrared "Fog Product" (the difference of the 10.7 micron and 3.9 micron brightness temps) to highlight potential fog areas. During the daytime, there are several algorithms which attempt to discern fog areas by brightness, shape, and other characteristics. Also applied are filters which help to distinguish fog from possible false signal features such as snow cover and mid-level clouds.

The application consists of a background processor on the px1 server, a D-2D display, and a simple extension table. The processor will continuously evaluate newly arrived satellite data, even when the display is not invoked. This allows the application to be a true "monitor", as opposed to a passive interrogator of fog data upon user request. The Fog Monitor was originally designed to run as a part of SAFESEAS, to try to address the serious problem of marine fog (which can often go undetected due to the relative sparseness of maritime observations). The application has evolved into an independent process, versatile enough to run at inland forecast offices while retaining SAFESEAS tie-ins at coastal WFO's.

As mentioned above, the OB6 version of Fog Monitor only uses satellite data for its observations. In the future, MDL plans to include in-situ observations to complement the current satellite observations.

This users' guide is limited in scope to the use of the Fog Monitor in AWIPS – how to run localization, start the processes, and interpret the displays. The science behind the Fog Monitor's algorithms, while discussed somewhat in this document, deserves much more substantial mention, and these scientific aspects (theory, algorithms, limitations, etc.) will be described in further documentation available on the Fog Monitor web site (see Chapter 3 for the IP address). Many of the algorithms used in Fog Monitor have been adapted from work performed by NWS colleagues and other experts in satellite meteorology. The scientific documentation described above will have references available for those who wish to read about the topic in greater detail.

2 Fog Monitor Functional Overview

The Fog Monitor consists of several processing and display components:

a) The FMprocessor runs persistently on px1, along with an associated DataController process.
b) The D-2D image display highlights areas of potential concern.
c) The Fog Monitor Table

The set-up/configuration components are the:

a) localization script,

b) Graphical User Interface (GUI) for editing the monitoring area,
c) GUI for editing the algorithm setup thresholds

2.1 Fog Monitor Localization

Fog Monitor's localization uses files which will already exist on a standard WFO server or workstation (including some new configuration files which will be delivered with the OB6 build.) There should be no need for manual installation of any files. The localization switch name is "fogmon", so the command for localization is

${FXA_HOME}/data/localization/scripts/mainScript.csh -fogmon

This localization step will create shared files visible to all machines under the ${FXA_DATA}/workFiles/fog_monitor/ directories. It is therefore only necessary to run this command on a single machine (lx, px, or dx).

2.2 Fog Monitor background process startup

To start the Fog Monitor's background processor user "fxa" should log into px1 and type the command: **startFMprocessor**. The processor and a parent **DataController** will start up (as will a script called **runFogMonitor.bash**, which links the processes). Note that the normal px1 ingest routines should start these process, so the manual command described above will usually not be necessary. To stop the Fog Monitor application, run **stopFMprocessor**.

2.3 SAFESEAS Monitor Tie-In

Unlike SAFESEAS, FFMP, or SCAN, the Fog Monitor does not have a D-2D alert button of its own. There is a tie-in, though, to the SAFESEAS alert button (see Figure 2.3-1). The user can allow the Fog Monitor background processor (described above) to contribute data to this button. The Fog Monitor looks for zones and counties which its monitoring area shares with that of SAFESEAS. The worst case fog conditions (and their attendant color values, described later) will be made available to be picked up by the SAFESEAS button, as an additional monitored parameter. Consult the SAFESEAS Users guide for information on the alert button.

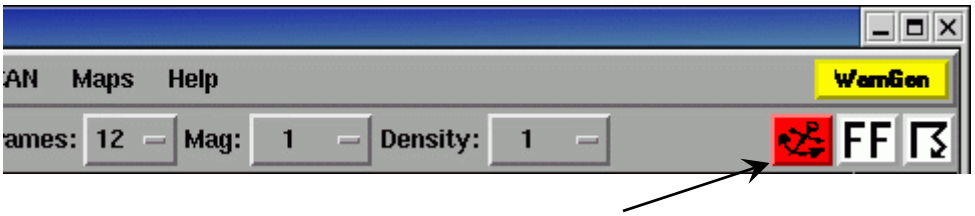

Figure 2.3-1. D-2D icon indicating SAFESEAS monitor threat level.

2.4 Fog Monitor D-2D Display

The selection for Fog Monitor is located near the bottom of D-2D's NCEP/Hydro menu (Figure 2.4-1). When selected, the application's output will appear on the screen, and a two-column table will accompany it (Figure 2.4-2). By default, the monitoring area will consist of the local County Warning Area, each adjoining CWA, and the marine zones monitored by the local and adjoining CWA's.

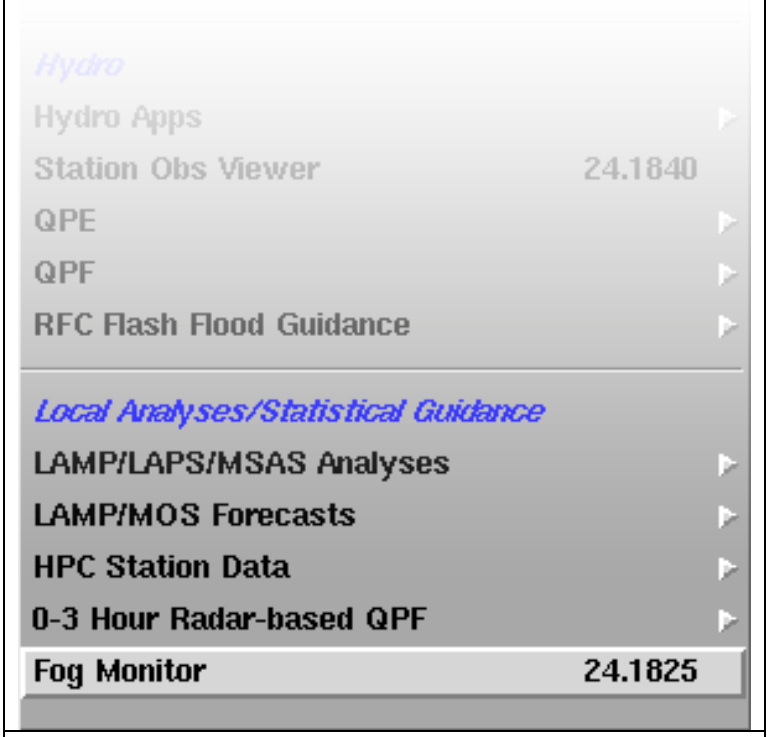

Figure 2.4-1 Fog Monitor menu selection under the D-2D NCEP/Hydro menu.

Red areas indicate the probable presence of fog, as determined by the algorithm settings (discussed in detail in sections 2.7.1 and 2.7.2). Yellow areas indicate the possible presence of fog, and the green areas indicate no fog. Black areas are not monitored.

Gray areas denote regions of the monitoring area with an undetermined status. Usually, gray areas will be caused by mid-level or high clouds, which will obstruct the Fog Monitor's view of the surface. Sometimes, though, a straight gray block can be seen cutting through the monitoring area. This indicates an area of twilight. The Fog Monitor is often ineffective near dawn and dusk, because those times provide "in-between" satellite data conditions: there is not enough reflected light for the visible-range algorithms to be effective, but there is too much scattering in the 3.9 micron channel to allow the use of the nighttime Fog Product channel differences (which assume black body emissions, not scattered returns). Figure 2.4-2 displays an example of all the scenarios described above. The twilight band cuts directly through the monitoring area. Areas to the west of the band are under the nighttime Fog Product regime, while areas to the east are being monitored with visible-range algorithms.

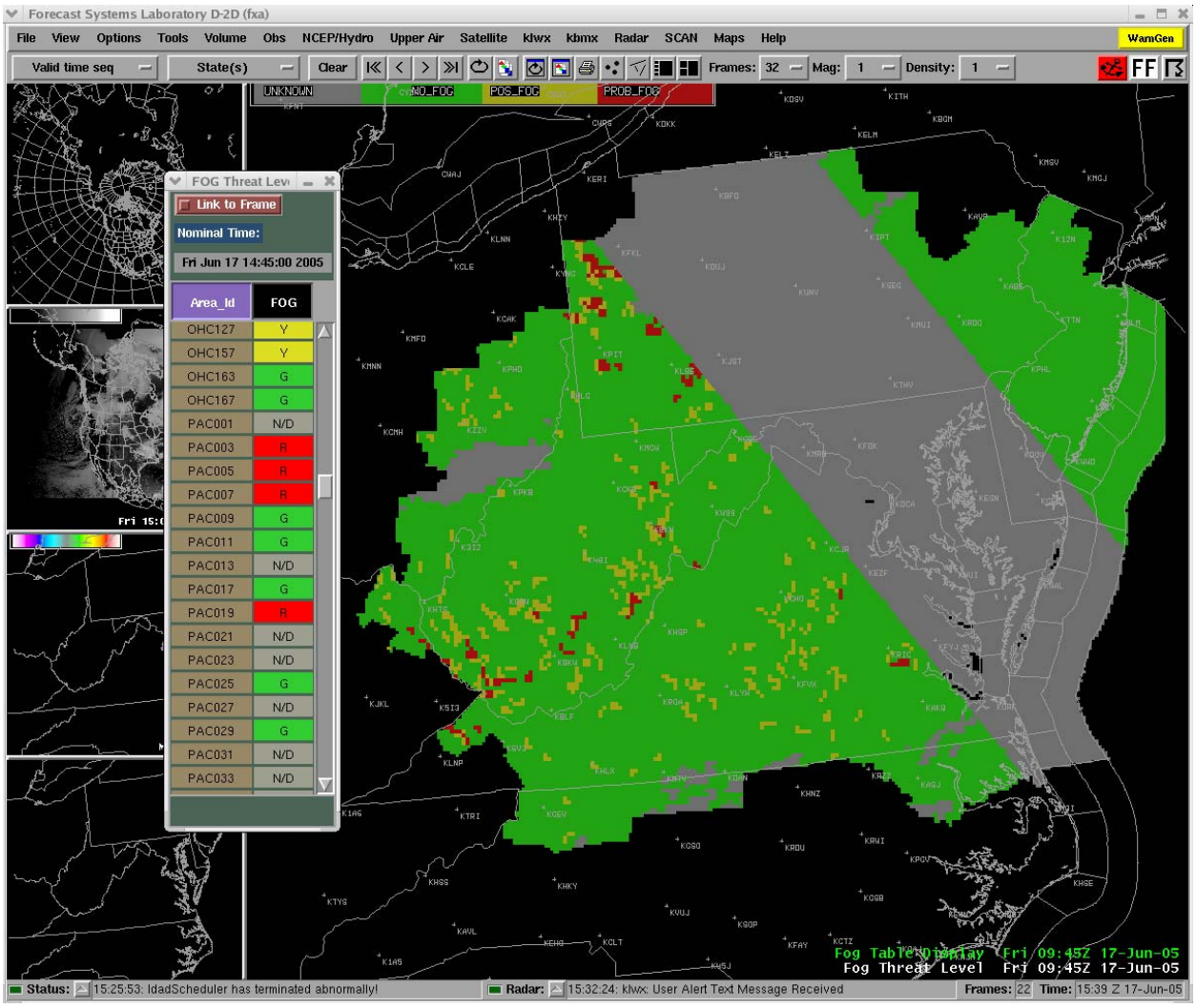

Figure 2.4-2: D-2D display with Fog Monitor image loaded in the main panel, showing the automatically-loaded Fog Monitor threat-level table in a separate pane.

2.5 The Zone Table

The zone/county table is automatically constructed and displayed when the Fog Monitor is launched. Each row provides information on the worst-case fog detection in the named zone or county. The table is illustrated in Figure 2.5-1. Table 2.5-2 summarizes the features and actions available in the zone table display. The colors in the Fog column have the same meanings as those in the D-2D display. Note that, unlike SAFESEAS, this Fog Monitor table cannot display any observational data. That functionality will be added in an upcoming build. The table will, however, enable the user to zoom and re-center into a D-2D county or zone area.

2.6 Configuring the Monitored Zones and Counties

Users can configure the area which this application monitors. Users may, for example, want to remove counties for neighboring CWA's, add additional counties, drop all counties in favor of marine zones, etc.

The editor for the monitoring area is launched from the AWIPS App Launcher (just like the D-2D). Left-click on the background screen to get the Apps Launcher menu. Within the menu, left-click "Fog Monitor Apps" to bring up the menu of Fog Monitor applications. Click the "Configure Monitoring Area" entry to bring up the editor.

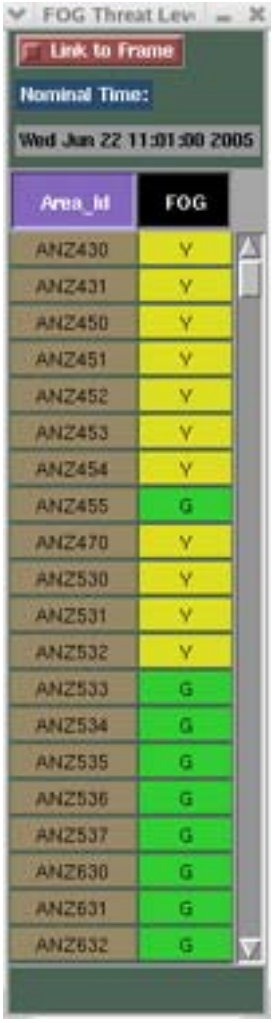

Figure 2.5-1. The Fog Table, sorted by Area ID.

Table 2.5-1: Contents of the zone and station table displays, by column.

COLUMN LABEL	DEFINITION	UNITS
Area_Id	Identifier for zone/county or station.	none (alphanumeric)
FOG	Displays threat level status for the corresponding zone: **N/A** (Gray --Not Available — usually indicates a county/zone within the monitoring area which has been intentionally removed by the user) **N/D** (Gray -- Not Determined). **G** (Green -- No Fog). **Y** (Yellow -- Possible Fog). **R** (Red --Probable Fog).	none (letter indicating threat level)

Table 2.5-2: Features and Action options for the zone table display.

Link to Frame	When link-to-frame is active, the nominal time in the zone and station tables always matches the valid time in the D-2D frame, and the data in the table animates with the D-2D looping. No matter what the "Link to Frame" mode is, the zone table will auto-update to display new data in the latest frame. Otherwise, the nominal time of the zone table remains unchanged at the last frame time in the D-2D display, until either you cause the table to be redrawn, or the D-2D frame advances to a new nominal hour valid time.
Nominal Time	Represents the time of the data in the threat-level table display.
Zoom/Re-center D-2D	Left-clicking on a zone ID (in the first (leftmost) column) causes the Fog Monitor image to zoom in and re-center on the selected zone.
Sort by Area-ID	Left-Clicking on "Area-ID" causes the table to be sorted alphabetically by zone-ID.
Sort by Threat-level	Left-clicking on "FOG" causes the table to be sorted by threat level with greatest threat-level appearing at the top of the table.

2.6.1 Zone Mode

There is currently one option on how to edit the monitoring area, which is the zone mode. (The station features on the right hand side of the GUI will be enabled in a later build). The "Zone" pushbutton will automatically be selected near the top of the Fog Monitor Area Configuration GUI (Figure 2.6.1-1). When editing, the GUI's upper left list (the "Monitor Area Zones" list) consists of the IDs for all the zones and counties currently comprising the monitoring area, and the lower left list (the "Additional Zones" list) consists of the IDs for other nearby zones/counties.

To Add Zones/Counties from the Additional Zones list:

Zones may be added to the monitoring area by selecting them from the "Additional Zones" list, then clicking the "Add" button above the list to move the selected zones into the "Monitor Area Zones" list. Zone selection capabilities are as follows:

- to select a zone, left-click on its ID. Multiple zones may be selected in this manner.
- to select a contiguous range of zones within the list, first left-click on the zone ID on one end of the desired range, and while holding down the mouse button, drag the cursor across the zone IDs in the desired range. Release the mouse button. The selected range of zones is added to any zones already selected.
- to de-select a zone, left click on its ID. De-selection can only be done one zone at a time.

To Remove a Zone/County from the Monitoring Area:

To remove a zone from the monitoring area, click on the zone's ID in the "Monitor Area Zones" list. Then click the "Remove" button located between the "Monitor Area Zones" list and the "Additional Zones" list. This can only be done one zone at a time.

To Modify the Time in which Notification affects past Fog Monitor images:

Adjust the slider bar in the "Time Window" to specify a retrospective time (from a range of .25 to 8 hours) that notification changes will be made to the Fog Image(s).

2.6.1.1 Saving Editing Changes to the Monitoring Area

When you are done editing the monitoring area in zone mode, click the "OK" button at the bottom of the "Fog Monitoring Area Configuration" GUI to save the changes, or "Cancel" to abandon the changes and abort the editor. If you click "OK", a confirmation box (Figure 2.6.1-2) will appear.

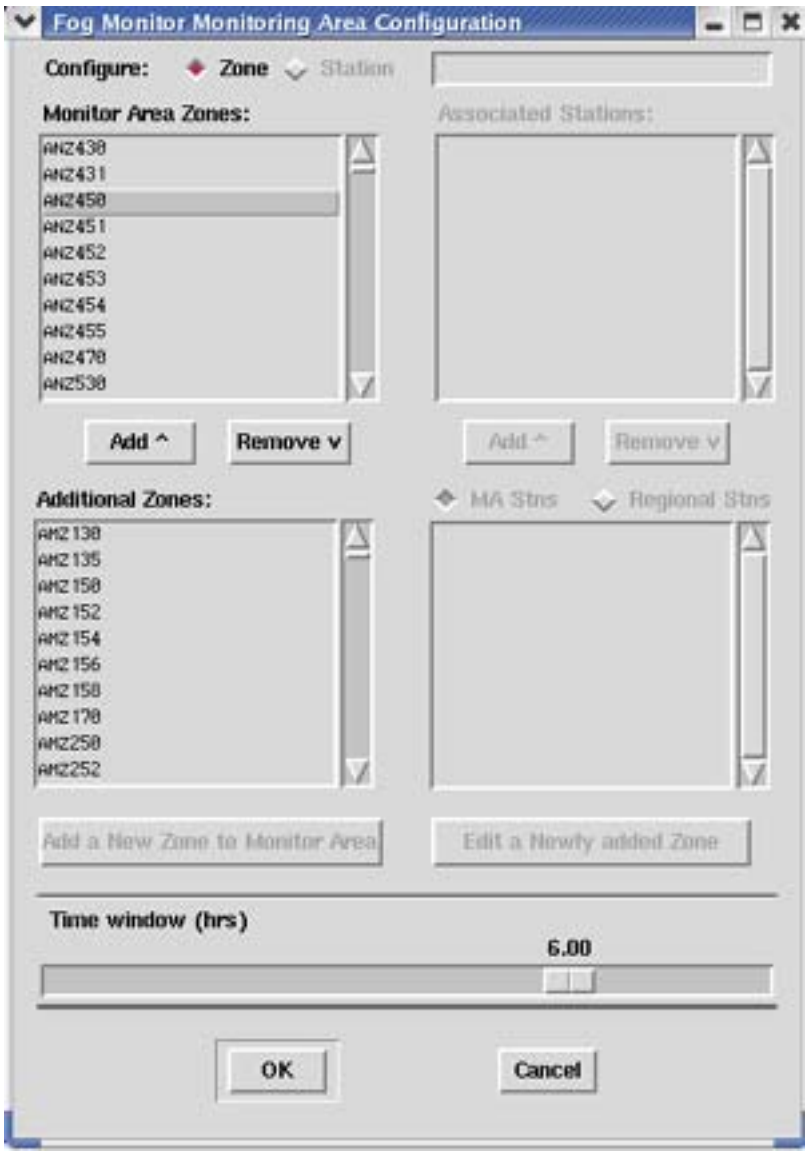

Figure 2.6.1-1. Fog Monitoring Area Configuration GUI.

Figure 2.6.1-2: First monitor area setup change confirmation.

If Zones were added or deleted to the Monitoring Area:

When you click the "Update" button in the first confirmation box, a second confirmation box (Figure 2.6.1-3) will appear.

Once you are certain the Fog Monitor display is not running anywhere in the office, click the "Continue" button. When the Fog Monitor zone configuration is changed, the Fog Monitor image display will automatically add or take out the zones to and from the Fog Monitor image display.

Figure 2.6.1-3: Selecting "Continue" will proceed to add new zones to the monitoring area.

2.7 Configuring the Fog Monitor Thresholds

The Fog Monitor's Thresholds GUI (Figure 2.7-1) allows users to adjust the behavior of the algorithms used to detect areas of fog. It can be reached via the App launcher menu (just like the Monitoring Area GUI), under the "**Fog Monitor -- > Configure Monitoring Thresholds**" selection. Users of Fog Monitor output data should be familiar with the operation of this GUI, since the optimum settings will vary based on several different factors (geography, season, and sky cover, to name a few). Note that none of the algorithms allows for exact fog detection; increasing the sensitivity to one type of fog scenario may hinder the Fog Monitor's ability to detect a different scenario. The intention is for the user to experiment with settings under varying conditions, and develop customized settings that match the situation.

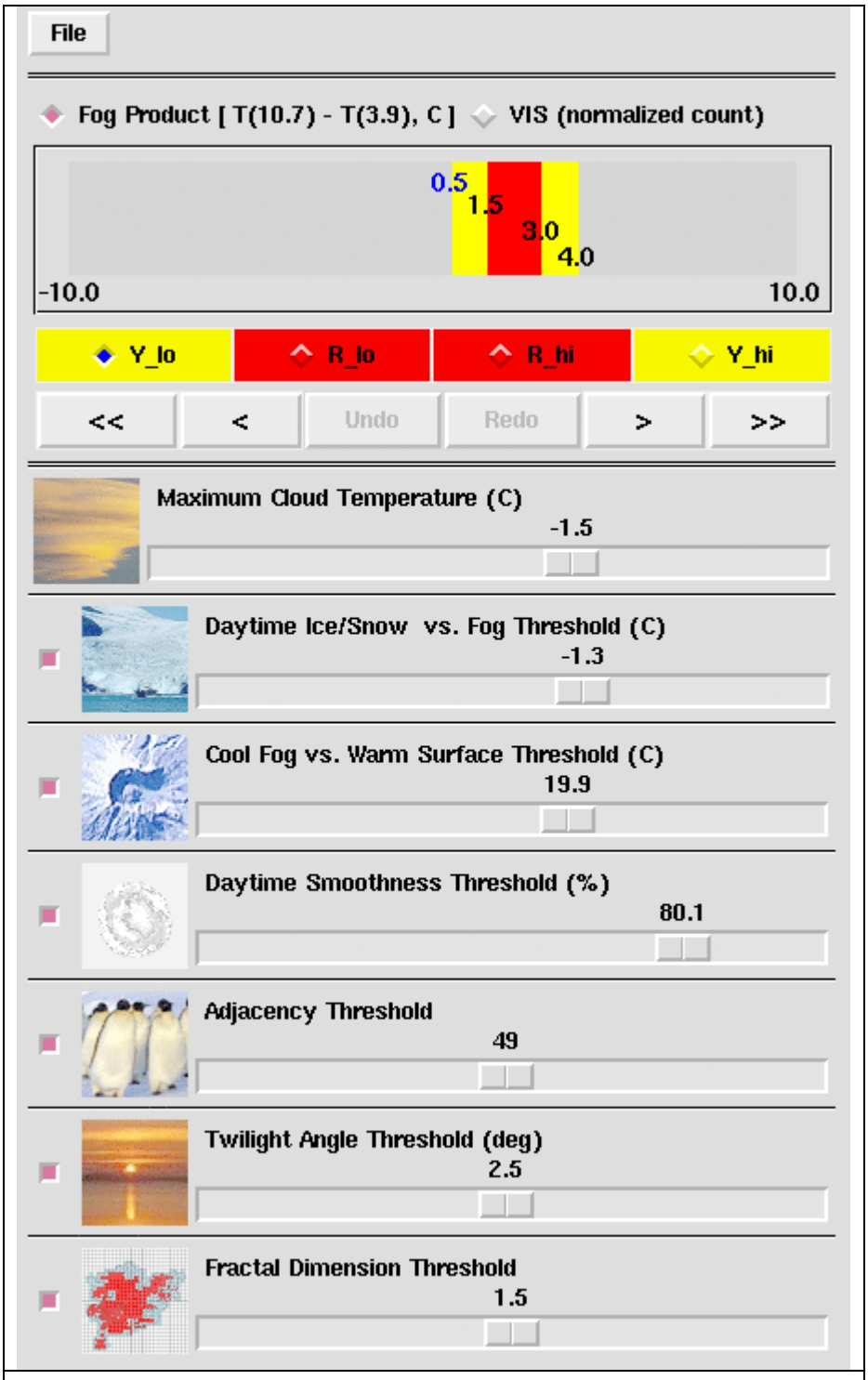

Figure 2.7-1: Fog Monitor Threshold Setup GUI

2.7.1 Configuring the Mandatory Thresholds.

There are three mandatory thresholds which the Fog Monitor uses to discern areas of fog. They are located at the top of the table.

Fog Product [T (10.7) – T (3.9)]

This nighttime threshold setting allows user to adjust the Fog Product's temperature difference range. Highlight the button by the text to select this threshold, and use the left and right arrows to modify the range in which yellow and red areas will appear. Increasing the area of yellow and red will increase the area which can be flagged as potential fog areas. The use of the buttons to modify this selection is described in Table 2.7.1-1.

VIS (Normalized Count)

This is a daytime range of normalized brightness values, perhaps less intuitive than the Fog Product, but the concept is similar. Increasing the range of red and yellow values will increase the likelihood that the application will highlight an area as fog.

Maximum Cloud Temperature (C)

This threshold allows the user to determine the temperature value which the Fog Monitor uses to decide if it is detecting clouds instead of fog. The greater the temperature, the more likely the fog monitor will discount an area as having cloud cover (and thus an unknown status with regards to fog). Lowering the temperature will increase the potential areas the Fog Monitor will consider. As with all algorithm thresholds within this GUI, the user should use meteorological knowledge to determine the settings. A temperature setting of -25 C, for example, is unnecessarily low for fog detection, while a setting of +15 C will be too warm for most clouds.

Table 2.7.1-1. Fog Product and Vis brightness adjustment buttons.

Button	Action
Y_lo	Selects the low-end yellow range for modification
R_lo	Selects the low-end red range for modification (note that the low red range cannot be changed to a lesser value than that of the low yellow range.)
R_hi	Selects the high-end yellow range for modification

Y_hi	Selects the high-end red range for modification (note that the high red range cannot be modified to a greater than that of the high yellow range.)
<	Moves the values lower (0.1 degree for the Fog Product, 1 normalized count value for the VIS thresholds.)
<<	Moves the values lower (1 full degree for the Fog Product, 5 normalized count values for the VIS thresholds.)
>	Moves the values higher (0.1 degree for the Fog Product, 1 normalized count value for the VIS thresholds.)
>>	Moves the values lower (1 full degree for the Fog Product, 5 normalized count values for the VIS thresholds.)
Undo	Revert to the default threshold ranges.
Redo	Restores the user's changes.

2.7.2 Configuring Optional Thresholds.

The rest of the threshold settings on the Fog Monitor's Threshold Setup GUI are for optional algorithms. The user can choose to turn them on (using the buttons on the left) or adjust them (with the scroll bars) based on how well each performs under different fog scenarios.

Daytime Ice/Snow vs. Fog Threshold (C)

This algorithm takes advantage of the strong scattering properties of fog at 3.9 microns when compared to snow or ice. This scattering leads to a higher brightness temperature for fog at 3.9 microns. If the Fog Monitor encounters a bright area that falls within the visible normalized count thresholds (set in this GUI, as described above), then this brightness temperature threshold will help the application distinguish fog from ice or snow cover. Raising the threshold will increase the brightness temperature range which the Fog Monitor will identify with snow or ice.

Cool Fog vs. Warm Surface Threshold (C)

This scroll bar will set a 10.7 micron brightness temperature threshold between a cold fog area and a warmer surface. Because of the assumption of a warmer surface, this threshold will likely work best with radiation fog or evaporation fog, especially when the fog layer is thick (since the satellite data will reveal the brightness temperature of the cool top of the fog layer). This threshold will likely not work as well during an advection fog scenario, when warm air travels over a cool surface.

Daytime Smoothness Threshold (%)

One distinguishing feature between fog and mid-level clouds in visible satellite data is the relative brightness uniformity of fog – it will tend to have a more uniform, "smoother" brightness profile than will clouds. Increasing this threshold will help to filter out bright areas which are not fog. This algorithm is not applicable to the nighttime regime, because both fog areas and mid-level cloud have relatively uniform IR signatures – it would be difficult to distinguish them using the smoothness algorithm.

Adjacency Threshold

Adjusting this threshold higher will increase the minimum size at which an area of fog will be flagged. This will filter out the noise of errant, bright data pixels, though care must be taken to not set the thresholds so high as to eliminate legitimate small-scale, patchy fog.

Twilight Angle Threshold (deg)

As mentioned previously, dawn and dusk pose challenges for the Fog Monitor – enough so that the application will apply an "unknown" determination to areas illuminated by low-angle sunlight. This threshold determines the maximum sun elevation (no lower than 0.1 degrees) at which to apply the twilight "unknown" default. The higher the angle, the more area will be covered by the twilight default.

Fractal Dimension Threshold

This is a measure of the "jaggedness" of the edges of the detected area. Decreasing the threshold will only allow the Fog Monitor to consider brightness areas with relatively straight edges, while increasing the ratio allows for shapes with more jagged edges. This algorithm will allow the user to filter out the rough edges of low-lying clouds, favoring the more linear edges of fog banks. Cases of valley fog can have jagged edges, though, so the user must be careful not to eliminate those features by setting this threshold too low.

2.7.3 Working with Threshold Changes.

Multiple sets of customized display thresholds may be saved, recalled, and deleted. For these capabilities, use the File menu options accessed on the menu bar of the editor (Figure 2.7.3-1.) "File" menu selections are described in Table 2.7.3-1

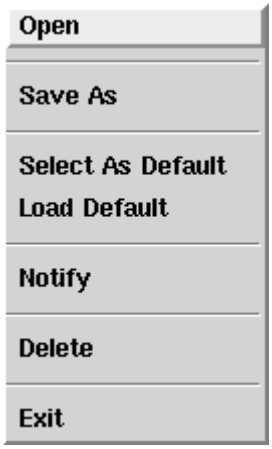

Figure 2.7.3-1 Fog monitor thresholds File menu

Table 2.7.3-1 Fog Thresholds File Menu selection descriptions.

Open	Open a file holding an existing set of thresholds and load the set into the editor.
Save As	A list of display threshold file names is presented. Select an existing file name from the list, or enter a new file name manually. The threshold values displayed in the editor are saved in the user-specified file.
Select As Default	A list of display threshold file names is presented. Select a file name from the list, or enter a file name manually. The threshold values stored in the selected file will be the threshold values subsequently used each time the zone table is launched. The threshold values in the selected file are not loaded into editor.
Load Default	The default threshold values are loaded into editor.
Notify	Signal the Fog Monitor that the configurations have been changed. This prompts the Fog Monitor to change the displays based on the new configurations.
Delete	Permanently delete a display thresholds file. Select a file name from the list, or enter the file name manually.
Exit	Closes the editor without saving or applying any additional editing changes.

Note that a "**Notify**" selection must be made if the Fog Monitor is to incorporate the threshold configuration changes. After the notification is received, the Fog Monitor will reach back to past output (as far as is selected in the Time Window of the Fog Monitor Area Configuration GUI). Subsequent output, though, will revert to the default threshold configurations. If the new changes are to apply to future output, then the user must "**Save"** the changes to a file, choose that file via the "**Select As Defaul"t** button, and then choose "**Notify"**. The intended use case scenario is for the user to repeatedly select "**Notify"** to calibrate the thresholds (based on the

quality of the output when compared to the in-situ observations available) then "**Save", "Select As Default"**, and "**Notify"** when satisfied with the results.

As can quickly be gleaned from the above paragraph, the Fog Monitor application is highly interactive and configurable, and requires some user input for best results. The default thresholds are reasonable as delivered, but it is hoped that the user will improve upon them, as the Fog Monitor is used during various types of fog events.

3 Getting Help

For OB6, questions about the Fog Monitor will be handled through SAFESEAS list server, (though a new, exclusive list server could be created in the future if the interest is high.) To join the SAFESEAS list server:

1. Go to "http://infolist.nws.noaa.gov/read/login/"

2. Select "all forums".

3. Scroll down to the SAFESEAS list, and click "subscribe" on the right column.

4. Enter your email address, name, and password.

Your membership will be approved by the list administrator, and then once approved, you can send, view, and receive messages.

Please also visit the Fog Monitor homepage at:

"http://www.nws.noaa.gov/mdl/fog_monitor/index.htm"

For more information, including discussions regarding the algorithms (theory, citations, weaknesses, etc), as well as build updates and troubleshooting tips.