PcModWin Manual

Version 4.0

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1 Introduction

Thank you for purchasing PcModWin. PcModWin provides a graphical environment in which to set up, run, and manipulate model calculations made by the MODTRAN atmospheric code. MODTRAN lets you calculate the spectral transmittance and radiance for arbitrary atmospheric paths from the microwave through the visible bands. The currently available non-beta version of MODTRAN (MODTRAN 3.7) is included in PcModWin. PcModWin also includes extensive documentation on the MODTRAN model in electronic (Acrobat PDF) form. Readers to display these files (Adobe Acrobat Reader) are included in the PcModWin package.

PcModWin is distributed on a CD-ROM, and is compatible with the Windows 95/98, Windows NT, ME, and 2000 operating systems.

If you run into problems during installation or running the code, you can contact Ontar’s technical support at (USA)-978-689-9622 during USA East Coast business hours (9 AM to 5 PM). Problem descriptions can also be FAX’ed to (USA)-978-681-4585, or e-mailed to ontar@shore.net, at any time. Please be sure to gather as many symptoms about the problem, as well as the characteristics of your machine, before calling. It is very helpful if you can either duplicate your problem with one of the supplied test cases, or provide a PcModWin database file that can reproduce the problem; this greatly assists problem diagnosis on our end. Extended technical support options, providing more detailed support and faster response times, are also available; contact Ontar for more details.

1.1 Software Installation

Installing PcModWin is a straightforward process of running first the PcModWin install program, and then installing the Adobe Acrobat Readers.

Quick install

Insert the PcModwin CD-ROM into the computer, run SETUP.EXE, and accept all the defaults.

If you are new to PcModWin, it is recommended that you then work through the tutorial run described in section 1.2.

For a more detailed discussion of the install steps and options, please read the remainder of this section.
1.1.1 PcModWin Installation

To use PcModWin, the following system requirements apply:

- Intel 80486 or higher PC running Windows 95/98, Windows ME, or Windows NT/2000
- 16 Mb of RAM minimum
- 20 megabytes of hard disk space
- CD-ROM drive

The disk space requirements show the minimum amount of room needed to install PcModWin. When you make MODTRAN calculations, you can generate very large additional files containing the results of calculations. How large depends on the width of the spectral region you are working in, as well as your resolution. You may also find yourself keeping previous calculations for later use, which requires additional disk space. At a minimum, you should plan to have at least 10 megabytes of additional space available on the drive used to run PcModWin.

To install PcModWin, follow these steps:

1. Insert the PcModWin CD into your CD-ROM drive,
2. Run the setup program in the root directory on the CD-ROM drive. You can do this by double-clicking on the SETUP.EXE program using Windows Explorer or File Manager, or you can execute it through the Run command, by typing

   D:setup

   where “D” is the letter of your CDROM drive,
3. Follow the setup instructions on the screen.

   During the PcModWin installation, you are asked to make several choices. These are described briefly below.

   **Software License Agreement**

   This displays the copyright and licensing terms under which PcModWin is sold. You must accept the terms of this agreement to continue with the installation.
Installation directory

The install program asks where you want to install the PcModWin software, as shown below:

![Choose Destination Location](image)

The default location is C:\PcModWin. You must select a drive that has adequate space (about 20 Mb minimum for a complete installation) to hold the PcModWin software and documentation. You probably want a drive that has significantly more free space than this, since all MODTRAN output files are stored within this directory, and after extensive use of the software program outputs can take up considerably more space than this minimum. If you want to change the base directory, click on the Browse button and input a new path. If you specify a directory that does not exist, the setup program prompts you to make sure that this is what you want to create.

PcModWin creates three directories within this root directory:

- `\bin` contains MODTRAN executables and data files
- `\usr` holds user test and working cases
- `\novam` contains NOVAM model code

This internal directory structure must be maintained for PcModWin to work properly.
Setup Type

There are three choices on this screen: Program Files, Example Files, or Help Files. Programs files are the actual MODTRAN executables and data files. Example files are versions of all the test cases described in chapter 9. Help files is the on-line windows help. For an initial installation, we strongly recommend that all components be left selected and installed. The total disk space required by all selected components, as well as the drive’s available space, are shown at the bottom of the window. An example of this window is shown below:
Select Program Folder

This dialog box lets you choose the name of the program folder where the PcModWin startup shortcut will be made. You can create a new folder, or place the PcModWin icon into an existing one.

![Select Program Folder dialog box]

Setup will add program icons to the Program Folder listed below. You may type a new folder name, or select one from the existing Folders list. Click Next to continue.

Program Folders:
PcModWin4.0

Existing Folders:
Accessories
ACSC_V3
ActivePerl
Adaptec Easy CD Creator 4
Ad-aware 4.55
Adobe
Adobe Acrobat 4.0
AutoQuart

After this last screen, PcModWin is installed on your computer, and upon completion is ready to run.

Acrobat Reader

This manual and some supporting MODTRAN documentation are provided with PcModWin in Adobe Portable Document Format (PDF) on the PcModWin CD-ROM. These documents can be viewed using the freely distributed Adobe Acrobat Reader. If you do not already have the Acrobat Reader installed on your system, a current version of the reader can be downloaded, free of change, from Adobe's web site www.adobe.com.
1.2 Sample Checkout Run

This section will walk through the calculation of a sample PcModWin test case. It lets you confirm that your installation is complete, and also gives a quick look at some of the PcModWin features. If you are reading the electronic version of this manual, items highlighted in blue are links to additional documentation about the option, which you can optionally follow by clicking on them. Complete documentation of all PcModWin commands and components, as well as the MODTRAN model itself, can be found in the following chapters. To simplify this example, we will be using a test case (CASE03) that is supplied with PcModWin.

Start PcModWin by clicking on the PcModWin icon in the program group created by the install program. You will see an opening screen like the one below:

![Opening Screen](image)

We can load the test case inputs from a PcModWin database file. This saves the effort of manually entering all the variable values prior to executing a MODTRAN run. The database files can be accessed through the File | Open menu. Click on that menu item (first click on File, and then on Open in the list displayed below it, as illustrated below).
You will see a file dialog box like the one shown below:

Select the database file by either double-clicking on the **case03.ltn** file in the file list, or by entering this name in the File Name box in the upper left corner and then typing Enter. The display returns to the top level window, but you will notice that the window title now echoes back the name of the currently loaded database file (along with its drive and path on disk).

The top level window also schematically displays the geometry of the currently loaded case, as shown below:
The path is drawn in red, and the observer location is denoted with the schematic “eye”. In this case, the observer is located at 1.5 km altitude and is looking straight up to 6 kilometers. This feature is handy for visualizing the path geometry. You can directly edit the geometry by clicking on the blue box in the middle or the red box at the end of the path. The blue box changes the angle of the path (the Zenith Angle), while the red boxes changes either of the the path endpoint altitudes (here labeled as Observer Height and H2). The actual values that will be used by MODTRAN are displayed in the text boxes at the top of the screen. Alternately, you can directly enter different values into these text boxes, and the schematic showing the path geometry will change accordingly. You can experiment with this now, but if you want your tutorial results to track what is shown here make sure to restore the geometry to its starting values. You can always just reload the database file to start over.

We can view the MODTRAN inputs set for CASE03 through the Modtran Input menu item. Click on this, and you will see a list screen of screen names as shown below:
Each item listed is an individual window with MODTRAN inputs. The list of screen names loosely tracks the input card structure of MODTRAN inputs (card numbers are displayed in parentheses after the window names that correspond directly to input cards). Most of the screens are displayed in light grey, which indicates they are disabled. Disabled inputs do nothing when you click on them or try to select them. MODTRAN is designed such that inputs for some options are only needed if those options are enabled. For example, the sun position only needs to be specified if you are including the effects of solar scattering in your calculation, or if you are making a calculation of directly transmitted solar irradiance. If your MODTRAN run does not enable the sun, the solar inputs are not needed. PcModWin uses the MODTRAN logic to only enable the screens needed by the current inputs. This reduces the number of inputs that need to be considered, and lets you focus on the ones of importance to your calculation. CASE03 is a very simple case, so only a few inputs are needed. As you change input variables, you will see the list of enabled screens change on this menu. See chapter 4 for a complete discussion of the contents of each input screen, and the rules used to control access to it.

For now, we will just look at the few input screens that contain inputs relevant to CASE03. You can examine the first input screen by clicking on the first item in this menu, Model Atmosphere (1). You will see the following window displayed:
Descriptive names of each input variable are shown on the left, and input boxes are displayed on the right. Many of the inputs whose value have a text equivalent have been replaced with list boxes that display brief text descriptions of each value. This lets you concentrate on the meaning of the inputs; PcModWin converts these prompts into the actual values and format required by MODTRAN. To change any of these items, simply click on the input box and then either enter a new value or, if the inputs are a list of values, use the mouse to select a new value. If you are changing a number, do not type \texttt{<Enter>} after changing the number. Doing this follows Windows input conventions and advances to the next screen. In this sample run, we will not change any variable inputs, but you are encouraged to explore the effects of altering variables on your own. Since the inputs are stored in a disk file, you can always return to the working case by simply reloading the inputs from disk (using \texttt{File | Open} or \texttt{Modtran Inputs | Open} menu items).

Each input variable has help stored for it in a Windows help file. To access the help on any variable, simply click on the descriptive text string that identifies the input (the strings on the left). A help window will appear with information on that variable. The following example is displayed if you click on \texttt{Calculation Option} (the first prompt down on the left):
This help screen shows the MODTRAN variable being set, lists the possible values for this variable, provides a description of it, and shows related variables. Since the help screen is an independent window, you can search around in it to find more information and keep it displayed while you browse through the PcModWin inputs. To close it, click on the box in its upper right corner.
Two buttons are displayed at the bottom left of the screen: Next and OK. These buttons are used to move between input screens. The Next button moves to the next input screen, in MODTRAN order, that is enabled. Clicking on this button will display screen **Atm Column Params and Files (1A)**, as shown below:

![Atmospheric Column Parameters and Files (1A)](image)

The OK button is used to exit the input screen list. Clicking on it returns you to the top PcModWin menu level. Notice that on this second screen there is both a Next and Prev button. The Next button advances to the next screen, while the Prev button moves back to the previous input screen. Use these buttons to navigate through the maze of MODTRAN input screens.

The Help button in the lower right provides a direct jump into the Help file summary for the current input window.
For our sample run, there are only two other MODTRAN screens that contain relevant inputs: First is the Aerosols (2) screen. Click on the Next button to view:

![Aerosols (2) screen](image)

Clicking the Next input button again shows the last screen, Geometry and Spectral Band:

![Geometry and Spectral Band screen](image)
Looking over these three input screens gives a good description of the scenario CASE03 calculates. The type of run, and atmospheric profile used, is shown on the first screen. The aerosol options are shown on the third screen. The path geometry and spectral band are shown on the last screen. We can click on OK to return to the top PcModWin menu and exit MODTRAN inputs.

The other important part of a MODTRAN run is the plotting configuration. PcModWin lets you define up to 10 plots associated with a model run. The plot inputs are stored in the database along with the run. To see the plot inputs stored for CASE03, click first on Modtran Input, and then on Plot Cards (bottom of the pull down menu). You will first see a small dialog box asking the total number of plots:

Just click the OK button to accept a single plot. Now you will see a window showing all the plot options:

This plot screen lets you choose which components to plot (on the left side), and how to configure each plot (on the right side). For now, we will leave these inputs alone, and click the OK button to exit the plot screens and return to the main PcModWin level.
With inputs loaded, we are ready to run MODTRAN. Do this by clicking on Run Model | Run Modtran. A separate DOS window is opened, and MODTRAN is executed in this window. A number of messages are displayed, showing the progress of the calculation. Since CASE03 is a fast-running case, you will quickly see the message ‘Press any key to continue’ displayed in the window. Type any key, and the window is closed. The MODTRAN run is now completed.

To plot the calculation just made, click on the Plot menu item from the main PcModWin menu. Choose Database from the entries shown below it. A plot will be drawn in the PcModWin window:

Here are the answers computed by MODTRAN for this scenario. The different line types are identified by a legend along the right side. The configuration of this plot is controlled by the plot inputs stored in the database file. You can change these inputs by selecting the Plot | Interactive option, as described in the next chapter.

A considerable amount of MODTRAN results are stored in text files generated as the model executes. To view the text output created by MODTRAN, use the Edit | Edit File menu option. A dialog box is displayed as shown below, letting you select one of the output files just created by MODTRAN.
There are three basic output files created by most MODTRAN runs. The file called MODOUT1 corresponds to the TAPE6 file in the MODTRAN documentation. This contains a complete rundown of the MODTRAN inputs, the atmospheric configuration, and the geometry, as well as the final outputs (see chapter 5 of this manual for a more complete discussion). This is normally the file you will want to look at, and the spectral and summary outputs can be found at the end of the file. The MODOUT2 file corresponds to the MODTRAN TAPE7 file, which contains a brief echo of the inputs, followed by a terse version of the spectral outputs. The MODOUT3 file corresponds to the MODTRAN TAPE8 file. This only contains outputs if you have specifically enabled it, in which case it contains the progress of the calculation layer by layer. To select a specific file, either click on it or type the name into the input box. Click on the Open button, and the DOS editor EDIT is launched with this file loaded. You will see a window like this:
You can use EDIT to scroll through the file and view it, independent of the main PcModWin window. When you are finished, use the File | Exit command of Edit to close the window.

That is all there is to running MODTRAN! Of course, we have only scratched the surface of the model capabilities, as well as the plotting, filtering, and scanning functions, that are provided with PcModWin. You are encouraged to load and run all the test cases provided with PcModWin in order to see demonstrations of additional model and PcModWin capabilities.
2 PcModWin Overview

2.1 PcModWin Components

PcModWin provides an environment to allow MODTRAN calculations to operate effectively. MODTRAN is a complex program with many options. PcModWin lets you concentrate on the problem you are solving, while insulating you from the details of setting up input files and running codes.

PcModWin consists of several distinct pieces. Each of these is documented in greater detail in other parts of the manual.

- **User interface program**

  A main program is provided that runs all the input interface programs, the MODTRAN executable itself, and the output tools. This is described in section 2.3.

- **MODTRAN**

  This is a compiled version of the MODTRAN source code. It uses a DOS extender for optimum performance under Windows. A general discussion of the technical features of MODTRAN can be found in chapter 3 and in the electronic documentation provided with PcModWin. A detailed discussion of each MODTRAN input can be found in chapter 4.

- **NOVAM Aerosol Model**

  This is a compiled version of the NOVAM aerosol model that is included with MODTRAN4. To use it, NOVAM must be run separately of MODTRAN; MODTRAN can then read its output files and use the results in aerosol calculations. PcModWin includes a user interface for the NOVAM model and capability to plot the NOVAM outputs.

- **Model output tools**

  Several tools are provided to view the resulting model calculations. A plotting function displays model outputs on the screen; these plots can be exported to the Windows clipboard (for use by other applications), or printed to create hardcopy. The ASCII output files can also be viewed directly with a text editor hooked into the PcModWin menus. These files are described in chapter 5.

- **Scanning function**

  The MODTRAN scanning function, along with an interface that makes it easy to use, is provided in PcModWin. The scanning function is useful for reducing the resolution of
MODTRAN model calculations, to match measured data, or to provide lower resolution results that include the higher spectral resolution source spectrum. Use of the scanning function is described in chapter 6.

- **Filter function**

  The MODTRAN filter function, along with a user interface, is provided as part of PcModWin. The filter function lets you compute integrals from a MODTRAN calculation, optionally including a spectral response shape to represent the effects of a sensor or a bandpass filter. Use of the filter function is described in chapter 7.

- **On-line help**

  A stand-alone help system provides extensive documentation on numerous technical aspects of MODTRAN, as well as complete descriptions of all model and PcModWin inputs. This help system can be accessed from within the input programs, or can be run separately to answer questions about various aspects of MODTRAN and LOWTRAN. Chapter 8 describes the PcModWin help system and its use.

- **Standard Test Cases**

  Eighteen test cases are provided with PcModWin. These test cases run ‘out-of-the-box’, and are intended for use as illustrations of the capabilities of MODTRAN and PcModWin. They can also be used as templates for setting up your own cases. The test cases are briefly discussed in chapter 9.

### 2.2 End-to-end MODTRAN Run

PcModWin requires several distinct steps in order to make a complete calculation. Briefly summarized, they are:

1. **Set up the model inputs.** MODTRAN inputs are configured using the MODTRAN Inputs entry on the main menu of PcModWin. You can start out with default inputs or load a set of values from a database file. This menu entry lets you view and edit any of the MODTRAN inputs. You can also configure inputs to the plotting option. When the model inputs are satisfactory, they can be saved to a database file for later re-use.

2. **Run the MODTRAN calculation.** MODTRAN is run using the Run Modtran entry in the PcModWin menu. Once started, a MODTRAN calculation executes in a separate window. When the calculation is finished, the output files are copied over into some additional locations, and then you must enter a key to close the window.

3. **Plot the model outputs.** Plots are displayed using the Plot entry in the PcModWin menu. You can create plots using the inputs configured when you set up the model run (in step 1), or you can select MODTRAN output files and set up new plotting inputs. You can also plot the results from 2 or more calculations on the same graph.
(4) View the tabular outputs. This is done using the Edit | Edit File entry from the PcModWin menu. This uses the DOS text editor EDIT to view the output files. Since the output files are all ASCII, you can also use a separate Windows text editor (such as Notepad or Wordpad) to view the output files in another window. See chapter 5 for a description of the names and contents of MODTRAN output files.

MODTRAN is a complicated model with many inputs, and it is not unusual to iterate many times through the process described above before you have a calculation that is satisfactory. Since there are many inputs to MODTRAN, it is easy to make a mistake when setting up a case; you are strongly encouraged to go back and check your inputs as part of your analysis of the model outputs. If you are new to MODTRAN, we recommend that you try out the test cases provided with PcModWin. Some of them run very quickly, and provide examples of how to use the code, as well as templates for your own use. The test cases are discussed in some detail in chapter 9.
2.3 Using the PcModWin Main Program

PcModWin is started by clicking on the PcModWin icon in the program group created by the PcModWin install program. Alternately, you can use Explorer to click on the main program executable called PcModWin.exe, located in the \bin directory where PcModWin was installed.

When PcModWin first starts, it displays the following screen:

![PcModWin 4.0](image)

User Interface Environment for MODTRAN 4.0

Release Version  June 2001

Copyright (c) Ontar Corporation  1994-2000
North Andover, MA  01845
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FAX [USA]: (978)-681-4585
Internet:  www.ontar.com

This screen contains a list of options along the menu bar at the top of the screen. These menu bar options are used to access the various components of PcModWin. They can be started either by positioning your mouse cursor over the item and clicking, or by holding down the Alt key on the keyboard and then typing the letter in the menu item that is underlined. For example, to access the File menu using the keyboard, hold down the Alt key and type F. Most of the menu items, once selected, display a list of additional options. The figure below shows the screen after the File menu has been selected:
The pulldown menu below the **File** item shows the menu choices available under **File**. Any of these options can be chosen either with the mouse (by placing the mouse cursor over the item of interest and clicking), or with the keyboard. For the keyboard, the selected item is shown in reverse print (with a black background). You can use the `<up arrow>` and `<down arrow>` keys to move the selection to other items in the menu. To run the selected item, type the `<Enter>` key. You can use the `<left arrow>` and `<right arrow>` keys to select other main menu items. Menu items can also be chosen directly by holding down the *Alt* key and typing the underlined letter. Some menu choices have shortcut keys. In the example above, typing *Alt*-X directly executes the **Exit** option (which exits PcModWin).

The following table summarizes all the menu choices available from the main PcModWin screen:

<table>
<thead>
<tr>
<th><strong>File</strong></th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Open</strong></td>
<td>load a PcModWin database file</td>
</tr>
<tr>
<td><strong>Save</strong></td>
<td>save current inputs away to current database file</td>
</tr>
<tr>
<td><strong>Save As</strong></td>
<td>save current inputs to a PcModWin database file</td>
</tr>
<tr>
<td><strong>Copy</strong></td>
<td>copy current plot to Windows clipboard</td>
</tr>
<tr>
<td><strong>Edit File</strong></td>
<td>run a DOS editor to view a file</td>
</tr>
<tr>
<td><strong>Print Plot</strong></td>
<td>print current plot</td>
</tr>
<tr>
<td><strong>Exit</strong></td>
<td>exit PcModWin software</td>
</tr>
</tbody>
</table>
PcModWin Manual

Edit
Edit Plot   edit inputs to an existing plot
Edit File   run a DOS editor to view a file
Edit Run    switch to a different run in inputs (in batch mode)
Delete Run  remove a MODTRAN run (in batch mode)
Append New Run  add a new MODTRAN run (in batch mode)

Modtran Input
Open        load a PcModWin database file
Save As     save current inputs to a PcModWin database file
Model Atmosphere (1)  run type, atm profile
Atm Column Params and Files  column density adjustments, filenames
Multiple Scattering  select multiple scattering options
Surface at Start of Path  set boundary temperature and surface albedo
Solar Irradiance  solar source function
Aerosols (2)  aerosols main input screen
Card A+  aerosol inputs
Clouds (2A)  cloud or cirrus configuration
User Supplied Cloud Profile (2E1)  cloud profiles
User Supplied Cloud Spectral Data (2E2)  user specified extinction/absorption
VSA Cloud (2B)   ARMY VSA option
New Model Atmosphere (2C)  user defined atmosphere profile
User Supplied Profile (2C1)  individual atmosphere layer inputs
User Supplied Aerosols (2D)  user specified aerosols
User Supplied Extinction (2D2)  user specified aerosol extinction/absorption
Geometry and Spectral Band (3)  geometry and spectral band
Solar/Lunar Irradiance (3A)  solar scattering (trans solar irrad)
Solar/Lunar Geometry (3A1)  solar scattering
Phase Function (3B/3C1-3C6)  user specified aerosol scattering
Surface Spectral Reflectance  inputs for BRDF and Lambertian surfaces
Plot Cards  plotting inputs

Novam Input
Open Novam Param  load NOVAM parameter database file
Save Novam Param  save NOVAM inputs to database file
Novam Parameters  primary screen of NOVAM inputs
Novam Table  vertical profile definition for NOVAM
Run Novam  execute NOVAM with current inputs
Plot Novam Output  plot NOVAM results

Filter
Open        load database file with filter inputs
Save        save filter inputs to database file
Screen 1    access first screen of filter inputs
Screen 2    access second screen of filter inputs
Run Filter  execute filter function

Scan
Open        load database file with scan inputs
Save        save scan inputs to database file
Screen 1    jump to input screen with scan inputs
Run Scan  execute scanning function

Run Model
Run MODTRAN  run MODTRAN model
2.3.1 PcModWin File menu

2.3.1.1 File | Open

This menu item is used to load a PcModWin database file. A database file contains MODTRAN model inputs and plot inputs for up to 10 plots. Use this command to load inputs in from a previously configured database file (or from the supplied test cases). A dialog box is first displayed to make selecting the database easier:

![Open File Dialog Box]

The default filename suffix for PcModWin database files is .LTN, so the dialog box is set to search only for files that have that suffix. This dialog box lets you input the filename
directly (File name box) or click on an existing file in a list (center area), as well as specify the drive and subdirectory location to load from (top controls). You can use the current name shown in the FileName box by clicking the Open button, or change your mind and stop the load by clicking the Cancel button.

After you load a file, its path and name are displayed in the title area of the main PcModWin window. This lets you know what database file you are currently using. If none are loaded, the message ‘NewCase’ is displayed in the title.

If you have been working on some inputs, and decide to load a database file, first make sure that you save your current variable settings (using File | Save As) if they are important. Any variable settings stored in memory are overwritten without warning when you load a database file.

Note that this menu command is equivalent to the Modtran Input | Open command.

2.3.1.2 File | Save

This menu item is used to save the current MODTRAN and plot inputs to a database file. Current inputs are saved away to the currently loaded PcModWin database file.

2.3.1.3 File | Save As

This menu item is used to save the current MODTRAN and plot inputs to a database file. You can configure a MODTRAN run through the PcModWin interface (using the Modtran Inputs menu) and then save all the variable values away to a file for later re-use (with the File | Open, or Modtran Input | Open menu commands). A dialog box is displayed to assist you in specifying the path and filename to save the variable settings to:

![Save MODTRAN File As dialog box](image)

The default filename suffix for PcModWin database files is .LTN, so the dialog box is set to search only for files that have that suffix. This dialog box lets you input the filename directly (File name box) or click on an existing file in a list (center area), as well as
specify the drive and subdirectory location to load from (top controls). You can use the current name shown in the FileName box by clicking the Save button, or change your mind and stop the save by clicking the Cancel button.

Note that this menu command is equivalent to the Modtran Input | Save As command.

2.3.1.3 File | Copy

This menu item copies the currently selected plot to the Windows clipboard. It can now be accessed by other Windows programs, through the standard Paste command. This is useful if you want to place a plot into a document or a graphic that you are developing with some other Windows application. After clicking on this menu option, simply switch to the other program and Paste the plot into it.

2.3.1.4 File | Edit File

This menu option runs a DOS based editor (EDIT) that lets you examine any of the large ASCII output files that may have been generated by a MODTRAN run. When you first start this command, it displays an open file dialog box that lets you select the file to view:

The default filename mask used to load the selection box is generally MODOUT2 or Tape7 and MODOUT3 or Tape8. MODOUT1 (equivalent of Tape6) is the most comprehensive output file. This dialog box lets you input the filename directly (File name box) or click on an existing file in a list (center area), as well as specify the drive and subdirectory location to load from (top controls). You can use the current name shown in the FileName box by clicking the Open button, or change your mind and stop the load by clicking the Cancel button.

After clicking OK, the DOS EDIT program will be run. Use the commands suitable to that editor to view the output file. The editing program is displayed in a completely
separate DOS window. After you exit this editor, you will be returned to the PcModWin top level.

### 2.3.1.5 File | Print Plot

This menu item is used to create hard-copies of plots. If you have not yet displayed a plot, this menu item does nothing when clicked. You must first have run a MODTRAN calculation with Run Model | Run MODTRAN and then used the Plot menu command to have created one or more plots in a series of windows. If you have more than 1 plot, all are displayed (in either a tiled or a cascading fashion, depending on the display mode chosen under the Window menu item). This will create hard-copy of the plot that has focus. If you have displayed the plots in a cascading fashion (using Windows | Cascade), then the top-most plot has focus, and this is the one that will plot. If the plots are displayed in a tiled fashion with Windows | Tile (i.e., a corner of each plot is displayed, with each plot adjacent to the other), then the plot with focus has its menu bar set to the system color for menu bars. All other plots have their menu bar region cleared to white.

After you click on File | Print Plot, a printer dialog box like the one below (it changes for different printers) is displayed:

![Printer dialog box](image)

This box shows the currently selected Windows printer, and lets you view or change some printer options before the plot hardcopy is actually made. The Print Range box is always forced to the “All” Print Range button, which means that it will print all of the selected plot. The “Properties” button lets you select an output resolution from the set supported by your printer. “Number of Copies” lets you print multiple copies of the plot. “Print to File” lets you direct the printer output to a file for later printing. If you check the Print to File box, an additional dialog box is displayed prior to the start of printing:
Here you specify a disk filename where the printer output will be stored. This binary file can later be copied to the printer (using the DOS COPY command, for example) to create a printout at a later date. This is useful for creating plots on printers that are not currently attached to your system. On some systems, printing to a file and then copying the file to the printer is significantly faster than directly using the printer.

After the printing is started, a small information box is displayed, showing the progress of the print by displaying the band number. When the print is finished, you will be returned to the PcModWin main menu.

PcModWin uses your currently installed Windows printer drivers to create hard-copy. If you want to set global printer defaults, use the Control Panel to configure or modify your global printer settings.

2.3.1.6 File | Exit

This menu option is used to exit PcModWin. Note that if you have any inputs set that are not stored away to a database file, they will be lost.
2.3.2 Edit Menu

2.3.2.1 Edit | Edit Plot

This menu entry lets you quasi-interactively edit the inputs used to create a plot without the need to edit the database file (*.plt). If you click on this entry before any plots have been created, it does nothing. If you click it with an existing plot, an input box is displayed with plot parameters that you can edit. Here is an example of the dialog box displayed after running test case CASE03:

The input box is loaded with the plot values used to create the plot. You can edit any of these parameters. If you click OK, the plot will be redrawn with the new values. If you click Cancel, the plot is unchanged. This provides a convenient way to ‘fine-tune’ the settings for a given plot without having to go through the database inputs menu.
2.3.2.2 Edit | Edit File

This menu option runs a DOS based editor (EDIT) that lets you examine any of the large ASCII output files that may have been generated by a MODTRAN run. When you first start this command, it displays an open file dialog box that lets you select the file to view:

The default filename mask used to load the selection box is generally MODOUT2 or Tape7 and MODOUT3 or Tape8. MODOUT1 (equivalent of Tape6) is the most comprehensive output file. This dialog box lets you input the filename directly (upper left), specify the name of an existing file, which will be overwritten (middle left), as well as specify the drive and subdirectory location to save to (middle two input boxes). You can use the current name shown in the FileName box by clicking the OK button (upper right), or change your mind and stop the edit by clicking the Cancel button.

After clicking OK, the DOS EDIT program will be run. Use the commands suitable to that editor to view the output file. The editing program is displayed in a completely separate DOS window. After you exit this editor, you will be returned to the PcModWin top level.

2.3.2.3 Edit | Edit Run (Batch Mode Operation)

This menu entry lets you select different MODTRAN runs for editing in the Modtran Input menu. MODTRAN supports multiple model calculations in a single pass. When you start out with new inputs, or if you load one of the standard case database files provided with PcModWin, only 1 run is enabled. You can add more runs using the Edit | Append New Run menu item. If more than one run is enabled, use this menu command to switch between different runs.

When you run this menu item, a dialog box is displayed that lets you select the run to change to. If only a single run is defined, the dialog box looks like this:
If you enter a number other than 1 at the **Edit Run Number** prompt, it is ignored. If you have 3 runs defined, the dialog box will look like this:

![Edit Run Number dialog box](image)

You can now change the run number from 1 to 3. The current run number is displayed in the window titles as you move between the screens under **Modtran Input**.

When you run MODTRAN, all of the runs that you have defined will be executed in order. PcModWin supports a maximum of 10 runs in a single MODTRAN pass.
2.3.2.4 Edit | Delete Run (Batch Mode Operation)

This menu item lets you remove a run from the MODTRAN inputs. MODTRAN supports multiple model calculations in a single pass. When you start out with new inputs, or if you load one of the standard case database files provided with PcModWin, only 1 run is enabled. You can add more runs using the Edit | Append New Run menu item. If more than one run is enabled, use this menu command to remove a run that is not needed.

When you run this menu item, a dialog box is displayed that lets you select the run to delete:

If only 1 run is defined, this box is still displayed, but any numbers entered for the Delete Run Number prompt are ignored. You cannot have less than 1 run defined. After you delete a run that is in the “middle” of a set, the higher numbered runs are renumbered to one lower.

2.3.2.5 Edit | Append New Run (Batch Mode Operation)

This menu item lets you add a run to the MODTRAN inputs. MODTRAN supports multiple model calculations in a single pass. When you start out with new inputs, or if you load one of the standard case database files provided with PcModWin, only 1 run is enabled. You can add more runs using the this menu item. Once more than 1 run is defined, use the Edit | Edit Run menu command to switch between runs, and use the Edit | Delete Run menu command to remove unneeded ones.

When you click this item, no dialog box or any other indication of change is displayed. An extra run is added to the inputs. You can see this by then clicking on the Edit | Edit Run menu command. The total number of runs will have been increased by 1.
2.3.3 Modtran Input Menu

This menu is the gateway to setting up MODTRAN and plot inputs for a given run.

2.3.3.1 Modtran Input | Open

This menu item is used to load a PcModWin database file. A database file contains MODTRAN model inputs and plot inputs for up to 10 plots. Use this command to load inputs in from a previously configured database file. A dialog box is first displayed to make selecting the database easier:

![Database File Dialog Box]

The default filename suffix for PcModWin database files is .LTN, so the dialog box is set to search only for files that have that suffix. This dialog box lets you input the filename directly (File name box) or click on an existing file in a list (center area), as well as specify the drive and subdirectory location to load from (top controls). You can use the current name shown in the FileName box by clicking the Open button, or change your mind and stop the load by clicking the Cancel button.

After you load a file, its path and name are displayed in the title area of the main PcModWin window. This lets you know what database file you are currently using. If none are loaded, the message ‘NewCase’ is displayed in the title.

If you have been working on some inputs, and decide to load a database file, first make sure that you save away your current variable settings (using File | Save As) if they are important. Any variable settings stored in memory are overwritten without warning when you load a database file.

Note that this menu command is equivalent to the File | Open command.
2.3.3.2 Modtran Input | Save As

This menu item is used to save the current MODTRAN and plot inputs to a database file. You can configure a MODTRAN run through the PcModWin interface (using the Modtran Inputs menu) and then save all the variable values away to a file for later re-use (with the File | Open, or Modtran Input | Open menu commands). A dialog box is displayed to assist you in specifying the path and filename to save the variable settings to:

The default filename suffix for PcModWin database files is .LTN, so the dialog box is set to search only for files that have that suffix. This dialog box lets you input the filename directly (File name box) or click on an existing file in a list (center area), as well as specify the drive and subdirectory location to load from (top controls). You can use the current name shown in the FileName box by clicking the Save button, or change your mind and stop the save by clicking the Cancel button.

Note that this menu command is equivalent to the File | Save As command.

2.3.3.3 Modtran Input | Input screen entries

All the menu entries below the Save As call up one of the MODTRAN input screens. Use these entries to locate specific MODTRAN variables and set them to new values. If you are new to MODTRAN, work through the screens from top to bottom on the menu. Not all screens will be enabled for a given case. PcModWin uses the MODTRAN rules to disable any screens that are not needed for the current model run. For example, screens 2C and 2C1 are used to set up a user defined atmospheric profile. If you have selected one of the default profiles built into MODTRAN, these input screens are not needed, and thus will be disabled (displayed in light grey) on this menu. For a description of the contents of each input screen, as well as the rules that control whether it is enabled or not for a given run, see chapter 4.
2.3.4 NOVAM Input Menu

This menu lets you set up and execute the standalone NOVAM aerosol code, developed by the Ocean and Atmospheric Sciences Division, Naval Command Control and Ocean Surveillance Center, RDT&E Division, in San Diego, CA. This model predicts the vertical distribution of aerosols in the first 6000 meters above the ocean and represents a significant improvement over the earlier maritime aerosol model options. MODTRAN 3.7 and higher provide an interface that can read the output files created by this model. NOVAM is run independently of MODTRAN. PcModWin 4 provides the capability to set up and prepare NOVAM calculations for use in MODTRAN.

2.3.4.1 NOVAM Input | Open NOVAM Param

This item lets you load a set of NOVAM input parameters that are stored in a file. A file open dialog like the one below is displayed:

![Open File Dialog](image)

The default filename suffix for NOVAM database files is .NPR, so the dialog box is set to search only for files that have that suffix. This dialog box lets you input the filename directly (File name box) or click on an existing file in a list (center area), as well as specify the drive and subdirectory location to load from (top controls). You can use the current name shown in the FileName box by clicking the Open button, or change your mind and stop the load by clicking the Cancel button.

After you load a file, you can edit its inputs or execute the case using the other NOVAM menu items in PcModWin.
2.3.4.2 NOVAM Input | Save NOVAM Param

This lets you save the current set of NOVAM input parameters to a file. A dialog box is displayed to assist you in selecting a filename to save current NOVAM variable settings to:

The default filename suffix for NOVAM database files is .NPR, so the dialog box is set to search only for files that have that suffix. This dialog box lets you input the filename directly (File name box) or click on an existing file in a list (center area), as well as specify the drive and subdirectory location to load from (top controls). You can use the current name shown in the FileName box by clicking the Save button, or change your mind and stop the save by clicking the Cancel button.
2.3.4.3 NOVAM Input | NOVAM Parameters

This provides access to the main NOVAM parameter input screen. This screen is shown below:

You can directly edit the parameter settings for the NOVAM calculation from this screen. Note that the detailed NOVAM vertical profile can be entered by clicking on the NOVAM Table button in the lower left of the screen.

When you have finished editing or viewing the inputs, click the OK button along the button to exit this screen.
2.3.4.4 NOVAM Input | NOVAM Table

This provides an editor to enter or change the vertical atmospheric profile used by NOVAM. This screen is shown below:

![Novam Table](image)

Use the vertical slider on the right of the screen to scroll through the inputs. When you are finished with viewing or editing the inputs, click the OK button to exit this screen. If you want to review or change the rest of the NOVAM inputs, click the NOVAM Param button.

The detailed vertical profile for a NOVAM calculation can get quite large, as NOVAM requires considerable vertical detail for an accurate calculation. The example shown in this screen is taken from one of the NOVAM test cases provided with PcModWin.

2.3.4.5 NOVAM Input | Run NOVAM

This executes the NOVAM model, using the last set of inputs viewed in PcModWin. Since the NOVAM executable is provided as a DOS executable, a DOS window is displayed and any model messages are echoed there. At the end, you must press a key to close the DOS window and complete NOVAM execution.
2.3.4.6 NOVAM Input | Plot NOVAM Output

This plots some of the NOVAM code outputs. When you click this menu, first a plot input screen is displayed, as shown below:

This screen lets you choose the NOVAM component ("Y Value") and wavelength to plot. Up to 15 separate wavelengths or components can be plotted on a single plot. On the far right is a column of inputs that configure the plot axes.

After you click OK the requested plot is displayed. An example plot is shown below:
2.3.5 Filter Menu

This menu item lets you set up and use the PcModWin filter function. The filter function use, and individual inputs, are described in chapter 7.

2.3.5.1 Filter | Open

This menu item is used to load a PcModWin filter database file. A filter database file contains inputs for the filter function. Use this command to load inputs from a previously configured filter database file. A dialog box is first displayed to make selecting the database easier:

The default filename suffix for PcModWin filter database files is .FLT, so the dialog box is set to search only for files that have that suffix. This dialog box lets you input the filename directly (File name box) or click on an existing file in a list (center area), as well as specify the drive and subdirectory location to load from (top controls). You can use the current name shown in the FileName box by clicking the Open button, or change your mind and stop the load by clicking the Cancel button.

If you select OK, the filter inputs will be changed to the ones read from the filter file. You can view the new input values using the Screen 1 and Screen 2 menu items under Filter.

2.3.5.2 Filter | Save

This menu item is used to save the current filter inputs out to a database file. You can configure a filter function through the PcModWin interface and then save all the variable values away to a file for later re-use with this menu command. A dialog box is displayed to assist you in specifying the path and filename to save the variable settings to:
The default filename suffix for PcModWin filter database files is .FLT, so the dialog box is set to search only for files that have that suffix. This dialog box lets you input the filename directly (File name box) or click on an existing file in a list (center area), as well as specify the drive and subdirectory location to load from (top controls). You can use the current name shown in the FileName box by clicking the Open button, or change your mind and stop the save by clicking the Cancel button.

2.3.5.3 Filter | Screen 1

This menu option displays part of the filter function inputs. Print options, run options, and the use of a blackbody in the calculation are covered here. For a detailed discussion of this input screen, see chapter 7.

2.3.5.4 Filter | Screen 2

This menu option displays the rest of the filter function inputs. The spectral coverage and size of the filter, as well as the actual filter values, are accessed through this menu item. For a detailed discussion of this input screen, see chapter 7.

2.3.5.5 Filter | Run Filter

This menu command executes the filter function, on the current MODOUT2 or TAPE7, using the currently defined filter function inputs. If you want to apply a filter that is defined in a database file, you must first load the database inputs using the Filter | Open command. See chapter 7 for additional filter function discussion.
2.3.6 Scan Menu

This menu item lets you set up and use the PcModWin scanning function. The scanning function use, and individual inputs, are described in chapter 6. MODTRAN 3.7 and higher provide some scanning functionality directly; this can be used during a MODTRAN calculation, using inputs on the Geometry and Spectral Band PcModWin input screen.

2.3.6.1 Scan | Open

This menu item is used to load a PcModWin scan database file. A scan database file contains inputs for the scanning function. Use this command to load inputs in from a previously configured scanning database file. A dialog box is first displayed to make selecting the database easier:

The default filename suffix for PcModWin scan database files is .SCN, so the dialog box is set to search only for files that have that suffix. This dialog box lets you input the filename directly (File name box) or click on an existing file in a list (center area), as well as specify the drive and subdirectory location to load from (top controls). You can use the current name shown in the FileName box by clicking the Open button, or change your mind and stop the load by clicking the Cancel button.

If you select OK, the scan inputs will be changed to the ones read from the scan file. You can view the new input values using the Screen 1 menu item under Scan.
2.3.6.2 Scan | Save

This menu item is used to save the current scan inputs out to a database file. You can configure a scanning function through the PcModWin interface (using the Scan menu) and then save all the variable values away to a file for later re-use (with the Scan | Open menu command). A dialog box is displayed to assist you in specifying the path and filename to save the variable settings to:

![Save Scan File As dialog box](image)

The default filename suffix for PcModWin scan function database files is .SCN, so the dialog box is set to search only for files that have that suffix. This dialog box lets you input the filename directly (File name box) or click on an existing file in a list (center area), as well as specify the drive and subdirectory location to load from (top controls). You can use the current name shown in the FileName box by clicking the Open button, or change your mind and stop the save by clicking the Cancel button.

If you have not previously loaded a scanning function database, the default name supplied for the save is new.scn, as shown in the example dialog box above.

2.3.6.3 Scan | Screen 1

This menu option displays all of the scanning function inputs. The spectral band and the new resolution to scan to are covered here. For a detailed discussion of this input screen, see chapter 6.

2.3.6.4 Scan | Run Scan

This menu command executes the scanning function, on the current MODOUT2 or TAPE7, using the currently defined scan function inputs. If you want to use a scan that is defined in a database file, you must first load the database inputs using the Scan | Open command. See chapter 6 for additional scanning function discussion.
2.3.7 Run Model Menu

The Run Model menu is used to execute the MODTRAN model, using the currently set MODTRAN inputs. A DOS window is displayed, since MODTRAN is run as a DOS extended executable. The progress of the calculation is echoed here. When the calculation has completed, you must press a key to close the window. Before pressing a key, you should check the text displayed in this window to ensure that the MODTRAN calculation completed successfully. If MODTRAN displayed any error messages, or crashed, the indications of this can be found in the text displays in this window.

PcModWin uses a compiled version of MODTRAN that conforms as closely as possible to the version distributed by the Air Force Research Laboratory. The resulting module does not communicate any information back to the main PcModWin program, other than through screen prompts and output files.

2.3.7.1 Run Model | Run MODTRAN

Clicking Run MODTRAN will start up MODTRAN execution of the currently loaded database file. The current inputs are used to build a file in the format required by MODTRAN (the file is modin or TAPE5 in the MODTRAN documentation). MODTRAN is then executed in a separate window. MODTRAN is provided as a DOS-extended executable in the PcModWin distribution. For compute-intensive FORTRAN models, a better execution time (and overall better system performance) is obtained with DOS-extended executables than with true Windows programs.

Information concerning the progress of the model calculation is displayed in this DOS window as it runs. When MODTRAN terminates (either normally or with an error condition), the window pauses, requiring a keystroke before closing. This lets you see that the model calculation completed successfully. If there are any error messages displayed, you can note them and take appropriate action to remove the errors before running again.
2.3.8 Plot Menu

The Plot menu provides access to graphical display of MODTRAN outputs. You can configure a plot in two ways: (1) set the plot inputs while you are configuring the MODTRAN run (using Modtran Input | Plot screens menu entry); or (2) interactively by selecting an existing MODTRAN output file. You can also modify an existing plot by first giving it focus and then using the Edit | Edit Plot menu item to change it. Finally, plots of data from separate runs can be made using the Multiple Files option.

Each plot is created in a separate window. Once these windows are created, you can either print them (using the File | Print Plot menu option) or copy them to the Windows clipboard (using the File | Copy menu option) for import into other Windows programs.

2.3.8.1 Plot | Database

This plot option uses the plot inputs that were specified under the Modtran Input | Plot screens menu item to build plots. Up to 10 plots can be specified in this manner. Each plot is created in a separate window. Use the Window menu option to control how the plots are displayed on screen and to remove old plots no longer needed.

When you click this item, the currently existing MODTRAN output files (MODOUT2 or TAPE7 and MODOUT3 or TAPE8) are used to create plots with the currently set database plot inputs. This can result in confusing plots if the database inputs that you loaded do not correspond with the existing MODTRAN output files. In general, if you switch input database files, the MODTRAN calculation should be repeated before attempting to use the this option. If you want to plot an existing MODTRAN output file, use the Plot | Interactive option, which is described in the next section.

If many complex plots are displayed on the screen, you might notice that performance of PcModWin is degraded. This is because the plot windows are being refreshed (replotted) as other items move across them. This problem can be alleviated by either minimizing the plot windows (using the Minimize option in the window box displayed by clicking on the upper left corner of each plot window) or by clearing out unneeded plots (using the PcModWin menu option Window | Close All).
2.3.8.2 Plot | Interactive

The Interactive option lets you plot an existing MODTRAN output file. First you must select the file containing the MODTRAN results to plot. A file dialog box is displayed, and files without extensions are displayed in the selection box:

On your system, many additional files may be displayed. Since the PcModWin plotting expects files in the MODTRAN output format (MODOUT2 or TAPE7), selecting a non-MODTRAN output file will result in errors and no plot. Generally you should limit yourself to MODOUT2, or one of the files with a .FL7 extension (created when a backup is made after a MODTRAN run). This dialog box lets you input the filename directly (File name box) or click on an existing file in a list (center area), as well as specify the drive and subdirectory location to load from (top controls). You can use the current name shown in the FileName box by clicking the Open button, or change your mind and stop the load by clicking the Cancel button.
Once you have selected a file for plotting, a plot inputs screen is displayed:

![Plot inputs screen]

This screen lets you configure the plot that will be created. The list of plot components shown in the left column will change, depending on the contents of the file selected for plotting. The above example is for a MODOUT2 or TAPE7 that contained a transmission run (CASEM3). For transmission files, a More button is displayed that provides access to additional transmission components.

The use and meaning of each of these plotting inputs is described in chapter 4.4. Set the inputs as you want for your plot. If you are not sure of the spectral range and the minimum and maximum Y axis values, use the Autoscale box (in the upper right corner) to choose initial reasonable defaults that are based on the contents of the file. Once you are satisfied with the inputs, click the Ok button. The plot will now be displayed in a new window. The max/min x and y values in the file will be shown in this dialog box the next time it is displayed. If you then want to modify the plot further, you can either use the Edit | Edit Plot menu option or repeat this Interactive plot option, selecting the same file as the source of data.
2.3.8.3 Plot | Multiple Files

This menu option lets you plot the results from several separate MODTRAN runs on a single plot. This is useful for comparing the outputs of different model calculations. First you must select the files that contain the data for the plots. When you click on this menu item, a file dialog box is displayed to assist in this process:

Files stored in the working (\usr) directory with a .FL7 extension (created after each MODTRAN run) are displayed in the selection box. This dialog box lets you input the filename directly (File name box) or click on an existing file in a list (center area), as well as specify the drive and subdirectory location to load from (top controls). You can use the current name shown in the FileName box by clicking the Open button, or change your mind and stop the load by clicking the Cancel button.

You select the files one at a time, clicking the Open button for each selection. When you are done selecting all the files, click the Cancel button, and the PcModWin plotting program will move on to display a plotting inputs screen, based on the type of data contained in the selected files (transmission or radiance plots). After you set the properties of the plot and click OK on the plot inputs window, all of the files and components selected are plotted.

Note that only files containing the same type of MODTRAN run (transmission, radiance, or irradiance) can be plotted together using the Multiple Files option. If you specify files with different types of outputs, the following error dialog box is displayed:
Clicking either OK or Cancel will end the Multiple Files plot option without any plots being created.

### 2.3.8.4 Plot | Difference Plot

This plotting option lets you plot the difference of the same component within a calculation that contains multiple runs, or the same component across multiple files. This allows graphical comparisons of two MODTRAN runs. To make multiple runs into a single set of MODTRAN outputs, use the Batch mode options on the Edit menu to add and configure multiple runs. When you click this menu item, you are first shown the following dialog box:

This selects which of the above options will be plotted.

If you choose to plot the difference between runs within a file (the upper option), the following dialog is then shown:

Next you must select a MODTRAN output file that contains the multiple runs. An open file dialog is displayed:
The file MultiM3.FL7 is selected in this example. This file was created by taking the standard Case03, appending a run to it (using the Edit | Append New Run command), and then changing the Zenith angle on the second run from 0 to 30 degrees. This lets us evaluate the effect of changing our look angle from straight up to 30 degrees to the side. After selecting the file and clicking open, a standard plotting inputs window is displayed, appropriate to the type of data stored in the file. In this case, it is a transmission run, so the transmission component plotting window is displayed:
You can now configure the plot, choosing which component(s) will be differenced, as well as the axes and size of the plot. After you click OK, the difference plot is displayed.

If you choose to plot the difference between files, two standard file selection dialog boxes are displayed. With these you choose the two files to plot. Next the appropriate plot inputs screen is displayed (either a transmission or a radiance version), and then finally the plot is displayed in a PcModWin window.

This feature only works on “Tape7”, or “File7” output files from MODTRAN. This is stored in the MODOUT2 file immediately after a run is completed. “File7” outputs are also archived in the \usr directory using the database filename, followed by a “.FL7” filename extension.

2.3.8.5 Plot | Plot Spec Flux

This option allows plotting of the spectral flux outputs from MODTRAN, after they have been enabled and created by a MODTRAN run. The spectral flux outputs are enabled by setting the Spectral Flux Table input to either Create table, 80 chars/line or Create table, single line. The table must be then created by running MODTRAN with these settings. Once this has been done, you can run this menu option.

First a set of plot input options is displayed on a window. The actual wavenumber bands are derived from the currently existing spectral flux file. An example window is shown below:
This screen lets you choose the spectral flux component ("Y Value") and wavelength to plot. The upward diffuse, downward diffuse, or direct solar fluxes are available. Up to 15 separate wavenumbers can be plotted on a single plot. On the far right is a column of inputs that configure the plot axes.

After you click OK the requested plot is displayed. An example plot is shown below:

![Example plot](image)

**2.3.8.6 Plot | Edit Plot**

This option lets you modify the plotting of the currently selected plotting window. All plotting windows are named at the bottom of the Window menu item, and the “current” one is displayed with a check mark next to it. If the current window is the Logo screen, this menu option does nothing. If the current window is a plot, this menu item can be used to adjust the plotting parameters used to make the plot.

After clicking this menu item, a plot inputs window that is suitable to the type of plot (transmission or radiance) is displayed. Below is shown the example of a plot inputs window for a transmission calculation. See chapter 4.4 for a complete discussion of plotting options.
This screen lets you configure the plot that will be created. The list of plot components shown in the left column will change, depending on the contents of the file selected for plotting. The above example is for a set of files that contained transmission runs. For transmission files, a More button is displayed that provides access to additional transmission components.

The use and meaning of each of these plotting inputs is described in chapter 4.4. Set the inputs as you want for your plot. If you are not sure of the spectral range and the minimum and maximum Y axis values, use the Autoscale box (in the upper right corner) to choose initial reasonable defaults that are based on the contents of the file. Once you are satisfied with the inputs, click the Ok button. The plot will now be displayed in a new window.
2.3.9 Window Menu

This menu item is used to organize the display of plots created with the Plot command. Note that individual plot windows can be resized, moved, minimized, or cleared away using the menu bar, enabled by clicking on the grey box in the upper right corner of each plot window.

2.3.9.1 Window | Cascade

This organizes all of the currently displayed plots as a series of overlapping windows. This provides a more detailed display of the top window. You can place other plots on top by clicking on the top bar of the window. The title of each plot is displayed in the title area of each window, to simplify moving between plots. An example of a cascaded display of three plots is shown below:
2.3.9.2 Window | Tile

This organizes all the currently displayed plots so that all are shown, side by side. This lets you see all the items at once. If you have many plots, only the lower left corner of each will be displayed, however, so it may be difficult to sort out which plot is which. An example of a tiled display of three plots is shown below:

![Tiled Display Example]

The lower left corner of each plot is displayed, and the window title is shifted to the left as far as possible. If your PcModWin window is very small, this mode can be difficult to use, but it provides an instant view of all the current plots without overlap.

2.3.9.3 Window | Close All

This menu option closes all the plot windows.
2.3.9.4 Window | Arrange

This item arranges the icons of all minimized plots along the lower left of the PcModWin window. This is useful if you have several plots minimized and you then resize the PcModWin window. The icons can get lost if other plots are still displayed. Clicking this menu item locates all the minimized plots and arranges them, as shown in the example window view below:

![Example window view](image)

To redisplay any of these plots, simply click on the icon and choose to either restore or maximize it.

2.3.10 Help Menu

This menu provides direct access to the PcModWin online help system. It also provides access to the manuals and documentation that is supplied with PcModWin.

2.3.10.1 Help | Contents

This menu item launches the PcModWin help file.

2.3.10.2 Help | Manual

This launches the Acrobat Reader program (if installed) and loads the electronic version of this manual. You can refer to the manual during program execution.

2.3.10.3 Help | Documentation

This launches an Acrobat PDF file that contains a summary and links to all of the online documentation provided with PcModWin.
2.3.10.4 Help | About

This displays the current version of the program, as shown below:

![About PcModWin for Windows](image)

PcModWin 4.0
Release Version  June 2001

Copyright (c) Ontar Corporation  1994-2000
North Andover, MA  01845
Telephone [USA]: (978)-689-9622
FAX [USA]: (970)-601-4505
Internet:  www.ontar.com

Click OK to close the About Window and return to PcModWin.
3 MODTRAN Overview

MODTRAN (MODerate resolution TRANsmission) is an atmospheric model developed over the past 25 years at the US Air Force Research Laboratory, Backgrounds Characterization Branch at Hanscom AFB, MA. It is the direct successor to the LOWTRAN family of codes; in fact, MODTRAN contains the complete LOWTRAN model as a user option. It can be used to calculate the transmission and/or the radiance for a specified path through the atmosphere. MODTRAN is useful as a stand-alone program; it is also implemented as a subroutine or separate module in many larger system codes. MODTRAN is written as a FORTRAN 77 program, and the full model source code is available to end users for a nominal distribution fee.

Extensive information on MODTRAN can be found in the electronic documentation that is provided on the PcModWin CD-ROM. This chapter just gives some highlights and a general overview of the MODTRAN model.

The MODTRAN transmission calculations use three temperature dependent parameters: an absorption coefficient, a line density parameter, and an average linewidth. The spectral region is partitioned into 1 cm\(^{-1}\) bins for each molecule. Within each bin, contributions from transitions whose line centers fall within the bin are molded separately from nearby lines centered outside the bin. The absorption due to lines within the bin is calculated by integrating over a Voigt lineshape. The Curtis-Godson approximation, which is accurate for the moderate temperature variations in the earth's atmosphere, is used to replace multilayered paths by an equivalent single homogeneous one. Molecular continuum absorption, molecular scattering, and aerosol absorption and scattering are also included. The radiance calculations consider contributions from the following sources:

- atmospheric self-emission
- solar and/or lunar radiance single-scattered into the path
- direct solar irradiance through a slant path to space
- multiple scattered solar and/or atmospheric emitted radiance into the path

MODTRAN is valid over the frequency range 0 to 50000 cm\(^{-1}\), or for wavelengths longer than 0.2 micrometers. MODTRAN's maximum spectral resolution is 2 cm\(^{-1}\); this spectral resolution is adequate for many tasks and is responsible for the name of the model.

The user has many ways of defining the calculation geometry. The geometry package considers effects caused by atmospheric refraction and the curvature of the earth. The atmosphere is treated as a stack of up to 33 atmospheric layers, from 0 to 100 km altitude. Physical parameters, ranging from pressure and temperature to molecular absorption and extinction coefficients, are defined for each layer. Several standard model atmospheres can be used, or the user can supply a custom atmospheric profile based on direct measurements or radiosonde profiles. Aerosol models can also be used to simulate the effects of dust, clouds, or other particulates in the path; standard aerosol profiles or user-supplied ones can be used. As the path travels through each layer in the model, the
atmospheric components of interest are computed and summed over the path and wavelength band.

### 3.1 Path Geometry

The path geometry is an important part of any MODTRAN calculation, since the geometry determines what parts of the atmosphere will play a role in the final answer. MODTRAN contains a general geometry package that provides a variety of ways of specifying the path. MODTRAN 3.x and higher geometry contains significant upgrades that allow many cases to run that failed in earlier versions of MODTRAN and LOWTRAN7. The different types of path inputs are selected by the input **Type of Atmospheric Path** on the PcModWin screen **Model Atmosphere**. Basically, the possibilities are **Horizontal Path**, **Slant Path**, and **Slant Path to Space**. Each type of path satisfies different types of requirements. In general, the geometrical inputs required can be found on the input screen **Geometry and Spectral Band**. Full discussion of individual MODTRAN inputs can be found in chapter 4.

A **Horizontal Path** is a constant pressure path short enough so that the earth curvature is negligible and atmospheric refraction can be ignored. The entire path is assumed to exist within a single atmospheric layer. The geometry is selected by setting **Type of Atmospheric Path** to **Horizontal Path**. The path is then defined using the **Observer Height** and **Path Length**. The height selects which atmospheric layer to use, while the length determines the column densities of each component in the path. This simple geometry is illustrated in the figure below:

![Illustration of Horizontal Path Geometry](image)

The horizontal path specification should not be used for long paths, since the assumption of staying within a single layer will eventually be violated. Note that a horizontal path does not actually have to be horizontal; the orientation of the path does not matter to the current version of MODTRAN, as long as the path stays within a layer.
A **Slant Path** is the general path specification. A schematic illustration of a slant path, for both upward and downward looking directions, is shown in the figure below:

![Schematic Illustration of a Slant Path Between Two Altitudes](image)

The observer is located at altitude H1 (**Observer Height**), and the other end of the path is located at H2 (**Final Height**). The angle $\theta$ between the vertical and the start of the path at H1 is the **Zenith Angle**. The angle between the vertical and the end of the path at H2 is the **Final Angle**. The geometrical distance between H1 and H2 (without atmospheric refraction) is the **Range** input (atmospheric refraction is added by MODTRAN, which is why for long paths the actual path length is usually larger than a directly specified **Range** value).

For the downlooking case (where **Final Height** is less than **Observer Height**), two locations of H2 are possible. These two possibilities are illustrated below. They are referred to as a **Short Path** and a **Long Path**. In general, MODTRAN defaults to the **Short Path**. You can explicitly select either the short or long option through the input **Path Length Type**. If you select a **Long Path**, then the altitude HMIN is specified in the input **Tangent Height**.
Illustration of “Short” and “Long” Paths Possible on Downlook Geometry

For paths of any significant length, atmospheric refraction can significantly extend the actual path length significantly beyond what one expects from just simple geometry. A more detailed example of an uplooking Slant Path is shown in the figure below.
With refraction, the actual path length $S$ is longer than a straight line connecting the Observer Height ($Z_a$ in the figure) and the Final Height ($Z_b$ in the figure). The total refractive bending along the path is shown by $\psi$. This figure also illustrates some of the other important inputs with which the path geometry can be determined: $\beta$ is the Earth Center Angle, $r_e$ is the Radius of Earth, and $\theta_o$ is the Zenith Angle at the observer.

In MODTRAN’s geometry package, you do not have to specify all of these inputs to set up a Slant Path. Instead, only a minimum set has to be defined, and then MODTRAN calculates the rest. PcModWin lets you directly select which method will be used through the input Path Type. Six combinations of inputs are available, all located on the PcModWin input screen Geometry and Spectral Band:

1. Observer Height, Zenith Angle, and Final Height;
2. Observer Height, Zenith Angle, and Range;
3. Observer Height, Final Height, and Range;
4. Observer Height, Final Height, and Earth Center Angle;
5. Final Height, Observer Height, and Final Angle; and
6. Final Height, Final Angle, and Range.

Note that for (2) and (3), MODTRAN will calculate the final altitude and the zenith angle and then proceed as in (1). The actual slant path range will differ from the input value of Range. Methods (2) or (3) should be used when refraction effects are not important (example: path length < 30 km at a zenith angle < 80 degrees). In method (4) MODTRAN determines the proper value of zenith angle, with refraction included, through an iterative procedure. This method should be used when the geometrical configuration of the source and receiver is known accurately, but the initial zenith angle is not known precisely due to atmospheric refraction. The location of the earth's surface for method (4) is determined from the Radius of Earth setting (or from a default radius, if this variable is left at 0). Methods (5) and (6) are new starting in MODTRAN 4, and provide flexibility in cases where the geometry is more accurately known at the end of the path than at the start.

The Slant Path to Space defines a path that ends beyond the top of MODTRAN's atmosphere (100 km altitude for the standard models). This is illustrated in the figure below:
Here the observer is at location H1 (this is the input Observer Height). For zenith angles less than 90°, the path proceeds directly to space. For zenith angles greater than 90°, the path can pass through layers of the atmosphere lower than the observer on its way to space. This provides an alternate way of defining the path, by specifying the tangent height, or the lowest altitude that the path ever reaches. This is commonly referred to as a “limb view”, since it occurs frequently when aircraft, balloons, or satellites observe the horizon of the earth.

The Slant Path to Space can be defined using 3 sets of inputs, all located on the input screen Geometry and Spectral Band. The actual method used is selected by the PcModWin input Path Type:

1. Observer Height and Zenith Angle;
2. Observer Height and Tangent Height; and
3. Tangent Height and Tangent Angle.

Method (2) is used for a limb viewing problem where the Tangent Height is used as the tangent height, or minimum altitude, of the path trajectory.

The top of the atmosphere, for the built in atmospheric profiles, is set by default to 100 km. If you are supplying your own atmospheric data, the top is determined by the altitude of the last layer that you specify.

The different types of geometry are selected by assigning the variables of interest non-zero values. The MODTRAN geometry package follows a complicated set of rules, where it checks variables in a certain order to determine which geometry system it will use. PcModWin simplifies this by through the input Path Type, at the top of the Geometry and Spectral Band input screen. With this input you choose the method you will use to specify the geometry, and then PcModWin ensures that this method is forced in the MODTRAN inputs. The actual geometry selected is reported in the output file (TAPE 6). In addition, the geometry that you define is shown schematically on the
“Visual Geometry” screen. These two features greatly simplify the task of defining an appropriate path geometry with PcModWin.

For a discussion of any of the path geometry variables, see the detailed discussion of the inputs in chapter 4.

### 3.2 Aerosol Models

A very useful feature of MODTRAN is its inclusion of aerosol transmission and radiance effects. Aerosols are basically particles suspended in the atmosphere. Examples of aerosols range from ground or volcanic dust to industrial soot or sea spray. These particles have widely varying sizes and are located only in certain parts of the atmosphere. The MODTRAN aerosol model classifies these particles into 4 regimes:

1. boundary layer aerosols (0 to 2 km)
2. upper troposphere aerosols (2 to 10 km)
3. lower stratosphere aerosols (10 to 30 km)
4. stratospheric (mesospheric) aerosols (30 to 100 km)

Properties of the particles predominantly found in each of these regions are averaged together and included in the provided atmospheric profiles built into MODTRAN. The two primary parameters of interest are the extinction and absorption coefficients.

Within a given atmospheric layer of path length $DS$, the transmittance, $t(v)$, due to aerosol extinction is given by

$$t(v) = \exp \left[ -EXTV(v) \times HAZE \times DS \right]$$

where $EXTV(v)$ is the normalized extinction coefficient for the wavenumber $v$ of the appropriate aerosol model and altitude. $HAZE$ is the aerosol scaling factor. $EXTV(v)$ is found by interpolation of the values stored in the code for the required wavenumber and relative humidity. The extinction tables used in MODTRAN start out with values normalized to 1.0 at 0.55 micrometers. This normalization point is used to scale the entire extinction curve with $HAZE$. $HAZE$ is determined by interpolation of the appropriate aerosol scaling factor profiles according to the meteorological range and season. In MODTRAN, you can either provide the extinction coefficients and scaling factors directly, or use average values provided for a wide range of generic, real-world aerosols - the built-in aerosol models.

Several different aerosol distributions are available for the boundary layer (0 to 2 km). The actual boundary layer aerosol model used is set in the input Aerosol Model Used. The Rural model is intended to represent the aerosol conditions one finds in continental areas which are not directly influenced by urban and/or industrial sources. This continental, rural aerosol background is partly the product of reactions between various gases in the atmosphere and partly due to dust particles picked up from the surface. The particle concentration is largely dependent on the history of the air mass carrying the aerosol particles. In stagnating air masses, for example, under winter-type temperature inversions, the concentrations may increase to values causing the surface layer visibilities
to drop to a few kilometers. The rural aerosols are assumed to be composed of a mixture of 70% water-soluble substance (ammonium and calcium sulfate and also organic compounds) and 30% dust-like aerosols.

The *Maritime* model represents the boundary layer over the ocean. The composition and distribution of oceanic aerosols is significantly different from continental aerosol types. These aerosols are largely sea-salt particles which are produced by the evaporation of sea-spray droplets and then have again grown due to accretion of water under high relative humidity conditions. Together with a background aerosol of more or less pronounced continental character they form a fairly uniform maritime aerosol. This model should be distinguished from the direct sea-spray aerosol which exists in the lower 10 to 20 meters above the ocean surface and which is strongly dependent on wind speed. The Maritime aerosol model is thus composed of two elements: one developed from sea spray, and the other is a continental component which is identical to the rural aerosol with the exception that the very large particles were eliminated, since these will eventually be lost due to fallout as the air masses move across the oceans.

The *Urban* model represents aerosol changes in urban areas, where the rural aerosol background gets modified by the addition of aerosols from combustion products and industrial sources. The urban aerosol model is basically the rural aerosol model with additional carbonaceous aerosols. The sootlike aerosols are assumed to have the same size distribution as both components of the rural model. The proportions of the sootlike aerosols and the rural type of aerosol mixture are set at 20% and 80%.

The *Tropospheric* model is used to represent extremely clear conditions. Above the boundary layer in the troposphere, the aerosol properties become more uniform and can be approximated with a general tropospheric aerosol model. The tropospheric model represents a clear condition and is the rural model without the large particle component, since large aerosol particles are depleted due to settling over time. The tropospheric option for the boundary layer allows use of this very clear condition in the lowest layer of the atmosphere.

The normalized extinction coefficients of the various boundary layer aerosol models are summarized in the plot below.
Advective and radiative fog and rainfall models are also available. The Army Vertical Structure Algorithm (VSA) allows modeling of variations in aerosol density within the boundary layer. A wind dependent oceanic model (Navy Maritime), which includes the effects of aerosols such as sea spray, is also available. The Desert aerosol model also contains a wind speed dependent component, with blowing particles such as sand.

The upper tropospheric aerosols (2 to 10 km) are much more uniform than the boundary layer. Their properties depend less on the effects of large particles, as these tend to settle out of the atmosphere fairly rapidly. The lower stratosphere aerosols (10 to 30 km) are dominated by seasonal changes, rather than local geography. The seasonal changes are linked to changes in the height of the tropopause between seasons. These aerosols exhibit a uniform global distribution. The primary constituent is sulfate particles caused by photochemical reactions. Volcanic dust can make significant changes in this layer, particularly around the time of major eruptions. MODTRAN includes several optional aerosol distributions to model volcanic effects. In the upper atmosphere (30 to 100 km), the primary aerosol is meteoric dust.

Humidity has an important effect on the extinction caused by aerosols. As the relative humidity increases, water condenses from the atmosphere onto the particles. This changes their size and refractive index. MODTRAN models take this effect into account by modifying the absorption and extinction coefficients used.
A significant recent addition to MODTRAN aerosol capability is the addition of support for the NOVAM aerosol code, developed by the Ocean and Atmospheric Sciences Division, Naval Command Control and Ocean Surveillance Center, RDT&E Division, in San Diego, CA. This model predicts the vertical distribution of aerosols in the first 6000 meters above the ocean and represents a significant improvement over the earlier maritime aerosol model options. The Navy aerosol model built into MODTRAN was based on a limited database of measurements made at the shipboard level at sea, and is essentially a non-dimensional model without any real vertical structure. When it is used at distances away from the ocean surface, it assumes that the marine boundary layer is well mixed and that the size distribution of the aerosols remains constant. NOVAM contains data developed from extensive vertical measurements and uses a more sophisticated treatment to consider the effects of the local meteorological conditions on the aerosols in the path.

MODTRAN 4.0 has some very significant upgrades to its aerosol models. Considerable flexibility has been added to the way you can use the aerosols, and an interface to an improved marine aerosol model (NOVAM) has been added. See section 3.5 for a brief listing of the upgrades. Consult the PcModWin on-line help and the electronic documentation provided with PcModWin to learn more about these new features and how to use them.
3.3 Model Atmospheres

MODTRAN offers two general ways to define atmospheric parameters. The user can either provide meteorological data (from measurements or radiosondes) or use one of several generic model atmospheres. These standard atmospheres are provided to allow modeling of average conditions. The model atmospheres contain a 34 layer atmosphere, with 1 km thick layers from 0 to 25 km altitude, 5 km thick layers from 25 to 50 km altitude, and two layers covering 70 and 100 km. Each profile contains the following data for each atmospheric layer: press, temperature, and concentration (in grams/cm²/km) of the 11 molecules supported in MODTRAN: water (H₂O), ozone (O₃), carbon dioxide (CO₂), carbon monoxide (CO), methane (CH₄), the nitrogen oxides (N₂O, NO, and NO₂), ammonia (NH₃), oxygen (O₂), and sulfur dioxide (SO₂). Concentrations of some additional molecules are also maintained so that continuum contributions can be calculated. The six generic profiles are named according to season and latitude:

- 1976 US Standard Atmosphere
- Tropical Model (15 degrees North)
- Midlatitude Summer (45 degrees North, July)
- Midlatitude Winter (45 degrees North, January)
- Subarctic Summer (60 degrees North, July)
- Subarctic Winter (60 degrees North, January)

The 1976 US Standard Atmosphere is taken from the NASA U.S. Standard Atmospheric Supplements, 1976. The other five seasonal models were put together using data from a variety of sources. They are intended to represent average seasonal and latitude variations in atmospheric properties. The three parameters that exhibit the most significant changes with location and time are the atmospheric pressure, temperature, and water concentration. All of the other constituent molecules are relatively uniformly distributed around the globe and thus have only minor variations with time and location. For most molecules, a single profile is included that is the same for all 6 atmospheres.

The following tables contain pressure, temperature, and water vapor concentration data extracted from the atmospheric profile tables. This is useful for providing typical reasonable values for average atmospheric conditions. These values can also be used to fill in gaps in user atmospheric profile data. The first two tables provide separate atmospheric pressure and temperature profiles from 0 to 120 km at 1 to 5 km resolution (50 layers). The last 6 tables report the pressure, temperature, and water concentrations for the 6 standard profiles using the 33 layer atmosphere boundaries.

You can also create custom atmospheric profiles if you want to consider cases more specific than the generic models above. Data from direct measurements of the atmosphere (i.e., radiosondes) can be entered into MODTRAN and used. In addition, the capability to mix and match your custom profiles with defaults is also provided. For example, you can specify your own pressure and temperature profile for a model, and then use the default molecular concentrations provided in one of the generic profiles. You can also alter the concentrations of one molecule and leave the others set to defaults. This flexibility is particularly important when working with incomplete data sets.
PcModWin Manual

Model Atmospheres

Pressure Profile for the 6 Built-in Atmospheric Profiles in MODTRAN
Altitude
0
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95
100
105
110
115
120

Tropical
1.01E+03
9.04E+02
8.05E+02
7.15E+02
6.33E+02
5.59E+02
4.92E+02
4.32E+02
3.78E+02
3.29E+02
2.86E+02
2.47E+02
2.13E+02
1.82E+02
1.56E+02
1.32E+02
1.11E+02
9.37E+01
7.89E+01
6.66E+01
5.65E+01
4.80E+01
4.09E+01
3.50E+01
3.00E+01
2.57E+01
1.76E+01
1.22E+01
8.52E+00
6.00E+00
4.26E+00
3.05E+00
2.20E+00
1.59E+00
1.16E+00
8.54E-01
4.56E-01
2.39E-01
1.21E-01
5.80E-02
2.60E-02
1.10E-02
4.40E-03
1.72E-03
6.88E-04
2.89E-04
1.30E-04
6.47E-05
3.60E-05
2.25E-05

MdLt Sum
1.01E+03
9.02E+02
8.02E+02
7.10E+02
6.28E+02
5.54E+02
4.87E+02
4.26E+02
3.72E+02
3.24E+02
2.81E+02
2.43E+02
2.09E+02
1.79E+02
1.53E+02
1.30E+02
1.11E+02
9.50E+01
8.12E+01
6.95E+01
5.95E+01
5.10E+01
4.37E+01
3.76E+01
3.22E+01
2.77E+01
1.91E+01
1.32E+01
9.30E+00
6.52E+00
4.64E+00
3.33E+00
2.41E+00
1.76E+00
1.29E+00
9.51E-01
5.15E-01
2.72E-01
1.39E-01
6.70E-02
3.00E-02
1.20E-02
4.48E-03
1.64E-03
6.25E-04
2.58E-04
1.17E-04
6.11E-05
3.56E-05
2.27E-05

MdLt Win
1.02E+03
8.97E+02
7.90E+02
6.94E+02
6.08E+02
5.31E+02
4.63E+02
4.02E+02
3.47E+02
2.99E+02
2.57E+02
2.20E+02
1.88E+02
1.61E+02
1.38E+02
1.18E+02
1.01E+02
8.61E+01
7.36E+01
6.28E+01
5.37E+01
4.58E+01
3.91E+01
3.34E+01
2.86E+01
2.44E+01
1.65E+01
1.11E+01
7.56E+00
5.18E+00
3.60E+00
2.53E+00
1.80E+00
1.29E+00
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9.50E-02
4.70E-02
2.22E-02
1.03E-02
4.56E-03
1.98E-03
8.77E-04
4.07E-04
2.00E-04
1.06E-04
5.98E-05
3.60E-05

Tropical = tropical profile (15 N latitude)
MdLt Sum = midlatitude summer (45 N latitude, July)
MdLt Win = midlatitude winter (45 N latitude, January)
SbAr Sum = subarctic summer (60 N latitude, July)
SbAr Win = subarctic winter (60 N latitude, January)

SbAr Sum
1.01E+03
8.96E+02
7.93E+02
7.00E+02
6.16E+02
5.41E+02
4.74E+02
4.13E+02
3.59E+02
3.11E+02
2.68E+02
2.30E+02
1.98E+02
1.70E+02
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1.26E+02
1.08E+02
9.28E+01
7.98E+01
6.86E+01
5.90E+01
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1.82E+00
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2.88E-01
1.47E-01
7.10E-02
3.20E-02
1.25E-02
4.51E-03
1.61E-03
6.06E-04
2.48E-04
1.13E-04
6.00E-05
3.54E-05
2.26E-05

SbAr Win
1.01E+03
8.88E+02
7.78E+02
6.80E+02
5.93E+02
5.16E+02
4.47E+02
3.85E+02
3.31E+02
2.83E+02
2.42E+02
2.07E+02
1.77E+02
1.51E+02
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1.10E+02
9.43E+01
8.06E+01
6.88E+01
5.88E+01
5.01E+01
4.28E+01
3.65E+01
3.11E+01
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3.23E+00
2.24E+00
1.57E+00
1.11E+00
7.90E-01
5.72E-01
2.99E-01
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4.00E-02
2.00E-02
9.66E-03
4.50E-03
2.02E-03
9.07E-04
4.23E-04
2.07E-04
1.08E-04
6.00E-05
3.59E-05

Altitude is in kilometers
Pressure is in millibars

78

1976 Std
1.01E+03
8.99E+02
7.95E+02
7.01E+02
6.17E+02
5.41E+02
4.72E+02
4.11E+02
3.57E+02
3.08E+02
2.65E+02
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1.94E+02
1.66E+02
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4.05E+01
3.47E+01
2.97E+01
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5.75E+00
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2.87E+00
2.06E+00
1.49E+00
1.09E+00
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2.19E-01
1.09E-01
5.22E-02
2.40E-02
1.05E-02
4.46E-03
1.84E-03
7.60E-04
3.20E-04
1.45E-04
7.10E-05
4.01E-05
2.54E-05


Temperature Profile for the 6 Built-in Atmospheric Profiles in MODTRAN

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<th>SbAr Sum</th>
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Tropical = tropical profile (15 N latitude)  
Altitude is in kilometers  
Temperature is in degrees Kelvin 
MdLt Sum = midlatitude summer (45 N latitude, July)  
MdLt Win = midlatitude winter (45 N latitude, January)  
SbAr Sum = subarctic summer (60 N latitude, July)  
SbAr Win = subarctic winter (60 N latitude, January)  
Pressure, Temperature, and Water Profile for Tropical Atmosphere

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Altitude is in kilometers  
Pressure is in millibars  
Temp is temperature in degrees Kelvin  
Rel Hum is relative humidity in percent  
Water is water molecule density in grams per cubic meter (Option/Units = (D) Mass Density (gm/m3))
## Pressure, Temperature, and Water Profile for Mid-Latitude Summer Atmosphere

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- **Altitude** is in kilometers
- **Pressure** is in millibars
- **Temp** is temperature in degrees Kelvin
- **Rel Hum** is relative humidity in percent
- **Water** is water molecule density in grams per cubic meter (Option/Units = *(D) Mass Density (gm/m3)*)
Pressure, Temperature, and Water Profile for Mid-Latitude Winter Atmosphere

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Altitude is in kilometers
Pressure is in millibars
Temp is temperature in degrees Kelvin
Rel Hum is relative humidity in percent
Water is water molecule density in grams per cubic meter (Option/Units = (D) Mass Density (gm/m3))
Pressure, Temperature, and Water Profile for Sub-Arctic Summer Atmosphere

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Altitude is in kilometers
Pressure is in millibars
Temp is temperature in degrees Kelvin
Rel Hum is relative humidity in percent
Water is water molecule density in grams per cubic meter (Option/Units = (D) Mass Density (gm/m3))
Pressure, Temperature, and Water Profile for Sub-Arctic Winter Atmosphere

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Altitude is in kilometers
Pressure is in millibars
Temp is temperature in degrees Kelvin
Rel Hum is relative humidity in percent
Water is water molecule density in grams per cubic meter (Option/Units = (D) Mass Density (gm/m3))
Pressure, Temperature, and Water Profile for 1976 US Standard Atmosphere

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Altitude is in kilometers
Pressure is in millibars
Temp is temperature in degrees Kelvin
Rel Hum is relative humidity in percent
Water is water molecule density in grams per cubic meter (Option/Units = (D) Mass Density (gm/m3))
3.4 LOWTRAN7

LOWTRAN 7 is the predecessor of MODTRAN, and is included as a complete option inside MODTRAN. The transmission calculations use single parameter band models to compute the molecular line absorption of selected atmospheric species. Molecular continuum absorption, molecular scattering, and aerosol absorption and scattering are also included. The radiance calculations consider contributions from the following sources:

- atmospheric self-emission
- solar and/or lunar radiance single scattered into the path
- direct solar irradiance through a slant path to space
- multiple scattered solar and/or self-emission radiance

The LOWTRAN model is valid over the frequency range 0 to 50000 cm\(^{-1}\), or wavelengths longer than 0.2 micrometers. LOWTRAN 7 calculates its results at lower spectral resolution (20 cm\(^{-1}\) full width at half-maximum of a triangular slit function). It can also be interpolated to a step size of 5 cm\(^{-1}\). This low spectral resolution is quite adequate for many tasks and is responsible for the name of the model.

The model uses a single parameter band model for its calculation of molecular absorption and emission. This approach is adequate for the low spectral resolution of LOWTRAN 7, and has the advantage of limiting the amount of computer calculations required, which greatly speeds execution of the program. The code includes effects caused by atmospheric refraction and the curvature of the earth. The atmosphere is treated as a stack of up to 33 layers, from 0 to 100 km altitude. Physical parameters, ranging from temperature and pressure to molecular absorption and extinction coefficients, are defined for each layer. As the path passes through each layer in the LOWTRAN calculation, the relevant atmospheric properties are computed and their effects are summed over the path and wavelength band. Several standard model atmospheres are provided for generic modeling, or direct measurements of atmospheric profiles from radiosondes can be entered. A general purpose geometry package allows considerable flexibility in specifying a given problem and takes into account the effects of both refraction and the curvature of the earth's surface. Note that LOWTRAN 7 assumes that each layer of the atmosphere is in thermal equilibrium, and thus is inappropriate for modeling upper atmosphere (non local thermodynamic equilibrium, or NLTE) paths. For many applications, however, the processes in the lower atmosphere part of the path, where the molecular concentrations are much higher, dominate the integrated result, so this assumption is valid over a wide range of cases.

MODTRAN and LOWTRAN 7 differ in their approaches to calculating molecular transmittance. For several different spectral intervals LOWTRAN 7 uses a one-parameter band model (absorption coefficient) plus molecular density scaling functions. The MODTRAN band model uses three temperature-dependent parameters, an absorption coefficient, a line-density parameter and an average linewidth. The spectral region is partitioned into 1 cm\(^{-1}\) bins for each molecule. Within each bin, contributions
from transitions whose line centers fall within the bin are modeled separately from
nearby lines centered outside that bin. The absorption due to lines within the bin is
calculated by integrating over a Voigt line shape. The Curtis-Godson approximation,
which is accurate for the moderate temperature variations found in the earth's
atmosphere, is used to replace multi-layered paths by an equivalent homogeneous one.

The k-distribution method, which is used in the multiple scattering treatment of
LOWTRAN 7 to correct for averaging over large spectral intervals, is not necessary in
the MODTRAN model. This is true because three (monochromatic) k values are used for
the 5 cm⁻¹ steps of LOWTRAN 7, while the 1 cm⁻¹ MODTRAN steps provide an
equivalent accuracy for the multiple scattering option.

MODTRAN is better suited than LOWTRAN for atmospheric paths which lie
completely above 30 km. This is due to the integration over the Voigt lineshape
combined with the explicit temperature and pressure dependencies of the band model
parameters. The Voigt lineshape is necessary at these altitudes because the Doppler
linewidth is greater than the Lorentz. The 20 cm⁻¹ versions of LOWTRAN suffer
because they use a single set of band model parameters (nominally sea level at 296 K)
coupled with spectrally independent scaling functions for the molecular densities. It is
also worth mentioning that, for paths which lie completely above 60 km, another problem
arises: many of the molecules are no longer in local thermodynamic equilibrium (LTE).
This means that the emissions of some molecular bands can no longer be determined
from the ambient temperature alone. MODTRAN gives reasonable results for those
bands which are in LTE; the problem is identifying those spectral regions which are not
in LTE.

The only reason to use the LOWTRAN7 option is for backwards compatibility when
comparing the results of calculations done in the past. The MODTRAN model contains a
very significant number of advances over the LOWTRAN models, and also fixes
numerous bugs present in the older LOWTRAN code. Recent advances in personal
computer computation capability have made the difference in run-time between the codes
a minor issue. Users are strongly urged to always use the MODTRAN option in all of
their calculations.

3.5 Upgrades in MODTRAN 3.7 and 4.0

Many new features have been added to MODTRAN recently. The version control on
various “releases” of MODTRAN is not tight, so it can be confusing when trying to sort
out exactly what features correspond to which version. We attempt to support the most
stable version that is available. It is easiest to group the discussion of new features into
the improvements made by recent major version numbers: 3.5 (which was never
officially released, although it was widely distributed in a “beta” form), 3.7, and now 4.0.
The discussion here is extracted from the beginning of the draft MODTRAN 4 manual.
Note that while MODTRAN 3.5 was widely distributed and used as a beta version, an
official release was never made, and during its debugging phase it turned into
MODTRAN 3.7. For this reason, Ontar never commercially sold a PcModWin interface.
that supported MODTRAN 3.5. However, a few of the listed features are present in the MODTRAN 3.0 version previously sold by Ontar.

MODTRAN Additions through Version 3.5

Many new features were introduced between MODTRAN 2 (1992) and MODTRAN 3.5 (1996). These include:

* A second multiple scattering option based on the multiple stream discrete ordinate DISORT algorithm (Smyrnies et al, 1988)
* A new carbon dioxide mixing ratio option
* "Heavy" molecule (e.g., CFCs) spectra and profiles
* A set of surface reflectivity (albedo) options added for the path start
* Upgrades to the cloud and rain models
* New solar TOA (Top of the Atmosphere) irradiance databases
* Wavelength/frequency inputs in wavenumbers and nanometers
* Built-in convolution with an instrument slit function
* New plot output files 'pltout', 'pltout.scn', and 'tape7.scn'
* Use of the HITRAN96 database to generate new band model parameters
* The format of the ASCII band model parameter file was changed to accommodate up to 11 temperatures within 132 columns
* Reformulation of the absorption coefficient, line spacing band model parameters, and temperature dependence of the Lorentz half-widths
* Lowering the minimum of the band model parameter temperature grid to 180 K for modeling of the Antarctic tropopause. The MODTRAN band model parameters are now tabulated at six temperatures: 180, 205, 230, 255, 280, and 305 K.
* Improving the line tail treatment by more carefully accounting for the line center locations. A companion refinement was made to the equivalent width calculation within MODTRAN. All Lorentz half-widths are now modeled to vary with temperature to the minus three-quarters power.
* When the observer altitude H1 is above the top of the defined atmosphere, MODTRAN lowers H1 to the top of the atmosphere and adjusts the path zenith angle appropriately. MODTRAN now corrects the solar geometry as well.
* Three new boundary layer altitudes have been added to the MODTRAN model atmospheres at 55, 60, and 80 km. Also, the MODTRAN ground altitude input GNDALT (Card 2) can now be negative.

* The solar vertical flux calculations using the two-stream method have been refined in an attempt to improve low sun angle calculations. Key inputs to the modification are the transmitted solar irradiance to the bottom and top of each layer. The ratio of these irradiances (effectively the decrease in solar transmittance across a layer) can sometimes exceed the calculated vertical layer transmittance. When this occurs, the solar vertical fluxes are calculated using the older approach and a warning is written to the 'tape8' output file. This warning does not mean that the calculations are invalid, only that methods were switched to preserve consistency in the calculation.

For runs not involving clouds, backward compatibility of the 'tape5' input file is maintained through MODTRAN 3.5. In MODTRAN 3.5 the cloud/rain models are made easier to modify and more flexible. Clouds can be placed anywhere within the defined atmosphere, can co-exist with aerosols, and can have a mixed phase composition.

The addition of new parameters necessitated the addition of new input cards and minor modifications to other cards. For MODTRAN discussions, a "card" is an input line in the tape 5 file. For PcModWin, a card is a group of inputs, or possibly a screen of inputs, in the user interface. PcModWin continues to try and group inputs in a manner that follows the MODTRAN card structure, so users can move back and forth between the two methods and can follow references in the printed literature that refer to input cards.

Two changes were made to Card 1. First, the SALB parameter now provides access to spectral surface reflectivity from a selection of default input options. Negative integer values from -1 through -16 select one from an assortment of rudimentary surface types, including snow, forest, farm, desert, ocean, cloud deck, and four sample grass models. Second, the MDEF value on Card 1 was previously either 0 or 1. The value 1 was used with MODEL = 0 or 7 to select a single set of pre-stored molecular profiles for O2, NO, SO2, NO2, NH3, and HNO3. Now, when MDEF = 2 and MODEL = 0 or 7, user specified profiles for the 13 "heavy" molecules consisting of nine chlorofluorocarbons (CFCs) plus ClONO2, HNO4, CCl4, and N2O5 are input. When MDEF < 2, defaults based on the 1990 photochemical predictions (M. Allen, 1990) are provided for the heavy molecules.

Card 1A was introduced to govern the DISORT option, the TOA solar irradiances scanning function, and the CO2 mixing ratio update. The CO2 option is offered because, for historic calibration studies, the mixing ratio of 330 ppmv has been preserved in the code even though the current value is closer to 355 ppmv. (Additional inputs were also appended to Card 1A for MODTRAN 3.7 and 4.0).

Additional new cards govern the cloud parameters. The older form of Card 2A still applies to cirrus clouds, but the format has been condensed. The new alternate form of Card 2A, mandatory for ICLD = 1 through 10, supplies water/ice vertical column densities, humidity, and Henyey-Greenstein scattering phase function asymmetry factors.
It also can trigger the reading of Cards 2E1 and 2E2; Card 2E1 defines cloud and rain profiles, while Card 2E2 defines cloud spectral properties.

The choice of instrument slit function is specified on an expanded Card 4. The new format allows frequency inputs to Card 4 in real numbers, wavenumbers, micrometers or nanometers, and can be used to specify choices of instrument slit functions. The code internally converts wavelength inputs (in micrometers or nanometers) to the nearest integer wavenumbers.

Changes were also made to the output files. Incremental (path within a single layer) column densities for each extinction source are now written to 'tape6', and the multiple scattering contribution to the thermal radiance is printed. There are three additional output files. The file 'pltout' is a two-column file containing frequency or wavelength in column one, and transmittance, radiance, or irradiance in column two. Using the slit function as defined by Card 4 results in the creation of the files 'tape7 scn' and 'pltout scn'. These are simply the convolved outputs for the specified instrument slit function and are analogous to 'tape7' and 'pltout'.

MODTRAN Upgrades to Version 3.7

MODTRAN 3.7 includes a number of upgrades to the aerosol models. The built-in aerosol models are no longer confined to fixed regions, but can be independently moved to any region and can be stretched, compressed, and scaled. The user-supplied spectral parameter input schemes for aerosols have also been improved. These options are invoked using a new input card, Card 2A+. In addition, extensive modifications now allow MODTRAN to incorporate NOVAM, the Navy Oceanic Vertical Aerosol Model (Gatham, 1993). Here, NOVAM is used as a stand-alone code, which is first executed to produce an output file consisting of spectral- and altitude-dependent aerosol extinction, absorption, and asymmetry parameters. MODTRAN, if the NOVAM option is enabled on Card 2, can then read this output file and incorporate the aerosols in subsequent calculations. The stand-alone NOVAM package, courtesy of NRaD (S.G. Gatham, Naval Command, Control and Ocean Surveillance Center, RDT&E Division), is delivered with MODTRAN 3.7 and 4.0. The user's manual for NOVAM is included in Acrobat PDF format on the MODTRAN distribution CDROM.

PcModWin 3.7 supported NOVAM as a completely external program - you were required to sort out use of the model using a text editor to create input files and running it from the DOS prompt. In PcModWin 4.0, additional input screens have been added to allow you to set up and run the model from within the PcModWin interface.

MODTRAN 3.7 also includes an update in its radiative transport algorithm. FASE (a newer version of FASCODE that is not widely distributed) and MODTRAN 3.5 in-band transmitted solar irradiances were compared for O₂, H₂O and CO₂ bands between 0.6 and 5.0 micrometers. The surface predictions based on a 45 degree sun differ by up to 10%, and generally by about 2%. Careful spectral comparison demonstrated that the
discrepancies arise because the MODTRAN 3.5 treatment of line tail absorption does not have sufficient spectral resolution. For MODTRAN 3.7, the spectral resolution of line tail parameters has been increased to 0.25 cm\(^{-1}\). The new band model parameter file, BMP97_01.ASC, contains the 0.25 cm\(^{-1}\) data (line center parameters are still tabulated at 1 cm\(^{-1}\)). The FASE and MODTRAN 3.7 in-band transmitted solar irradiances now agree to within a fraction of a percent.

MODTRAN Upgrades to Version 4.0

MODTRAN 4.0 adds the following features:

* Two correlated-k options: a standard option and a slower, finer resolution option necessary for upper-altitude (>40 km) cooling rate and weighting function calculations. Both options permit more accurate calculation of molecular absorption in the presence of multiple scattering (Card 1)

* A high-speed option, only appropriate in shortwave and UV spectral regions, that uses 15 cm\(^{-1}\) band model parameters (Card 1A)

* Scaling options for water vapor and ozone column amounts (Card 1A)

* An improved, high resolution cloud spectral parameter database.

In addition, some bugs with aerosol calculations in MODTRAN 3.7 have been fixed in MODTRAN 4.0.

3.6 Electronic MODTRAN Documentation

The PcModWin CD-Rom has a directory called MODTRAN Documentation which contain a number of files in the Adobe Acrobat PDF file format. They are excellent reference documents for users who wish to obtain more information about MODTRAN in particular and atmospheric transmission and radiance in general. These files are briefly described below.

There is no installation procedure for these files; they can be read directly from the CD. The Acrobat Reader is freely distributed by Adobe and versions for a wide number of computing platforms can be downloaded from their web site at www.adobe.com.

1 Addition of NOVAM to MODTRAN in Support of OMPS.pdf: This document describes the approach the Air Force Research Laboratory used to add the Navy NOVAM aerosol model to MODTRAN.

2 Atmospheric Transmittance Radiance Computer Code LOWTRAN 5.pdf: This document, along with the next one and the “Users Guide to LOWTRAN 7”, describes the LOWTRAN atmospheric transmission and radiance model. LOWTRAN was the predecessor to MODTRAN. The last version of LOWTRAN was LOWTRAN 7. These documents are helpful in understand the physical assumptions and approaches used in the models.
Atmospheric Transmittance-Radiance Computer Code LOWTRAN 6.pdf: This document is similar to the one above and describes LOWTRAN 6.

Flexible Aerosol Scheme of MODTRAN 37.pdf: MODTRAN 3.7 contains several upgrades to the current aerosol models in MODTRAN, which are described here. The four built-in aerosol models are no longer confined to fixed and essentially non-overlapping regions. Each can be independently moved to any region, and additionally, can be stretched, compressed and scaled. Because they can be moved independently, they can occupy overlapping regions.

Handbook of Geophysics and the Space Environment.pdf: This is a comprehensive reference book which provides engineers and systems operators with facts and data about the earth’s atmosphere and space environment.

Installation and Running MODTRAN with NOVAM.pdf: This document provides information not found in the NOVAM manual (“The Navy Oceanic Vertical Aerosol Model (NOVAM).pdf”) for running NOVAM with MODTRAN.

MODTRAN User's Manual Versions 37 and 40.pdf: This documentation provides complete user instructions for MODTRAN 3.7 and 4.0 and brief descriptions of recently added features. It does not provide the theoretical basis for the models.

MODTRAN 3 User Instructions.PDF: This document is an earlier version of the “MODTRAN User's Manual Versions 37 and 40.pdf”. It is provided here for completeness.

PcModWin30.pdf: This document is the Ontar Manual for our PcModwWin software based on MODTRAN 30.

PcModWin37.pdf: This document is the Ontar Manual for our PcModwWin software based on MODTRAN 3.7 (It is this document).

The MODTRAN 2-3 and LOWTRAN 7 Model.pdf: These documents describe the theoretical basis for the MODTRAN and LOWTRAN atmospheric models. It is an excellent reference source for understanding the physical assumptions in the models.

The Navy Oceanic Vertical Aerosol Model (NOVAM).pdf: NOVAM predicts the vertical distribution of aerosol in the first 6000 meters above the ocean. This model is a significant enhancement to the Navy Maritime model found in MODTRAN, and is described in this document.

Upgrade to MODTRAN Layer Cloud-Rain Models.PDF: The MODTRAN layer cloud/rain models have been upgraded, making them both easier to modify and more flexible. The cloud models affected are all the cumulus and stratus type clouds, both with and without rain.

Users Guide to LOWTRAN 7.pdf: This document is similar to the ones above for LOWTRAN 5 and 6. It described LOWTRAN 7.
### 4 MODTRAN Inputs

Setting up model and plotting inputs for MODTRAN is one of the most challenging tasks of working with this model. PCModWin provides an extensive user interface to assist you when doing this. Inputs for a MODTRAN calculation are accessed under the [MODTRAN Input](#) entry in the main PCModWin menu bar.

### 4.1 MODTRAN Input Screens

MODTRAN inputs are organized into a series of screens of related inputs. Some input screens have only 1 or 2 inputs; these screens have frequently been combined with others, to make the layout of the inputs easier to use. Not all the screens are accessible at a single time. See the discussion in the following section for how to move about between screens and enable/disable them.

The individual screens are accessed through the PCModWin menu entry called MODTRAN Inputs. They are listed with simply a screen number. Once you get familiar with using MODTRAN, the screen number locations of various variables becomes second nature, but for new users the general content of each screen is listed below:

<table>
<thead>
<tr>
<th>Screen Name</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>Model Atmosphere (1)</td>
<td>run type, atm profile</td>
</tr>
<tr>
<td>Atm Column Params and Files</td>
<td>column density adjustments, filenames</td>
</tr>
<tr>
<td>Multiple Scattering</td>
<td>select multiple scattering options</td>
</tr>
<tr>
<td>Surface at Start of Path</td>
<td>set boundary temperature and surface albedo</td>
</tr>
<tr>
<td>Solar Irradiance</td>
<td>solar source function</td>
</tr>
<tr>
<td>Aerosols (2)</td>
<td>aerosols main input screen</td>
</tr>
<tr>
<td>Card A+</td>
<td>aerosol inputs</td>
</tr>
<tr>
<td>Clouds (2A)</td>
<td>cloud or cirrus configuration</td>
</tr>
<tr>
<td>User Supplied Cloud Profile (2E1)</td>
<td>cloud profiles</td>
</tr>
<tr>
<td>User Supplied Cloud Spectral Data (2E2)</td>
<td>user specified extinction/absorption</td>
</tr>
<tr>
<td>VSA Cloud (2B)</td>
<td>ARMY VSA option</td>
</tr>
<tr>
<td>New Model Atmosphere (2C)</td>
<td>user defined atmosphere profile</td>
</tr>
<tr>
<td>User Supplied Profile (2C1)</td>
<td>individual atmosphere layer inputs</td>
</tr>
<tr>
<td>User Supplied CrossSections</td>
<td>cross-section molecule inputs for each layer</td>
</tr>
<tr>
<td>User Supplied Aerosols (2D)</td>
<td>user specified aerosols</td>
</tr>
<tr>
<td>User Supplied Extinction (2D2)</td>
<td>user specified aerosol extinction/absorption</td>
</tr>
<tr>
<td>Geometry and Spectral Band (3)</td>
<td>geometry and spectral band</td>
</tr>
<tr>
<td>Solar/Lunar Irradiance (3A)</td>
<td>solar scattering (trans solar irrad)</td>
</tr>
<tr>
<td>Solar/Lunar Geometry (3A1)</td>
<td>solar scattering</td>
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<tr>
<td>Phase Function (3B/3C1-3C6)</td>
<td>user specified aerosol scattering</td>
</tr>
<tr>
<td>Surface Spectral Reflectance</td>
<td>inputs for BRDF and Lambertian surfaces</td>
</tr>
<tr>
<td>Plot Cards</td>
<td>plotting inputs</td>
</tr>
</tbody>
</table>

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4.2 Using the Input Interface

There are two steps to setting inputs in the input interface program:

1. Position to the screen containing the input
2. Position to the variable and view/change it

There are several ways to find specific input screens and move around between them. The only way to enter into the screen input screens is through the MODTRAN Inputs item on the PCModWin menu bar. Select this item either with the mouse or by typing 
\( <\text{Alt}><M> \) on the keyboard. Once the menu item is selected, you must then select the specific screen to start at. Use the summary table shown in chapter 2 to see the general layout of the screens within this menu. If you are just starting out, click on the first input screen (Model Atmosphere), since that provides access to the top level inputs that control many general features of a MODTRAN calculation. Select the item of interest by either clicking on it with a mouse, or using the \( <\text{up arrow}> \) and \( <\text{down arrow}> \) keys on the keyboard to position the reverse text, and then typing \( <\text{Enter}> \) to select that item. If the screen name is shown in grey text, that screen has been disabled by the value of a variable controlling access to it, and you will not be able to enter it. This means that the screen contains inputs that are not relevant to the calculation as currently set up. For example, if your Model Atmosphere (on the first input screen) is set to use one of the built-in default profiles, then the user specified atmosphere input screens 3C and 3C1 are greyed out, because a user supplied atmosphere is not needed for a default profile. This can get confusing until you are familiar with which variables control access to each input screen. See the discussion of each individual screen in section 4.3 to find out what variables control access to it.

Once you are within an input screen (screen), the primary way to move around is to use the buttons along the bottom of each screen. These buttons generally look like this:

![Buttons](image)

These buttons provides the following functions:

**Next**: This button advances to the next screen in the list. The ‘next’ screen is determined from the MODTRAN screen number hierarchy; generally, it is the next highest numbered screen that is relevant. Screens that are irrelevant to your modeling case (because they are disabled by a variable setting) are skipped over. You can also advance to the next screen by depressing the return key.

**Prev**: This button moves backwards through the input screen stack. Generally, it moves to the screen where you just were, if you were advancing through the screen stack with the Next button.

**Ok**: This button exits the input screens and returns you to the top level PCModWin menu. If you have a particular input screen that you want to position to, this provides a convenient way to access the MODTRAN Inputs menu item, which then lets you position...
to a particular input screen, as described in the previous manual section. This provides an alternate way of moving to a specific input screen.

Once you position to a screen, you can edit the values of any of the variables shown that are enabled by your current settings. Some variables will be displayed in light grey (‘greyed out’), which means that they are disabled and thus do not need to be changed. For example, if you do not enable the Navy Maritime or Desert Aerosols in the input Aerosol Model Used (at the top of the Aerosols screen), then the Wind Speed - Navy Maritime Aerosol input 7 items below will be greyed out because it does not apply. If you find a variable greyed out that you want to use, consult the on-line help (or printed documentation) to see what MODTRAN variables control access to it. You may have to move to the input screen containing that input and change its value first, to enable access to the variable of interest.

You can position to any variable on the screen either with the mouse (by clicking on it), or by using the <Tab> key to position the blinking cursor to it. Selected items are frequently displayed in reverse text, or are highlighted in some manner (for example, by emphasizing their boundaries with a rectangle), to show where the currently selected variable is.

Once you position to a specific variable, you can change its value. There are several ways to edit variable values, all corresponding to different types of Windows input controls. The generic types of inputs are summarized below:

**Numeric input box:**

This is the most commonly found variable input tool in the MODTRAN interface. This box basically displays the current numeric value of a variable. To edit it, select the box, erase the current value, and type in a new one. Frequently, when you first position to a numeric input box, all of the text is displayed in reverse. If you just start typing, all the reverse text will be replaced by the newly typed value. You can also use the arrow keys (or the mouse) to position the text cursor within the input box to edit the value.

**Combo box:**

This input control is used to set variables that have a fixed number of inputs, usually with each input value representing some specific condition for the model. It replaces the non-intuitive numbers with text prompt equivalents, so that you can see exactly what you are specifying. For example, the graphic example shown above is for the MODTRAN variable MODEL. This variable selects the default atmospheric profile used by MODTRAN. It has 8 allowed integer values: 0, which tells MODTRAN to use a user defined atmosphere for a horizontal path; 1 through 6, which select specific model atmospheres; and 7, which specifies a user supplied atmosphere. Each integer value represents a model condition; the actual values of the variable (0 through 8) are arbitrary numbers assigned by the authors of MODTRAN. Instead of forcing you to remember these variables, the input interface assigns descriptive text prompts to each value. If you
click on the down arrow on the right side of this control, it expands to show all the possible values of this variable. The values are listed in parentheses on the left, but a descriptive text equivalent explains what is being selected by each variable. The currently selected value is displayed in reverse text. You can change the value of this variable by either clicking on the other options with the mouse, or by using the <up arrow> and <down arrow> keys to select different values, and then typing <Tab>. After you change the value of the variable, the new text prompt is displayed in the combo box, informing you of the setting of that particular variable.

**Check box:**

A check box is used for those variables that generally have only a Yes or No possible value. Usually, checking the box sets the variable to a ‘Yes’ value, while clearing the box sets the variable to a ‘No’ value. On the example above, the IMULT variable (that corresponds to this prompt) is set to a value of 1, which corresponds to ‘Yes’, since the box is checked. You can toggle the state of the check box between checked and unchecked by either clicking on the box with your mouse, or by selecting it with the <Tab> key and then typing a <space> on the keyboard. If you have several check boxes in sequence, selecting with the <Tab> key can be difficult, since there are no visual clues as to which box is selected.

As you are viewing and changing variable values, on-line help is always available. If you want a description of any input variable, simply left-click on the text prompt for the variable, and the PCModWin help system is run. This type of help is context sensitive, in that you will be placed on the page in the help that corresponds to the variable you just clicked on. You can also launch the help system by clicking on the Help button in the lower right of each input screen. Once the help is running, you can move around within it and search for information as much as you want. See chapter 8 for details on running the on-line help. You can leave the help running in a separate window while you continue to work on your inputs, or you can close the window (using either the exit option from the help menu bar, or by typing <Alt>F4> when the help window has focus) and call up help later for different prompts.

There are several levels of error checking applied when you set variable inputs. On numeric input boxes, some error checking is applied as you type values. For example, if you type in a negative number for a value that does not allow a negative value, the negative number is generally reset to 0. Another type of error checking makes sure that variable inputs are consistent. For these cases, if an inconsistency is noted, an error message will be displayed when you try to leave the screen (using the buttons on the bottom), and you will not be allowed to leave until the inconsistent value is replaced.
4.3 Individual Model Inputs

The documentation for model inputs is organized by input screens. Each screen is shown, along with the rules for accessing it and a detailed description of each input item. If you are looking for help on a particular screen, this is the place to start. If you are searching for help on a particular variable, and know what screen it is located on, this is also the place to look. All the input variables are referred to by the descriptive prompt that is shown on the input screen. For example, the Calculation Option input on the screen Model Atmosphere, which sets the value for the MODTRAN variable LMODTRN, is referred to throughout this text as Calculation Option. The number in parentheses next to the variable prompt is the input screen number. A complete list of variable input prompts, as well as the MODTRAN variables, can be found in the index for this manual. Note that most of this information can also be found in the PCModWin on-line help; you can use the Search button to find individual variable names or prompts, or you can jump to summaries on the input screens.

Throughout this text, the following convention is adopted: Variable prompt strings are shown as links to the description of the prompt, while the allowed values of a particular variable are shown in italic text. For example, the Model Atmosphere input can be set to Tropical Model or 1976 US Standard. Screen names are shown as links to the screen description.
4.3.1 Screen “Model Atmosphere”

This screen is the starting point for setting up a MODTRAN calculation. It controls inputs for the model used and its mode, the geometry, the atmospheric profile defaults (if any), multiple scattering, and the path start boundary. Its screen layout is shown below:

This screen controls access to a number of important MODTRAN options. The first input, for example, selects whether the MODTRAN or LOWTRAN model will be used. Model Atmosphere controls access to the user defined atmospheric profiles (screens New Model Atmosphere and User Supplied Profile). Mode of Execution controls access to the solar inputs (screen Solar/Lunar Geometry). The Type of Atmospheric Path selected affects the geometry and provides the only access to the horizontal path screen (screen Geometry and Spectral Band). Reviewing the settings on this screen tells a lot about the type of MODTRAN calculation that will be made.
4.3.1.1 Calculation Option

**MODTRAN Variable:** LMODTRN  
**Card:** 1  
**Input Screen:** Model Atmosphere

**Valid selections**
- MODTRAN = use MODTRAN band model for calculations
- LOWTRAN from MODTRAN = run the LOWTRAN7 model contained in MODTRAN
- MODTRAN correlated k = use MODTRAN with correlated-k option

**Description**
This variable lets you select which mode to run MODTRAN in for your atmospheric path calculations. MODTRAN selects the standard MODTRAN band model approach, which is used for most tasks. LOWTRAN from MODTRAN uses the older LOWTRAN band models for calculation. The LOWTRAN from MODTRAN option is provided primarily for historical compatibility with previously made calculations; in general, the improvements made in the MODTRAN band model approach are so significant that you should not use the LOWTRAN option, except for historical comparisons.

MODTRAN correlated k enables the correlated k option in the calculations, which is new to MODTRAN 4. This option improves accuracy in radiance calculations at the expense of additional calculation time. When this option is enabled, you can control the number of absorption coefficients for each spectral bin and trade off speed for accuracy. This option generally makes a difference only at higher altitudes (> 40 km). If you choose this option, an additional input, Correlation k speed, is enabled which provides this control.

LOWTRAN spectroscopy is considered obsolete by the current MODTRAN authors. Given the very rapid increases in computing speed of recent years, the faster execution times of LOWTRAN are no longer compelling reasons for its use in most applications. The higher spectral resolution of MODTRAN (the internal resolution of the LOWTRAN band models is 20 cm\(^{-1}\), while the MODTRAN band models are 1 cm\(^{-1}\)), as well as numerous other improvements made to its band model parameters, mean that the recommended setting of this parameter is MODTRAN.

**Related variables**
- Correlation-K Speed
  access to FWHM of Slit Function is controlled by this variable
### 4.3.1.2 Correlation-K Speed

**MODTRAN Variable:** SPEED  
**Card:** 1  
**Input Screen:** Model Atmosphere

**Valid selections**  
*Slow* = 'S' or blank = enable 'slow' correlated-k option with 33 absorption coefficients per spectral bin  
*Medium* = 'M' = enable 'medium' speed correlated-k option using 17 absorption coefficients per spectral bin

**Description**  
This variable lets you increase the number of absorption coefficients used in calculating each MODTRAN spectral bin. Normally MODTRAN uses 17 k values (absorption coefficients) per spectral bin when making calculations. This corresponds to the *Medium* setting. This input lets you double the number of k values used to 34 by selecting *Slow*. Model run-times are significantly extended when using this option.

Using the *Slow* setting can make a significant difference when calculating upper atmosphere (> 40 km) cooling rates and weighting functions. At lower altitudes the impact on the calculation accuracy is minimal and generally not worth the added calculation expense. Note that caution must always be used when making MODTRAN calculations of paths that are exclusively located in the upper atmosphere. At very high altitudes non-local thermodynamic equilibrium conditions (NLTE) become quite common (i.e., the particle density becomes so low that inhomogeneous distributions of temperature are possible). In NLTE conditions the emission of some molecules is changed, and in general simple assumptions about the uniformity of atmospheric layers might no longer be valid. A fundamental assumption of MODTRAN is that the atmosphere along its path is in thermodynamic equilibrium. If NLTE effects are important to your calculation, codes other than MODTRAN should be used for path radiance calculations.

This option is enabled by setting Calculation Option to *MODTRAN Correlated-k*. It only has effect for radiance calculations (i.e., with Mode of Execution set to either Radiance or Radiance w/ Scattering).

**Related variables**  
Calculation Option  
Mode of Execution
4.3.1.3 Model Atmosphere

**MODTRAN Variable:** MODEL  
**Card:** 1  
**Input Screen:** [Model Atmosphere](#)

**Valid selections**

*Meteorologic Data Input = 0 =* layer meteorological data user supplied (for horizontal paths only)

- **Tropical Model** = 1 = use tropical model (15 N latitude)
- **MidLatitude Summer** = 2 = use midlatitude summer model (45 N latitude, July)
- **MidLatitude Winter** = 3 = use midlatitude winter model (45 N latitude, Jan)
- **SubArctic Summer** = 4 = use subarctic summer model (60 N latitude, July)
- **SubArctic Winter** = 5 = use subarctic winter model (60 N latitude, January)
- **New Model Atmosphere** = 7 = use data supplied on separate layer input cards

**Description**

This variable selects either one of 6 standard model atmospheres or allows user-defined meteorological data. The model atmospheres define a 34 layer atmosphere and contains the following data for each layer: altitude, pressure, temperature, water vapor density, and layer concentration of ozone, methane, nitrous oxide, carbon monoxide, carbon dioxide, oxygen, nitric oxide, sulphur dioxide, nitrogen dioxide, and ammonia. The models also contain additional data for calculation of continuum contributions and nitric acid absorption. The *1976 U.S. Standard Atmosphere* is from a standard atmospheric model; the other 5 seasonal models were put together using data from a wide variety of sources to represent average seasonal and latitude variations in atmospheric properties. The latitude values and months shown above represent mean values for the models.

*Meteorologic Data Input* defines a single layer, which is used for horizontal paths (which stay within a single layer). *New Model Atmosphere* lets the user define their own atmospheric profiles. Selecting this option enables the [New Model Atmosphere](#) screen, which is the gateway to inputting your own atmospheric profile.

**Related variables**

- [Temperature and Pressure Altitude Profile](#)
- [Water Vapor Altitude Profile](#)
- [Ozone Altitude Profile](#)
- [Methane Altitude Profile](#)
- [Nitrous Oxide Altitude Profile](#)
- [Carbon Monoxide Altitude Profile](#)
- [Other Gases Altitude Profile](#)

screens [New Model Atmosphere](#) and [User Supplied Profile](#) (if [New Model Atmosphere](#) selected)
4.3.1.4 Type of Atmospheric Path

**MODTRAN Variable:** ITYPE  Card: 1  Input Screen: Model Atmosphere

**Valid selections**
- **Horizontal Path** = 1 = use horizontal path (a constant pressure path)
- **Slant Path** = 2 = use slant path between two altitudes
- **Slant Path to Space or Ground** = 3 = use slant path to space

**Description**
This variable partially defines the geometry of the calculation to be done. A *Horizontal Path* is a constant pressure path short enough so that the earth curvature is negligible and atmospheric refraction can be ignored. It is defined using the Observer Height and Path Length. An alternative way to define a horizontal path is to specify Meteorological Data Input for Model Atmosphere. Then an alternative version of input card 3 appears that allows you to define the atmospheric parameters for the single atmospheric layer that the path is located in. The horizontal path specification should not be used for long paths.

A *Slant path* is the general path specification. It can be defined using 6 sets of inputs:

1. Observer Height, Zenith Angle, Final Height
2. Observer Height, Zenith Angle, and Range
3. Observer Height, Final Height, and Range
4. Observer Height, Final Height, and Earth Center Angle
5. Final Height, Observer Height, and Final Angle
6. Final Height, Final Angle, and Range

The method used is selected with the input Path Type at the top of the window, and only the appropriate inputs are then displayed. Note that the actual slant path range might differ from the input value due to atmospheric refraction. In method (4) MODTRAN determines the proper value of zenith angle, with refraction included, through an iterative procedure. This method should be used when the geometrical configuration of the source and receiver is known accurately, but the initial zenith angle is not known precisely due to atmospheric refraction. Methods (5) and (6) were added to MODTRAN 4, to support cases where the path zenith angle is only known at the end of the path (where it is renamed Final Angle).

The *Slant Path to Space or Ground* defines a path that starts or ends beyond the top of MODTRAN's atmosphere (100 km altitude for the standard models). It can be defined using 3 sets of inputs:

1. Observer Height and Zenith Angle
2. Observer Height and Tangent Height
3. Tangent Height and Tangent Angle
Again, the method used is selected with the input Path Type at the top of the window, and only the appropriate inputs are then displayed. Method (2) is used for a limb viewing problem where the final altitude is the tangent height or minimum altitude of the path trajectory.

See section 3.1 in this manual on geometry for diagrams and additional discussion on setting up MODTRAN path geometry.

**Related variables**

<table>
<thead>
<tr>
<th>Path Type</th>
<th>Final Height</th>
</tr>
</thead>
<tbody>
<tr>
<td>Observer Height</td>
<td>Final Angle</td>
</tr>
<tr>
<td>Zenith Angle</td>
<td>Earth Center Angle</td>
</tr>
<tr>
<td>Range</td>
<td></td>
</tr>
<tr>
<td>Tangent Height</td>
<td></td>
</tr>
</tbody>
</table>
4.3.1.5 Mode of Execution

**MODTRAN Variable:** IEMSCT  **Card:** 1  **Input Screen:** Model Atmosphere

**Valid selections**
- *Transmittance* = 0 = MODTRAN calculates path transmittance
- *Thermal Radiance* = 1 = MODTRAN calculates path radiance and path transmittance
- *Radiance with Scattering* = 2 = MODTRAN calculates atmospheric radiance and single scattered solar/lunar radiance
- *Direct Solar Irradiance* = 3 = MODTRAN calculates directly transmitted solar irradiance

**Description**
This parameter determines what calculations MODTRAN will do for the conditions you have specified. *Transmittance* means that MODTRAN will calculate only the transmittance of the atmospheric path. When you run transmittance, you can plot values for both the total transmittance as well as each of the transmission components calculated (each molecular band, continuums, aerosols, etc.). *Thermal Radiance* means that MODTRAN will calculate BOTH the transmittance and the emitted atmospheric radiance of the path. Only the total transmittance (i.e., the product of each of the transmission components) is available in the outputs. *Radiance w/ Scattering* will calculate the path transmittance, the path emitted radiance, and will add in the solar and lunar radiance single scattered into the path by the atmosphere. *Direct Solar Irradiance* computes the solar emitted irradiance that passes through the atmospheric path from space to the observer.

Note that multiple scattering of path radiance components is controlled by the separate input **Execute with Multiple Scattering**, that is the next input down on this card.

**Related variables**
- access to screen *Solar/Lunar Geometry* is controlled by this variable
- the list of outputs available for plotting is affected by this variable
4.3.1.6 Execute with Multiple Scattering

**MODTRAN Variable:** IMULT  
**Card:** 1  
**Input Screen:** Model Atmosphere

**Valid selections**

*No* = 0 = MODTRAN executes without multiple scattering  
*MS on Flux at Observer* = 1 = MODTRAN adds multiple scattering, flux calculated at observer  
*MS on Flux at H2* = -1 = MODTRAN adds multiple scattering, flux calculated at H2

**Description**

The radiation in the path comes from path emission, sources external to the path (the sun, moon, earth, or a target), and scattering in/out of the path. Multiple scattering is a process applied to radiation in the path that can result in either a loss or an addition to the path radiance. "Multiple" means that more than one scattering event is allowed. The two primary sources of multiple scattering are molecular scattering, which is significant in the visible wavelength regions, and particle (aerosol) scattering, which can play a significant role out into the near and mid infrared regions. In MODTRAN, multiple scattering is treated as an additional path radiance term that is calculated for each layer along the atmospheric path.

You can disable multiple scattering by setting this input to *No*. The other two options enable multiple scattering. For a multiple scattering calculation, the contribution from each layer in the model atmosphere must be calculated (which is one reason why the MS option can appreciably extend run time). In previous versions of MODTRAN, this flux calculation was always done at the observer location, and this is selected by setting *MS on Flux at Observer*. The option has now been added to calculate the flux streams at the other end of the path, which is selected by setting *MS on Flux at H2*. This latter option is primarily useful for limb viewing calculations from satellites, where the multiple scattering fluxes are better calculated at the path end, which is down lower in the atmosphere and is where the MS effects can be very important. In PcModWin, H2 is the Final Height or the Tangent Height on the Geometry and Spectral Band screen, depending on how you specify your geometry.

For simulation of sensors on satellite platforms, this input should be set to *MS on Flux at H2*, since the multiple scattering will be significant primarily nearer to H2. For other applications entirely within the atmosphere, in general setting this to *MS on Flux at Observer* is recommended.

Multiple scattering is implemented in two ways in MODTRAN. One approach uses a finite stream approximation that approximates the scattering source function. This approximation is matched to the band model (broad spectral band) calculations of MODTRAN through an interface that makes a series of monochromatic calculations within the band which are then summed to give a spectrally averaged result. This approach reduces the potential computation time while still maintaining an accuracy of less than 20% for the scattered radiance source term. A second method of calculating
multiple scattering, known as the DISORT option, as also been added. These options are selected on the Multiple Scattering input window.

Note that solar and lunar radiance can still be single-scattered into the path without use of this option, by selecting Radiance with Scattering for Mode of Execution and by setting this parameter to No.

This option only has affect in the radiance modes of MODTRAN, when Mode of Execution is equal to Thermal Radiance or Radiance with Scattering. It is very computation intensive, and slows execution of cases down considerably, so if run-time is important you should determine if it has a significant impact on your particular modeling problem before using it regularly.

**Related variables**
- Mode of Execution
- Final Height
- Tangent Height
- Multiple Scattering input screen
4.3.1.7 Temperature and Pressure Altitude Profile

**MODTRAN Variable:** M1  **Card:** 1  **Input Screen:** Model Atmosphere

**Valid selections**
- **Use Default** = 0 = use profile selected by Model Atmosphere
- **Tropical Model** = 1 = use tropical model (15 N latitude)
- **MidLatitude Summer** = 2 = use midlatitude summer model (45 N latitude, July)
- **MidLatitude Winter** = 3 = use midlatitude winter model (45 N latitude, Jan)
- **SubArctic Summer** = 4 = use subarctic summer model (60 N latitude, July)
- **SubArctic Winter** = 5 = use subarctic winter model (60 N latitude, January)
- **New Model Atmosphere** = 7 = use data supplied on separate layer input cards

**Description**
This variable allows you to modify or supplement the temperature and pressure altitude profile that the model atmosphere will contain. For normal operation, this variable is *Use Default*, which directs MODTRAN to use the temperature and pressure profile data supplied with the model atmosphere selected at the beginning of this screen. You can, however, select temperature and pressure profiles from a different model atmosphere for your calculations. This other profile might offer a better fit to your data or conditions.

You can bypass the model atmospheres completely by specifying *New Model Atmosphere* for Model Atmosphere near the top of this screen. Then you must provide the temperature and pressure data in the proper units for each atmospheric layer that you are creating. A separate input card must be specified for each layer (screens User Supplied Profile).

**Related variables**
profile selected by Model Atmosphere if this variable = *Use Default*
4.3.1.8 Water Vapor Altitude Profile

**MODTRAN Variable:** M2  
**Card:** 1  
**Input Screen:** Model Atmosphere

**Valid selections**
- Use Default  = 0  = use profile selected by Model Atmosphere
- Tropical Model  = 1  = use tropical model (15 N latitude)
- MidLatitude Summer  = 2  = use midlatitude summer model (45 N latitude, July)
- MidLatitude Winter  = 3  = use midlatitude winter model (45 N latitude, Jan)
- SubArctic Summer  = 4  = use subarctic summer model (60 N latitude, July)
- SubArctic Winter  = 5  = use subarctic winter model (60 N latitude, January)
- New Model Atmosphere  = 7  = use data supplied on separate layer input cards

**Description**
This variable allows you to modify or supplement the water vapor altitude profile that the model atmosphere will contain. For normal operation, this variable is Use Default, which directs MODTRAN to use the water vapor profile data supplied with the model atmosphere selected at the beginning of this screen. You can, however, select water vapor profiles from a different model atmosphere for your calculations. This other profile might offer a better fit to your data or conditions.

You can bypass the model atmospheres completely by specifying New Model Atmosphere for Model Atmosphere near the top of this screen. Then you must provide the ozone amounts in the proper units for each atmospheric layer that you are creating. A separate input card must be specified for each layer (screens User Supplied Profile).

**Related variables**
profile selected by Model Atmosphere if this variable = Use Default
4.3.1.9 Ozone Altitude Profile

**MODTRAN Variable:** M3  **Card:** 1  **Input Screen:** Model Atmosphere

**Valid selections**

- **Use Default** = 0 = use profile selected by Model Atmosphere
- **Tropical Model** = 1 = use tropical model (15 N latitude)
- **MidLatitude Summer** = 2 = use midlatitude summer model (45 N latitude, July)
- **MidLatitude Winter** = 3 = use midlatitude winter model (45 N latitude, Jan)
- **SubArctic Summer** = 4 = use subarctic summer model (60 N latitude, July)
- **SubArctic Winter** = 5 = use subarctic winter model (60 N latitude, January)
- **New Model Atmosphere** = 7 = use data supplied on separate layer input cards

**Description**

This variable allows you to modify or supplement the ozone altitude profile that the model atmosphere will contain. For normal operation, this variable is **Use Default**, which directs MODTRAN to use the ozone profile data supplied with the model atmosphere selected at the beginning of this card by Model Atmosphere (1). You can, however, select ozone profiles from a different model atmosphere for your calculations. This other profile might offer a better fit to your data or conditions.

You can bypass the model atmospheres completely by specifying **New Model Atmosphere** for Model Atmosphere near the top of this screen. Then you must provide the ozone data in the proper units for each atmospheric layer that you are creating. A separate input card must be specified for each layer (screens User Supplied Profile).

**Related variables**

profile selected by Model Atmosphere if this variable = Use Default
4.3.1.10 Methane Altitude Profile

MODTRAN Variable: M4    Card: 1    Input Screen: Model Atmosphere

Valid selections
Use Default = 0 = use profile selected by Model Atmosphere
Tropical Model = 1 = use tropical model (15 N latitude)
MidLatitude Summer = 2 = use midlatitude summer model (45 N latitude, July)
MidLatitude Winter = 3 = use midlatitude winter model (45 N latitude, Jan)
SubArctic Summer = 4 = use subarctic summer model (60 N latitude, July)
SubArctic Winter = 5 = use subarctic winter model (60 N latitude, January)
New Model Atmosphere = 7 = use data supplied on separate layer input cards

Description
This variable allows you to modify or supplement the methane altitude profile that the model atmosphere will contain. For normal operation, this variable is Use Default, which directs MODTRAN to use the methane profile data supplied with the model atmosphere selected at the beginning of this card by Model Atmosphere (1). You can, however, select methane profiles from a different model atmosphere for your calculations. This other profile might offer a better fit to your data or conditions.

You can bypass the model atmospheres completely by specifying New Model Atmosphere for Model Atmosphere near the top of this screen. Then you must provide the methane data in the proper units for each atmospheric layer that you are creating. A separate input card must be specified for each layer (screens User Supplied Profile).

Related variables
profile selected by Model Atmosphere if this variable = Use Default
4.3.1.11 Nitrous Oxide Altitude Profile

**MODTRAN Variable:** M5  **Card:** 1  **Input Screen:** Model Atmosphere

**Valid selections**
- **Use Default** = 0 = use profile selected by Model Atmosphere
- **Tropical Model** = 1 = use tropical model (15 N latitude)
- **MidLatitude Summer** = 2 = use midlatitude summer model (45 N latitude, July)
- **MidLatitude Winter** = 3 = use midlatitude winter model (45 N latitude, Jan)
- **SubArctic Summer** = 4 = use subarctic summer model (60 N latitude, July)
- **SubArctic Winter** = 5 = use subarctic winter model (60 N latitude, January)
- **New Model Atmosphere** = 7 = use data supplied on separate layer input cards

**Description**
This variable allows you to modify or supplement the nitrous oxide altitude profile that the model atmosphere will contain. For normal operation, this variable is **Use Default**, which directs MODTRAN to use the nitrous oxide profile data supplied with the model atmosphere selected at the beginning of this card by Model Atmosphere (1). You can, however, select nitrous oxide profiles from a different model atmosphere for your calculations. This other profile might offer a better fit to your data or conditions.

You can bypass the model atmospheres completely by specifying **New Model Atmosphere** for Model Atmosphere near the top of this screen. Then you must provide the nitrous oxide data in the proper units for each atmospheric layer that you are creating. A separate input card must be specified for each layer (screens User Supplied Profile).

**Related variables**
profile selected by Model Atmosphere if this variable = Use Default
4.3.1.12 Carbon Monoxide Altitude Profile

**MODTRAN Variable:** M6  **Card:** 1  **Input Screen:** Model Atmosphere

**Valid selections**
- **Use Default** = 0 = use profile selected by Model Atmosphere
- **Tropical Model** = 1 = use tropical model (15 N latitude)
- **MidLatitude Summer** = 2 = use midlatitude summer model (45 N latitude, July)
- **MidLatitude Winter** = 3 = use midlatitude winter model (45 N latitude, Jan)
- **SubArctic Summer** = 4 = use subarctic summer model (60 N latitude, July)
- **SubArctic Winter** = 5 = use subarctic winter model (60 N latitude, January)
- **New Model Atmosphere** = 7 = use data supplied on separate layer input cards

**Description**
This variable allows you to modify or supplement the carbon monoxide altitude profile that the model atmosphere will contain. For normal operation, this variable is *Use Default*, which directs MODTRAN to use the carbon monoxide profile data supplied with the model atmosphere selected at the beginning of this card by Model Atmosphere (1). You can, however, select carbon monoxide profiles from a different model atmosphere for your calculations. This other profile might offer a better fit to your data or conditions.

You can bypass the model atmospheres completely by specifying *New Model Atmosphere* for Model Atmosphere near the top of this screen. Then you must provide the carbon monoxide data in the proper units for each atmospheric layer that you are creating. A separate input card must be specified for each layer (screens User Supplied Profile).

**Related variables**
profile selected by Model Atmosphere if this variable = *Use Default*
4.3.1.13 Other Gases Altitude Profile

**MODTRAN Variable:** MDEF  **Card:** 1  **Input Screen:** Model Atmosphere

**Valid selections**
- Use Atm Layer Card  = 0 = use profile selected by Model Atmosphere
- Use US Standard 76  = 1 = use built-in default heavy species profiles
- Use CFCs  = 2 = supply custom heavy species concentrations

**Description**
This variable allows you to modify or supplement the 'other gases' altitude profile that the model atmosphere will contain. The 'other gases' are the uniformly mixed gases that make up a relatively small fraction of the total atmosphere. This variable has now been extended to also apply to the CFC concentrations for the MODTRAN calculation. If this variable is set to *Use Atm Layer Card*, then a default profile for the CFCs is selected, for each layer, using the input Cross section units. If this is set to *Use US Standard 76*, then the built-in default profiles are used. If this is set to *Use CFCs*, an additional input screen (*User Supplied XSections*) is enabled that lets you specify the CFC concentrations for each atmospheric layer.

Note that the "default" heavy species are stored internally in MODTRAN and are based on 1990 photochemical predictions (by M. Allen, JPL). Since some of the CFCs have increased by as much as 8% per year, the user might wish to change these defaults. For example, both CFC11 and CFC12 are now as much as 80% larger than the default profiles.

**Related variables**
this variable controls access to the *User Supplied XSections* screen
4.3.1.14 Output File Options

**MODTRAN Variable:** NOPRNT  **Card:** 1  **Input Screen:** Model Atmosphere

**Valid selections**
- File8 + Spectral Cooling Rate Data = makes FILE8 and a cooling rate data file
- Include Cloud/Rain Profiles & Data to FILE8 = -1 = enables creation of TAPE8 file
- Include ATM Profiles = 0 = atmospheric profile and ray trace info will be included in MODOUT1
- Suppress ATM Profiles = 1 = omit profile and geometry information from MODOUT1 (TAPE6)

**Description**
This option allows you to suppress printing of the profile data and some of the geometry calculations to the MODOUT1 (TAPE6) file. Include ATM Profiles is the normal operation of the model, and will echo the atmospheric profile and geometry ray-trace data that MODTRAN is using for its calculations. These numbers and tables are normally found at the start of the TAPE6 output file. Selecting Suppress ATM Profiles will disable these outputs. This makes the MODOUT1 file smaller and lets the calculation run somewhat faster, since the computer has less disk output to generate. The disadvantage, of course, is that the profile and geometry data is not included with your calculated results. This output can reveal subtle errors or inconsistencies in input parameters that can lead to erroneous results, and is valuable for checking the accuracy of your modeling.

Selecting Include Cloud/Rain Profiles & Data to FILE8 enables the generation of an additional output file, called FILE8 or TAPE8 (MODOUT3 in PcModWin), which contains more MODTRAN results. If you are running in the Transmittance mode (selected with Mode of Execution (1)), this file will contain the final transmittance for each gas that has a band model. When using Thermal Radiance or Radiance with Scattering for Mode of Execution TAPE8 contains a layer by layer summary of the progress of the calculation. For multiple scattering calculations, the spectral diffuse and total flux values along the line-of-sight will be written to the TAPE8 file. Selecting File8 + Spectral Cooling Rate Data creates a FILE8 file and also another file called "clrates".

**Related variables**
- Mode of Execution (1)
4.3.2 Screen “Atmospheric Column Parameters and Files (1A)”

This screen provides some additional inputs for the model atmosphere description, as well as some other general MODTRAN inputs. It is shown below:
4.3.2.1 Water Vapor Column Choices

**MODTRAN Variable:** H2OSTR  **Card:** 1A  **Input Screen:** Mdl Atm (1A)

**Valid selections**
- *Use default water vapor column* = use the default water vapor column density
- *Column in gm/cm$^2$* = specify water vapor column density in grams per cm$^2$
- *Column in atm-cm* = specify water vapor column density in atm-cm
- *Water column scaling factor* = scale MODTRAN values for water vapor column density

**Description**
This input lets you modify the water vapor column density used in the MODTRAN calculation. *Use default water vapor column* is the normal mode of operation, and no changes are made to the default water column density. *Column in gm/cm$^2$* and *Column in atm-cm* let you directly specify a new column density in either of these units. The new value is set in the input *Water Column*. Option *Water column scaling factor* lets you scale the default column density up or down by a fixed amount. For example, 2.0 would double the water vapor column density, while 0.5 would decrease it by half. The scaling factor is specified in the input *Column Scaling Factor*. Note that the water number density at each profile altitude will not be increased above 100% relative humidity or by more than 5 times its original value. When the 100% relative humidity level is reached, the water is distributed to other levels to the extent possible to achieve the input water column.

This option should not be used on a constant pressure (horizontal) path, with *Type of Atmospheric Path* set to *Horizontal Path*.

The water density within water clouds (input *Use Cloud / Rain Aerosol Extensions* set to any of its first 10 values, 1 through 10) is not scaled by this parameter.

**Related variables**
- Water Column
- Column Scaling Factor
4.3.2.2 Water Column

**MODTRAN Variable:** H2OSTR  **Card:** 1A  **Input Screen:** Mdl Atm (1A)

**Valid selections**
floating point number in either grams per cm$^2$ or in atm-cm

**Description**
This input lets you input the water vapor column density for your case. The units used are selected by the setting of Water Vapor Column Choices. You can either use grams per square centimeters or atmospheres-cm.

This input is only enabled if Water Vapor Column Choices is set to Column in gm/cm$^2$ or Column in atm-cm.

**Related variables**
Water Vapor Column Choices
4.3.2.3 Column Scaling Factor

**MODTRAN Variable:** H2OSTR  
**Card:** 1A  
**Input Screen:** Mdl Atm (1A)

**Valid selections**
floating point number greater than 0

**Description**
This input lets you scale the default column density up or down by a fixed amount. For example, 2.0 would double the water vapor column density, while 0.5 would decrease it by half. Note that the water number density at each profile altitude will not be increased above 100% relative humidity or by more than 5 times its original value. When the 100% relative humidity level is reached, the water is distributed to other levels to the extent possible to achieve the input water column.

This input is only enabled if [Water Vapor Column Choices](#) is set to *Water Column Scaling Factor*.

**Related variables**
[Water Vapor Column Choices](#)
4.3.2.4 Ozone Column Parameter

**MODTRAN Variable:** O3STR  **Card:** 1A  **Input Screen:** Mdl Atm (1A)

**Valid selections**

*Use default ozone column* = use the default ozone column density  
*Column in gm/cm^2* = specify ozone column density in grams per cm^2  
*Column in atm-cm* = specify ozone column density in atm-cm  
*Ozone column scaling factor* = scale MODTRAN values for ozone column density

**Description**

This input lets you modify the ozone column density used in the MODTRAN calculation.  
*Use default ozone column* is the normal mode of operation, and no changes are made to the default ozone column density.  
*Column in gm/cm^2* and *Column in atm-cm* let you directly specify a new column density in either of these units.  
The new value is set in the input *Ozone Column*.  
*Option Ozone column scaling factor* lets you scale the default column density up or down by a fixed amount.  
For example, 2.0 would double the ozone vapor column density, while 0.5 would decrease it by half.  
The scaling factor is specified in the input *Column Scaling Factor*.  
Note that the ozone number density at each profile altitude will not be increased by more than 5 times its original value.

This option should not be used on a constant pressure (horizontal) path, with *Type of Atmospheric Path* set to *Horizontal Path*.

**Related variables**

- Ozone Column
- Column Scaling Factor
4.3.2.5 Ozone Column

**MODTRAN Variable:** O3STR  **Card:** 1A  **Input Screen:** Mdl Atm (1A)

**Valid selections**
floating point number in either grams per cm$^2$ or in atm-cm

**Description**
This input lets you input the ozone column density for your case. The units used are selected by the setting of **Ozone Column Choices**. You can either use grams per square centimeters or atmospheres-cm.

This input is only enabled if **Ozone Column Choices** is set to *Column in gm/cm$^2$* or *Column in atm-cm*.

**Related variables**
**Ozone Column Choices**
4.3.2.6 Column Scaling Factor

MODTRAN Variable: O3STR Card: 1A Input Screen: Mdl Atm (1A)

Valid selections
floating point number greater than 0

Description
This input lets you scale the default column density up or down by a fixed amount. For example, 2.0 would double the ozone vapor column density, while 0.5 would decrease it by half.

This input is only enabled if Ozone Column Choices is set to Ozone Column Scaling Factor.

Related variables
Ozone Column Choices
4.3.2.7 Use Default Band Model

**MODTRAN Variable:** LBMNAM  **Card:** 1A  **Input Screen:** Mdl Atm (1A)

**Valid selections**

unchecked = explicitly specify the band model file to use  
checked = use the default 1 cm⁻¹ resolution band model (bmp99_01.bin)

**Description**
This input, new to MODTRAN 4, gives you the option of using a different band model data file for the MODTRAN calculation. For most users, this is only useful for switching between the 1 cm⁻¹ and the 15 cm⁻¹ band model files provided with MODTRAN. The 15 cm⁻¹ file is provided to accelerate calculations in the visible and UV bands, where the wavenumber spacing is quite close. In general, the 1 cm⁻¹ default band model should be used.

The band model files provided with MODTRAN are provided in the \pcmodwin\bin\data directory.

This option also lets you use a completely different band model parameter file than those provided with MODTRAN. If you go this route, you must create a file fully compatible with the MODTRAN band model file format, which is not described with the MODTRAN documentation.

If this input is unchecked, the [Band Model File Name](#) input is enabled.

**Related variables**

[Band Model File Name](#)
4.3.2.8 Band Model File Name

**MODTRAN Variable:** LBMNAM  **Card:** 1A2  **Input Screen:** Mdl Atm (1A)

**Valid selections**
valid path and filename indicating correctly formatted band model data file

**Description**
This input lets you explicitly specify which band model file MODTRAN will use. You can directly specify the name of the file in the input box, or use the Browse button at the right to use Windows to navigate to the file of interest. The initial directory for searching defaults to the "\bin\data" subdirectory in the PcModWin directory.

If you choose the 15 cm\(^{-1}\) band model file, and then attempt to make a MODTRAN calculation with a step size smaller than 15 cm\(^{-1}\), you will get a MODTRAN error message (in the DOS window) that says "Specified resolution too fine. Must be .GE. than 15 cm\(^{-1}\)". This band model file is only appropriate for calculations at step sizes of 15 cm\(^{-1}\) or greater. To fix this, you must either reduce the step size of your calculation, or switch to the other band model file (with 1 cm\(^{-1}\) step size resolution).

The band model files provided with MODTRAN are provided in the \bin\data directory.

This option also lets you use a completely different band model parameter file than those provided with MODTRAN. If you go this route, you must create a file fully compatible with the MODTRAN band model file format, which is not described with the MODTRAN documentation.

This input is only enabled if Use Default Band Model is unchecked.

**Related variables**
Use Default Band Model
4.3.2.9 Use Instrument Filter File

**MODTRAN Variable:** LFLTNM  **Card:** 1A  **Input Screen:** Mdl Atm (1A)

**Valid selections**
- *unchecked* = do not use instrument filter file option
- *checked* = apply instrument filter file to MODTRAN outputs

**Description**
This input lets you choose whether to apply a spectral filter function to the MODTRAN outputs. A filter function is basically a list of points showing the relative response (between 0 and 1) across a spectral band. It is very useful for determining the response of an instrument with a broad spectral response that is not flat over frequency. PcModWin has provided the filter function as a separate option (and continues to do so), but now this option has been added to MODTRAN directly. The PcModWin option is preserved because this lets you apply a filter function to MODTRAN runs previously completed.

If this input is *checked*, then the instrument function defined in a file set in Instrument Filter File Name will be applied to the MODTRAN outputs. If it is *unchecked*, the filter function is not used.

**Related variables**
Instrument Filter File Name
4.3.2.10 Instrument Filter File Name

**MODTRAN Variable:** LFLTNM  **Card:** 1A  **Input Screen:** Mdl Atm (1A)

**Valid selections**
valid path and filename indicating a file in the required format

**Description**
This input specifies the name of the disk file that contains the filter function to apply to the MODTRAN outputs. You can directly specify the name of the file in the input box, or use the Browse button at the right to use Windows to navigate to the file of interest. The initial directory for searching defaults to the "\bin\data" subdirectory in the PcModWin directory. An example file (AVIRIS.FLT) is provided with MODTRAN 4.

The filter file uses the following format:

```
UNITS_HEADER
HEADER(1)
  w11 r11
  w12 r12
  w13 r13
  ...
HEADER(2)
  w21 r21
  w22 r22
  w23 r23
  ...
```

e tc.

Here, UNITS_HEADER is a string whose first character is 'N' (for nm), 'W' (for wavenumber), or 'M' (for microns), denoting the wavelength or frequency unit.

HEADER(i) is a string, whose first character is non-numeric and not a decimal point, denotes the start of a list of (wavelength, response) pairs for the i\(^{th}\) channel.

\((w_{ij}, r_{ij})\) are the j\(^{th}\) wavelength and response values for the i\(^{th}\) channel.

This input is only enabled if **Use Instrument Filter File** is set to checked. Note that the filter function provided separately in PcModWin accomplishes a similar task. The filter files used by MODTRAN use a different format from the filter files defined by PcModWin.

**Related variables**
**Use Instrument Filter File**
4.3.2.11 CO₂ Mixing Ratio

**MODTRAN Variable:** CO2MIX  **Card:** 1A  **Input Screen:** Mdl Atm (1A)

**Valid selections**
floating point number in parts per million

**Description**
This parameter allows you to modify the carbon dioxide concentration. In recent years, carbon dioxide concentrations have been steadily increasing; however, many historical calibration studies have been done using a standard concentration of 330 ppmv. The recommended values as of 1995 are about 355 - 360 ppmv, and the carbon dioxide mixing ratio has been increasing by about 0.5 of 1 percent per year. The current value for 1999 is 365 ppmv. For comparisons to historical studies, a value of 330 ppmv is used as default.
4.3.3 Screen “Multiple Scattering”

This screen selects the type of multiple scattering algorithm that MODTRAN will use in your calculation. MODTRAN 3.7 and higher includes two methods for making multiple scattering calculations. To keep run-time within acceptable levels, all multiple scattering algorithms use a variety of approximations and simplifications in their treatment of the problem. For users whose calculations are dominated by the multiple scattering component, this lets you select which method is best suited for your application. A full discussion of the advantages and disadvantages of each method is beyond the scope of this help; interested users are directed to the various information resources cited in the references and other published MODTRAN literature. This screen is shown below:

This card is only enabled if Execute with Multiple Scattering on the Model Atmosphere window is set to MS on Flux at Observer or MS on Flux at H2.
4.3.3.1 Scattering Algorithm

MODTRAN Variable: DIS Card: 1A Input Screen: Multiple Scattering

Valid selections
Disort = activate the DISORT multiple scattering algorithm
Modtran 2 = use original Isaacs two-stream algorithm for multiple scattering

Description
MODTRAN 3.7 now includes two methods for making multiple scattering calculations. To keep run-time within acceptable levels, all multiple scattering algorithms use a variety of approximations and simplifications in their treatment of the problem. For users whose calculations are dominated by the multiple scattering component, this lets you select which method is best suited for your application. A full discussion of the advantages and disadvantages of each method is beyond the scope of this help; interested users are directed to the various information resources cited here and other published MODTRAN literature.

Two main algorithms for multiple scattering are implemented in MODTRAN 4.0. The newly added algorithm is referred to as the DISORT model. DISORT stands for Discrete Ordinates Radiative Transfer, and is a scattering program developed for a multi-layered plane-parallel medium. DISORT was designed to be the most general and versatile plane-parallel radiative transfer program available, applicable to problems from the ultraviolet to the radar regions of the electromagnetic spectrum. It is available as a stand-alone FORTRAN program; this program has been converted into several subroutines for use in MODTRAN, and many of its input values are extracted internally from the other MODTRAN inputs. Interested users are directed to the Internet site

ftp://climate.gsfc.nasa.gov/pub/wiscombe/Discr_ord/

A standalone version of the code can be downloaded from this site.

Setting this parameter to DISORT selects use of the DISORT algorithm for all multiple scattering calculations. If you use DISORT, you can choose the number of streams (which affects both calculation accuracy and run-time) in the Number of Streams parameter on this same screen. Selecting MODTRAN 2 uses the original MODTRAN two-stream multiple scattering algorithm.

This card is only enabled if Execute with Multiple Scattering on the Model Atmosphere window is set to MS on Flux at Observer or MS on Flux at H2. If you are not familiar with the complex issues surrounding the use of multiple scattering, using the Modtran 2 option for this parameter will likely provide acceptable results.

Related variables
Number of streams DISORT Azimuthal Dependence
4.3.3.2 Number of Streams

**MODTRAN Variable:** NSTR  
**Card:** 1A  
**Input Screen:** Multiple Scattering

**Valid selections**
- 2 Streams = 2
- 4 Streams = 4
- 8 Streams = 8
- 16 Streams = 16

**Description**
This input sets the number of streams to be used in the DISORT multiple scattering calculation. Using 8 Streams is the recommended value. DISORT in MODTRAN has been optimized for 4, 8, and 16 streams only. Using higher values adds significantly to the calculation run-times.

This variable is only used if **Scattering Algorithm** is set to DISORT.

This card is only enabled if **Execute with Multiple Scattering** on the **Model Atmosphere** window is set to **MS on Flux at Observer** or **MS on Flux at H2**. If you are not familiar with the complex issues surrounding the use of multiple scattering, using the **Modtran 2** option for this parameter will likely provide acceptable results.

**Related variables**
- Scattering Algorithm
- Execute with Multiple Scattering
4.3.3.3 DISORT Azimuthal Dependence

**MODTRAN Variable:** DISAZM   **Card:** 1A   **Input Screen:** Multiple Scattering

**Valid selections**
checked = 't' = enable azimuthal dependence option  
unchecked = 'f' or blank = disable azimuthal dependence

**Description**
This input controls the azimuthal dependence option for DISORT. If this input is checked, MODTRAN includes azimuthal dependence in the line-of-sight calculation of solar multiple scattering. This option can significantly increase execution time. It generally makes a small effect (and thus can be safely ignored) in the following cases: (1) only vertical fluxes are needed; (2) the solar or viewing zenith angle is near vertical (vertical zenith angles have values close to 0; click here to see the observer zenith angle variable help); and (3) at longer wavelengths, when the solar multiple scattering component is only a small part of the total radiance calculation.

This input is only used if [Scattering Algorithm](#) is set to DISORT.

This card is only enabled if [Execute with Multiple Scattering](#) on the [Model Atmosphere](#) window is set to MS on Flux at Observer or MS on Flux at H2.

**Related variables**
- [Scattering Algorithm](#)
- [Execute with Multiple Scattering](#)
4.3.4 Screen “Surface at Start of Path”

This screen defines the properties of an opaque surface at the opposite end of the atmospheric path from the observer. It is shown below:

Some paths may run into an opaque surface like the earth or an object being observed. By setting the temperature of this object, and specifying a surface emissivity, you can use MODTRAN to propagate that signal through your atmospheric path and observe the effects. If you leave both of these inputs at 0, the effects of the surface will not be included.

This card is only enabled if Mode of Execution is set to Thermal Radiance or Radiance w/ Scattering.
4.3.4.1 Temperature at First Boundary

**MODTRAN Variable:** TPTEMP  
**Card:** 1  
**Input Screen:** Surface

**Valid selections**  
0 = MODTRAN uses the temperature of the first boundary layer in the path for radiance calculation  
> 0 MODTRAN uses this number as the apparent temperature of an opaque radiating surface at the start of the path (in degrees Kelvin)

**Description**  
This parameter controls the contribution to the path radiance at the ending point of the path (usually the Final Height, or H2). The meaning of this variable has changed in MODTRAN 4 from earlier versions. When in the Thermal Radiance or Radiance with Scattering modes (selected with Mode of Execution), MODTRAN computes the radiance of each atmospheric layer, passes it through the other layers (to the observer), and sums the results to arrive at the atmospheric radiance. If this variable is less than or equal to zero, then the following logic applies. If the Final Height (H2 in the MODTRAN documentation) is above the ground, then no surface thermal emission is added to the path radiance calculation. If the path intersects the earth, then MODTRAN uses the temperature of the first atmospheric layer as the boundary temperature. If this variable is greater than 0, then it is treated as the boundary temperature of the path endpoint for slant paths that intersect the earth or terminate at a grey boundary (a cloud or an opaque target). The emissivity of this surface is controlled by the variables Surface Albedo Flag and Surface Albedo.

In both cases, if the Area Averaged Ground Surface Temp is left at 0 and the line-of-sight intersects the earth, then the temperature of the first atmospheric level is also used as the lower boundary temperature in the multiple scattering models.

This variable was TBOUND in earlier versions of MODTRAN.

This screen is only enabled if Mode of Execution is set to Thermal Radiance or Radiance w/ Scattering.

**Related variables**  
Mode of Execution  
Surface Albedo Flag  
Surface Albedo  
Final Height  
Area Averaged Ground Surface Temp
4.3.4.2 Surface Albedo Flag

**MODTRAN Variable:** SURREF  Card: 1  Input Screen: Surface

**Valid selections**
- **Use Surface Albedo Value** = numeric value = directly set surface albedo (reflectance)
- **Surface Spectral BRDF** = 'BRDF' = specify BRDF function for surface reflectance
- **Spectral Lambertian Surface** = 'LAMBER' = specify Lambertian function for surface reflectance

**Description**
This input controls how the reflectance (albedo) of the surface at the end of the path will be set. There are three options. First, **Use Spectral Albedo Value** lets you specify either a single number for the albedo, independent of wavelength, or select a reflectance function from the spec_alb.dat file. This is compatible with the options that existed in MODTRAN prior to version 4. **Surface Spectral BRDF** lets you choose one of the parametrized BRDF (Bidirectional Reflectance Distribution Functions) to describe the surface reflectance. Choosing this option provides access to a separate screen of inputs titled **Surface Spectral BRDF**, that can be accessed under the "Surface Spectral Reflectance" menu entry in MODTRAN inputs. **Spectral Lambertian Surface** lets you select a surface spectral reflectance function from either the spec_alb.dat file or another file in a format compatible with it. This option provides access to a separate screen of inputs titled **Spectral Lambertian Surface**, that is also accessed under the "Surface Spectral Reflectance" menu entry in MODTRAN inputs. The main difference between this last option and the first one is that you can specify the filename with the surface reflectances, and also enable use of the **Area Averaged Ground Surface Temp** input for adjacency effect modeling.

This screen is only enabled if **Mode of Execution** is set to **Thermal Radiance** or **Radiance w/ Scattering**.

**Related variables**
- **Temperature at First Boundary**
- **Surface Albedo (.000 - Blackbody)**
- Access to **Surface Spectral BRDF** screen
- Access to **Spectral Lambertian Surface** screen
4.3.4.3 Surface Albedo (.000 - Blackbody)

**MODTRAN Variable:** SURREF  
**Card:** 1  
**Input Screen:** Surface

**Valid selections**
if Combo box is set to *Numeric Value*
numeric values equal to or between 0.0 and 1.0
if Combo box is set to anything else
select one of several spectral reflectivities built into MODTRAN (REFBKG file)

**Description**
The surface albedo is the reflectivity of the radiating surface at the start of the path defined in the parameter *Temperature at First Boundary*. This reflectivity is combined with the temperature of the surface (defined in *Temperature at First Boundary*) to calculate the blackbody source spectrum from the edge of the path. Surface albedo is related to the more commonly used parameter emissivity by the relation

\[
surface\ \text{albedo} = 1 - \text{emissivity}
\]

If the Combo box is set to Numeric Value, then you set a single value of reflectivity is used for all wavelengths. If the Combo box is set to anything other than Numeric Value, then you are selecting (by name) one of the spectral reflectivity functions provided with MODTRAN in the spec_alb.dat file. This option lets you specify more realistic reflectivity functions for the start of your atmospheric path. These functions are stored in the ASCII file spec_alb.dat, which can be found in the bin\data subdirectory in your PcModWin installation. You can modify this file and add your own reflectivity functions. It can be found in the \bin\data directory in a PcModWin installation. Its format has changed significantly from the REFBKG file used in earlier versions of MODTRAN. The format is summarized briefly at the top of the file. This information is repeated below:

Lines beginning with an exclamation (!) are ignored.  
Comments after an exclamation are also ignored.

Each surface is defined by a positive integer label, a surface name, and its spectral data. The integer label and surface name must appear as a pair on a header line with the integer label followed by a blank (this name is what PcModWin displays in the combo box part of this input).

Header lines must not include a decimal point (.) before an exclamation, and spectral data must include a decimal point.

Spectral data is entered with one wavelength (in microns) and one spectral albedo per line, separated by one or more blanks. The spectral wavelengths for each surface type must be entered in increasing order. Spectral albedos should be between 0. and 1., inclusively.
Only the first 80 characters of each line is read in.

It is important to ensure that the wavelength limits on the surface properties match or exceed the spectral range specified for the MODTRAN calculation. MODTRAN will use the endpoint values at any wavelength outside the range of data provided in the file (i.e., no extrapolation is provided).

You can only access this option if **Surface Albedo Flag** is set to *Use Surface Albedo Value*.

This screen is only enabled if **Mode of Execution** is set to *Thermal Radiance* or *Radiance w/ Scattering*.

It is important to ensure that the wavelength limits on the surface properties match or exceed the spectral range specified for the MODTRAN calculation. MODTRAN will use the endpoint values at any wavelength outside the range of data provided in the file.

The built-in functions are shown below.

**Snow cover (fresh)  1**

Spectral coverage is 1.4 to 50. micrometers (200 to 7143 wavenumbers)

<table>
<thead>
<tr>
<th>Wavelength</th>
<th>Albedo</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.40</td>
<td>.48</td>
</tr>
<tr>
<td>1.46</td>
<td>.05</td>
</tr>
<tr>
<td>1.55</td>
<td>.05</td>
</tr>
<tr>
<td>1.85</td>
<td>.24</td>
</tr>
<tr>
<td>1.93</td>
<td>.02</td>
</tr>
<tr>
<td>2.08</td>
<td>.02</td>
</tr>
<tr>
<td>2.25</td>
<td>.17</td>
</tr>
<tr>
<td>2.35</td>
<td>.06</td>
</tr>
<tr>
<td>2.45</td>
<td>.02</td>
</tr>
<tr>
<td>3.00</td>
<td>.02</td>
</tr>
<tr>
<td>3.20</td>
<td>.07</td>
</tr>
<tr>
<td>5</td>
<td>.02</td>
</tr>
<tr>
<td>20</td>
<td>.02</td>
</tr>
<tr>
<td>50</td>
<td>.02</td>
</tr>
</tbody>
</table>
**Forest 2**
Spectral coverage is 1.5 to 14. micrometers (714 to 6666 wavenumbers)

<table>
<thead>
<tr>
<th>Wavelength</th>
<th>Albedo</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.5</td>
<td>0.83</td>
</tr>
<tr>
<td>2.0</td>
<td>0.83</td>
</tr>
<tr>
<td>2.5</td>
<td>0.68</td>
</tr>
<tr>
<td>2.7</td>
<td>0.42</td>
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<tr>
<td>3.0</td>
<td>0.08</td>
</tr>
<tr>
<td>3.5</td>
<td>0.16</td>
</tr>
<tr>
<td>4.0</td>
<td>0.19</td>
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<tr>
<td>4.5</td>
<td>0.26</td>
</tr>
<tr>
<td>5.0</td>
<td>0.29</td>
</tr>
<tr>
<td>6.0</td>
<td>0.27</td>
</tr>
<tr>
<td>7.0</td>
<td>0.15</td>
</tr>
<tr>
<td>8.0</td>
<td>0.15</td>
</tr>
<tr>
<td>10.</td>
<td>0.17</td>
</tr>
<tr>
<td>12.</td>
<td>0.19</td>
</tr>
<tr>
<td>14.</td>
<td>0.22</td>
</tr>
</tbody>
</table>

**Farm 3**
Spectral coverage is 1.5 to 14. micrometers (714 to 6666 wavenumbers)

<table>
<thead>
<tr>
<th>Wavelength</th>
<th>Albedo</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.5</td>
<td>0.90</td>
</tr>
<tr>
<td>2.0</td>
<td>0.90</td>
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<tr>
<td>2.5</td>
<td>0.42</td>
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<tr>
<td>3.0</td>
<td>0.12</td>
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<tr>
<td>4.0</td>
<td>0.44</td>
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<tr>
<td>5.0</td>
<td>0.60</td>
</tr>
<tr>
<td>5.5</td>
<td>0.43</td>
</tr>
<tr>
<td>6.0</td>
<td>0.20</td>
</tr>
<tr>
<td>6.5</td>
<td>0.23</td>
</tr>
<tr>
<td>7.0</td>
<td>0.15</td>
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<tr>
<td>8.0</td>
<td>0.09</td>
</tr>
<tr>
<td>9.0</td>
<td>0.12</td>
</tr>
<tr>
<td>10.</td>
<td>0.15</td>
</tr>
<tr>
<td>11.</td>
<td>0.22</td>
</tr>
<tr>
<td>12.</td>
<td>0.25</td>
</tr>
<tr>
<td>13.</td>
<td>0.20</td>
</tr>
<tr>
<td>14.</td>
<td>0.16</td>
</tr>
</tbody>
</table>
### Desert 4
Spectral coverage is 1.5 to 14. micrometers (714 to 6666 wavenumbers)

<table>
<thead>
<tr>
<th>Wavelength</th>
<th>Albedo</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.5</td>
<td>.71</td>
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<tr>
<td>2.0</td>
<td>.56</td>
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<tr>
<td>2.5</td>
<td>.38</td>
</tr>
<tr>
<td>3.0</td>
<td>.13</td>
</tr>
<tr>
<td>3.5</td>
<td>.20</td>
</tr>
<tr>
<td>4.0</td>
<td>.20</td>
</tr>
<tr>
<td>5.0</td>
<td>.20</td>
</tr>
<tr>
<td>6.0</td>
<td>.18</td>
</tr>
<tr>
<td>8.0</td>
<td>.15</td>
</tr>
<tr>
<td>10.</td>
<td>.12</td>
</tr>
<tr>
<td>12.</td>
<td>.10</td>
</tr>
<tr>
<td>14.</td>
<td>.08</td>
</tr>
</tbody>
</table>

### Ocean (not grazing angles) 5
Spectral coverage is 1.0 to 14. micrometers (714 to 10000 wavenumbers)

<table>
<thead>
<tr>
<th>Wavelength</th>
<th>Albedo</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.0</td>
<td>.03</td>
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<tr>
<td>1.5</td>
<td>.03</td>
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<tr>
<td>2.0</td>
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<tr>
<td>2.6</td>
<td>.01</td>
</tr>
<tr>
<td>2.9</td>
<td>.05</td>
</tr>
<tr>
<td>3.4</td>
<td>.02</td>
</tr>
<tr>
<td>4.0</td>
<td>.02</td>
</tr>
<tr>
<td>6.0</td>
<td>.02</td>
</tr>
<tr>
<td>8.0</td>
<td>.01</td>
</tr>
<tr>
<td>10.</td>
<td>.02</td>
</tr>
<tr>
<td>12.</td>
<td>.04</td>
</tr>
<tr>
<td>14.</td>
<td>.06</td>
</tr>
</tbody>
</table>

### Cloud Deck 6
Spectral coverage is 1.0 to 20. micrometers (500 to 10000 wavenumbers)

<table>
<thead>
<tr>
<th>Wavelength</th>
<th>Albedo</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.0</td>
<td>1.0</td>
</tr>
<tr>
<td>1.4</td>
<td>1.0</td>
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<tr>
<td>1.5</td>
<td>1.0</td>
</tr>
<tr>
<td>1.8</td>
<td>1.0</td>
</tr>
<tr>
<td>2.0</td>
<td>.50</td>
</tr>
<tr>
<td>2.1</td>
<td>1.0</td>
</tr>
<tr>
<td>2.13</td>
<td>1.0</td>
</tr>
<tr>
<td>2.25</td>
<td>1.0</td>
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<td>2.3</td>
<td>.70</td>
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<td>.70</td>
</tr>
<tr>
<td>2.6</td>
<td>.02</td>
</tr>
<tr>
<td>3.3</td>
<td>.02</td>
</tr>
</tbody>
</table>
### Old grass 7

Spectral coverage is 0.3 to 2.5 micrometers (4000 to 33333 wavenumbers)

<table>
<thead>
<tr>
<th>Wavelength</th>
<th>Albedo</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.3</td>
<td>0.07</td>
</tr>
<tr>
<td>0.45</td>
<td>0.275</td>
</tr>
<tr>
<td>0.6</td>
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</tr>
<tr>
<td>0.7</td>
<td>0.5</td>
</tr>
<tr>
<td>0.8</td>
<td>0.52</td>
</tr>
<tr>
<td>0.9</td>
<td>0.53</td>
</tr>
<tr>
<td>1.0</td>
<td>0.52</td>
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<tr>
<td>1.1</td>
<td>0.52</td>
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<tr>
<td>1.2</td>
<td>0.51</td>
</tr>
<tr>
<td>1.3</td>
<td>0.51</td>
</tr>
<tr>
<td>1.4</td>
<td>0.50</td>
</tr>
<tr>
<td>1.5</td>
<td>0.42</td>
</tr>
<tr>
<td>1.6</td>
<td>0.44</td>
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<tr>
<td>1.7</td>
<td>0.44</td>
</tr>
<tr>
<td>1.8</td>
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<tr>
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<tr>
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<tr>
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<tr>
<td>2.2</td>
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</tr>
<tr>
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<td>0.3</td>
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<tr>
<td>2.4</td>
<td>0.29</td>
</tr>
<tr>
<td>2.5</td>
<td>0.24</td>
</tr>
</tbody>
</table>
### Dead grass  8
Spectral coverage is 0.3 to 2.5 micrometers (4000 to 33333 wavenumbers)

<table>
<thead>
<tr>
<th>Wavelength</th>
<th>Albedo</th>
</tr>
</thead>
<tbody>
<tr>
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<td>.1</td>
</tr>
<tr>
<td>0.45</td>
<td>.2</td>
</tr>
<tr>
<td>0.6</td>
<td>.28</td>
</tr>
<tr>
<td>0.7</td>
<td>.35</td>
</tr>
<tr>
<td>0.8</td>
<td>.40</td>
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<tr>
<td>0.9</td>
<td>.42</td>
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<td>.45</td>
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<tr>
<td>1.1</td>
<td>.47</td>
</tr>
<tr>
<td>1.2</td>
<td>.50</td>
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<td>1.4</td>
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</tr>
<tr>
<td>1.5</td>
<td>.50</td>
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<tr>
<td>1.6</td>
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<td>1.7</td>
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</tr>
<tr>
<td>2.0</td>
<td>.48</td>
</tr>
<tr>
<td>2.1</td>
<td>.42</td>
</tr>
<tr>
<td>2.2</td>
<td>.45</td>
</tr>
<tr>
<td>2.3</td>
<td>.4</td>
</tr>
<tr>
<td>2.4</td>
<td>.4</td>
</tr>
<tr>
<td>2.5</td>
<td>.3</td>
</tr>
</tbody>
</table>

### Maple leaves  9
Spectral coverage is 0.3 to 2.5 micrometers (4000 to 33333 wavenumbers)

<table>
<thead>
<tr>
<th>Wavelength</th>
<th>Albedo</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.3</td>
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</tr>
<tr>
<td>0.45</td>
<td>.03</td>
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<tr>
<td>0.53</td>
<td>.07</td>
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<tr>
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<td>.04</td>
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<tr>
<td>0.7</td>
<td>.05</td>
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<tr>
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<td>.55</td>
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<td>.35</td>
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<td>1.9</td>
<td>.10</td>
</tr>
<tr>
<td>2.0</td>
<td>.10</td>
</tr>
</tbody>
</table>
Burnt grass 10
Spectral coverage is 0.3 to 2.5 micrometers (4000 to 33333 wavenumbers)

<table>
<thead>
<tr>
<th>Wavelength</th>
<th>Albedo</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.3</td>
<td>0.02</td>
</tr>
<tr>
<td>1.1</td>
<td>0.05</td>
</tr>
<tr>
<td>1.7</td>
<td>0.105</td>
</tr>
<tr>
<td>2.5</td>
<td>0.20</td>
</tr>
</tbody>
</table>

Constant 21
Spectral coverage is entire band of MODTRAN

<table>
<thead>
<tr>
<th>Wavelength</th>
<th>Albedo</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.0</td>
<td>0.0</td>
</tr>
</tbody>
</table>

Constant 22
Spectral coverage is entire band of MODTRAN

<table>
<thead>
<tr>
<th>Wavelength</th>
<th>Albedo</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.0</td>
<td>0.5</td>
</tr>
</tbody>
</table>

CCM3 Sea Ice 31
Spectral coverage is 2500 to 50000. wavenumbers (0.2 to 4 micrometers)

<table>
<thead>
<tr>
<th>Wavelength</th>
<th>Albedo</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.2</td>
<td>0.7</td>
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<tr>
<td>0.7</td>
<td>0.7</td>
</tr>
<tr>
<td>0.7001</td>
<td>0.5</td>
</tr>
<tr>
<td>4.0</td>
<td>0.5</td>
</tr>
</tbody>
</table>

The remaining tables are omitted due to their size and high level of spectral detail.

Related variables

Temperature at First Boundary
4.3.5 Screen “Solar Irradiance”

This screen provides optional control over the solar source function used in MODTRAN calculations. It is shown below:

You can choose the built-in function, or one provided as a separate file with MODTRAN. Some additional controls, for advanced users, are also provided.

This screen is only enabled for MODTRAN calculations when the sun will be used. This is when Mode of Execution is set to Radiance w/ Scattering or Direct Solar Irradiance.
4.3.5.1 Solar Irradiance Source

**MODTRAN Variable:** LSUN  Card: 1A  Input Screen: Solar Irradiance

**Valid selections**
*File Sun 2* = read solar irradiance function from a file
*MODTRAN 2* = use previous solar function built into MODTRAN

**Description**
This input controls whether the new options for solar irradiance functions at the top of the atmosphere (TOA) are used. If this input is set to *File Sun 2*, then the solar function used comes from one of the new files supplied with MODTRAN 3.7, or a user supplied file. If this input is set to *MODTRAN 2*, the solar data built-in to MODTRAN is used. This data is stored in the block data routine sunbd.f. The latter option lets users use the previous solar data for compatibility with past runs of MODTRAN.

If this input is set to *MODTRAN 2*, the rest of the inputs on this card are not used.

This screen is only enabled for MODTRAN calculations when the sun will be used. This is when **Mode of Execution** is set to Radiance w/ Scattering or Direct Solar Irradiance.

**Related variables**
*Triangular Function Width*
*Modify Solar Database*
*Solar Database Option*
4.3.5.2 Top of Atmosphere Parameters

**MODTRAN Variable:** SOLCON  **Card:** 1A  **Input Screen:** Solar Irradiance

**Valid selections**

*Do not scale TOA irradiance* = 0 use unmodified TOA irradiance from selected function

*Scale TOA irradiance* = < 0 = input scale factor for TOA solar irradiance

*Use solar constant* = > 0 = scale by specifying solar constant in watts per meter\(^2\)

**Description**

This input provides some ability to scale the magnitude of the top of the atmosphere (TOA) solar irradiance, which in turn will scale the solar contribution to the MODTRAN calculation. *Do not scale TOA irradiance* leaves the solar function alone and uses the magnitude of the solar function selected under Solar Database Option. For example, the Corrected Kurucz database integrates to 1368.0 W/m\(^2\), the Cebula + Chance database integrates to 1362.12 W/m\(^2\), the Chance database integrates to 1359.75 W/m\(^2\), and the Thulier + corrected Kurucz database integrates to 1376.73 W/m\(^2\).

If you select *Scale TOA irradiance*, you then provide a Scale Factor input that the entire selected solar database function is multiplied by. Using a value of 1 for this scale factor leaves the magnitude unchanged. Values less than 1 reduce it, values greater than 1 increase it. MODTRAN assumes that for this case the scaling factor will be reasonably close to 1.

Selecting *Use solar constant* lets you directly input the integral of the solar irradiance function in Solar Constant. The entire solar function is adjusted to produce this integral. This is merely another method of scaling the magnitude of the solar function, and might be more convenient than adjusting by a percentage scaling factor as in the other method.

Note that in all cases an additional scaling factor is applied to the solar irradiance value to account for variations throughout the year in the earth to sun distance. This calculation is based on the setting of the Day of Year input. This earth-to-sun correction factor is reported in the tape6 or modout1 output file.

This screen is only enabled for MODTRAN calculations when the sun will be used. This is when Mode of Execution is set to Radiance w/ Scattering or Direct Solar Irradiance.

**Related variables**

<table>
<thead>
<tr>
<th>Scalar Factor</th>
<th>Mode of Execution</th>
</tr>
</thead>
<tbody>
<tr>
<td>Solar Constant</td>
<td>Day of Year</td>
</tr>
</tbody>
</table>
4.3.5.3 Scalar Factor

**MODTRAN Variable:** SOLCON  **Card:** 1A  **Input Screen:** Solar Irradiance

**Valid selections**
floating point number > 0, typically close to 1

**Description**
This prompt lets you provide a scaling input that the entire selected solar database function is multiplied by. Using a value of 1 for this scale factor leaves the magnitude unchanged. Values less than 1 reduce it, values greater than 1 increase it. MODTRAN assumes that for this case the scaling factor will be reasonably close to 1. This is one method of scaling the magnitude of the top of atmosphere solar function. The other method is to set Top of Atmosphere Parameters to Use Solar Constant. Then the Solar Constant input is displayed, and you can directly specify the solar constant to force the integrated irradiance to.

This input is only enabled if Top of Atmosphere Parameters is set to Scale TOA Irradiance.

Note that in all cases an additional scaling factor is applied to the solar irradiance value to account for variations throughout the year in the earth to sun distance. This calculation is based on the setting of the Day of Year input. This earth-to-sun correction factor is reported in the tape6 or modout1 output file.

This screen is only enabled for MODTRAN calculations when the sun will be used. This is when Mode of Execution is set to Radiance w/ Scattering or Direct Solar Irradiance.

**Related variables**
Top of Atmosphere Parameters
Solar Constant
Day of Year
Mode of Execution
4.3.5.4 Solar Constant

**MODTRAN Variable:** SOLCON  **Card:** 1A  **Input Screen:** Solar Irradiance

**Valid selections**
floating point number $> 0$ in units of watts per square meter

**Description**
This prompt lets you directly input the integral of the solar irradiance function at the top of the atmosphere. The entire solar function is adjusted to produce this integral. This is one method of scaling the magnitude of the top of atmosphere solar function. The other method is to set Top of Atmosphere Parameters to Scale TOA irradiance. Then the Scale Factor input is displayed, and you can directly specify the scaling factor to use.

Note that in all cases an additional scaling factor is applied to the solar irradiance value to account for variations throughout the year in the earth to sun distance. This calculation is based on the setting of the Day of Year input. This earth-to-sun correction factor is reported in the tape6 or modout1 output file.

This screen is only enabled for MODTRAN calculations when the sun will be used. This is when Mode of Execution is set to Radiance w/ Scattering or Direct Solar Irradiance.

This input is only displayed if Top of Atmosphere Parameters is set to Use Solar Constant.

This screen is only enabled for MODTRAN calculations when the sun will be used. This is when Mode of Execution is set to Radiance w/ Scattering or Direct Solar Irradiance.

**Related variables**
- Top of Atmosphere Parameters
- Scale Factor
- Day of Year
- Mode of Execution
4.3.5.5 Triangular Filter Width

**MODTRAN Variable:** ISUN  
**Card:** 1A  
**Input Screen:** Solar Irradiance

**Valid selections**
integer = or greater than 2 in units of wavenumbers

**Description**
This input sets the full width at half maximum of the triangular scanning function that is used to smooth the top of the atmosphere solar irradiance function. The solar data is provided at the maximum resolution supported by MODTRAN. Normally this should be set to the same resolution of the final output. However, you can smooth (or preserve at higher resolution) the solar irradiance function that is used internally in the MODTRAN calculations.

This input is only needed if Solar Irradiance Source is set to File Sun 2.

This screen is only enabled for MODTRAN calculations when the sun will be used. This is when Mode of Execution is set to Radiance w/ Scattering or Direct Solar Irradiance.

**Related variables**
Solar Irradiance Source  
Modify Solar Database  
Solar Database Option
4.3.5.6 Modify Solar Database

**MODTRAN Variable:** LSUNFL  **Card:** 1A  **Input Screen:** Solar Irradiance

**Valid selections** [check box input]
- unchecked = use solar irradiance data internal to MODTRAN
- checked = use TOA solar irradiance data stored in an external file

**Description**
This input determines whether the solar irradiance data will be read from a separate file, or will use the built-in solar data. If it is unchecked, the solar data built into MODTRAN will be used. If it is checked, then the Solar Database Option input is enabled, and you can select one of several external files for the top of the atmosphere solar irradiance, or supply your own.

This input is only used if Solar Irradiance Source is set to File Sun 2. If not, this input is ignored by MODTRAN, and the solar data internal to MODTRAN is used.

This screen is only enabled for MODTRAN calculations when the sun will be used. This is when Mode of Execution is set to Radiance w/ Scattering or Direct Solar Irradiance.

**Related variables**
- Solar Irradiance Source
- Solar Database Option
4.3.5.7 Solar Database Option

**MODTRAN Variable:** SUNFL2  
**Card:** 1A1  
**Input Screen:** Solar Irradiance

**Valid selections**
- Corrected Kurucz database = 1 = use data in file data\newkur.dat
- Older Kurucz database = 2 = use data in file data\oldkur.dat
- Chance database = 3 = use data in file data\chkur.dat
- Cebula + Chance database = 4 = use data in file data\cedchkur.dat
- Thullier + corrected Kurucz database = 5 = use data in file data\thkur.dat
- User supplied file = blank = specify name + location of user defined TOA solar irradiance

**Description**
This input specifies the location of the top of the atmosphere (TOA) solar irradiance function to use in the MODTRAN calculation. Each of these options selects one of the files located in the \pcmodwin\bin\data directory. This gives you flexibility over use of solar databases from various sources.

If you select *User supplied file*, you must set the *User Supplied File* input to point to a file in the correct format for MODTRAN.

This input is only used if *Modify Solar Database* is checked, and if *Solar Irradiance Source* is set to *File Sun 2*. If not, this input is ignored by MODTRAN, and the solar data internal to MODTRAN is used.

This screen is only enabled for MODTRAN calculations when the sun will be used. This is when *Mode of Execution* is set to *Radiance w/ Scattering* or *Direct Solar Irradiance*.

**Related variables**
- Modify Solar Database
- Solar Irradiance Source
- User Supplied File
4.3.5.8 User Supplied File

**MODTRAN Variable:** SUNFL2  
**Card:** 1A1  
**Input Screen:** Solar Irradiance

**Valid selections**  
path + filename that points to a valid TOA solar irradiance file

**Description**  
This input lets you use your own top of the atmosphere (TOA) solar irradiance database file. You must set this input box to a valid path and filename for your system. You can directly type this in, or use the Browse button to display a dialog box that interactively selects the path and file to use for this. Relative paths can be used, and are encouraged to minimize the dependence on a given software setup. For example, files located in the \pcmodwin\bin\data directory can be referred to as simply the "data" directory. MODTRAN executes in the \pcmodwin\bin directory, so you can set paths relative to this location.

The format of the file specified here must match certain MODTRAN requirements, or a run-time error will result. The first line must contain a pair of integers that tell MODTRAN the units used for the frequency and irradiance entries. The first integer on the first line designates units for wavelength or frequency, using the following allowed values:

1 = wavenumbers  
2 = nanometers  
3 = micrometers

The second integer on the first line sets the units for the irradiance entries, using the following allowed values:

1 = watts/cm^2/wavenumber  
2 = photons/sec/cm^2/nm  
3 = watts/m^2/micrometer or milliwatts/m^2/nm (the two units are equivalent)

The subsequent lines in the file contain one pair of frequency and irradiance entry per line. There is no restriction on frequency or wavelength increments. Data beyond 50000 wavenumbers is ignored. If needed, data from the user supplied file are padded by numbers from newkur.dat so that the data encompasses the range of 50 to 50000 wavenumbers.

No checking is applied to this file, prior to MODTRAN execution. It is the user's responsibility to ensure that the file exists, and matches the above format, prior to executing MODTRAN.
This input is only used if Solar Database Option is set to User supplied file, if Modify Solar Database is checked, and if Solar Irradiance Source is set to File Sun 2. If not, this input is ignored by MODTRAN, and the solar data internal to MODTRAN is used.

This screen is only enabled for MODTRAN calculations when the sun will be used. This is when Mode of Execution is set to Radiance w/ Scattering or Direct Solar Irradiance.

Related variables
- Modify Solar Database
- Solar Irradiance Source
- Solar Database Option
4.3.6 Screen “Aerosols”

This screen specifies the use of aerosol profiles (built-in or user provided), cloud models, the rain option, the elevated ground option, and some specific inputs required by one of the built-in aerosol profiles (the Navy Maritime profile). It is shown below:

This screen is always available when setting up MODTRAN inputs. Note that aerosols can be removed from your calculation by setting the first input on this card, Aerosol Model Used, to No Aerosol Attenuation. When aerosols are included, access to many additional cards (cards 2.x) is controlled by variables on this screen.
4.3.6.1 Aerosol Model Used

**MODTRAN Variable:** IHAZE  **Card:** 2  **Input Screen:** Aerosols

**Valid selections**

No Aerosol Attenuation  = 0 = no aerosol effects included in the calculation
Rural - VIS=23km  = 1 = RURAL extinction, default VIS = 23 km
Rural - VIS=5km  = 2 = RURAL extinction, default VIS = 5 km
Navy Maritime  = 3 = NAVY MARITIME extinction, sets its own VIS
Maritime - VIS=23km  = 4 = MARITIME extinction, default VIS = 23 km
Urban - VIS=5km  = 5 = URBAN extinction, default VIS = 5 km
Tropospheric - VIS=50km  = 6 = TROPOSPHERIC extinction, default VIS = 50 km
User Defined - VIS=23km  = 7 = USER DEFINED extinction, default VIS = 23 km
Fog advection - VIS=.5km  = 8 = FOG1 (advection fog) extinction, default VIS = 0.2 km
Fog radiation - VIS=.2km  = 9 = FOG2 (radiation fog) extinction, default VIS = 0.5 km
Desert extinction  = 10 = DESERT extinction, sets its own VIS from WSS

**Description**

This parameter selects the aerosol model that is used for the boundary layer (0 to 2 km) calculations as well as the default meteorological range at the surface. Note that the relative humidity dependence of the boundary layer aerosol extinction coefficients is based on the water vapor content of the model atmosphere selected in Model Atmosphere. The meteorological range is defined in an equation found in the discussion of Surface Range for Boundary Layer. The default value for the meteorological range (shown as 'default VIS' above) can be overridden by inputting a value in the parameter Surface Range for Boundary Layer.

The Rural, Maritime, and Urban models provide aerosol extinction characteristic of an air mass that has just moved through one of these types of areas. The Tropospheric model characterizes very clear conditions.

Option Navy Maritime (IHAZE = 3) selects use of the Navy Maritime Aerosol model. Aerosol population over the ocean is significantly different from continental aerosols, and this model attempts to model this difference. Three distinct types of aerosols are assumed: a 'continental' component contributed by nearby land mass (controlled by Air Mass Character); a 'stationary' component affected by the winds (controlled by the 24-hour Average Wind Speed); and a 'fresh' component caused by wind over the water (controlled by Wind Speed - Navy Maritime Aerosols). Note that the NOVAM option, new starting with MODTRAN 3.7, provides an improved aerosol option for the boundary layer over the ocean.

If you select User Defined as the input here, the screen User Supplied Aerosols is enabled in the MODTRAN inputs. This screen and another display a list of wavelength values.
and allows you to input an aerosol extinction and aerosol absorption coefficient for each wavelength.

Fog forms when the air is saturated with water vapor. This saturation can occur in two different ways: (1) the mixing of air masses with different temperatures and/or humidities (advection fogs), and (2) cooling of the air to the point where its temperature approaches the dew point temperature (radiation fogs). Thus two basic fog models are provided for use in the boundary layer. The first model, labeled Fog advection - VIS = .2 km, represents the advection fog, while the other, labeled Fog radiation - VIS = .5 km, is for radiation fogs. The extinction coefficients for radiation fogs are higher between 2 - 4 microns but significantly lower longer than 5 microns (compared to advection fogs). The absorption coefficients for radiation fogs are generally 10% - 20% lower than advection fogs.

Desert extinction is an aerosol profile that models particles over desert conditions. It contains a wind speed dependent parameter.

The aerosol model calculations can be bypassed by selecting No Aerosol Attenuation.

**Related variables**
- Surface Range for Boundary Layer
- Model Atmosphere
- Air Mass Character
- 24-hour Average Wind Speed
- Wind Speed - Navy Maritime Aerosols

access to screens User Supplied Aerosols are controlled by this variable
4.3.6.2 Seasonal Modifications to Aerosols

**MODTRAN Variable:** ISEASN  **Card:** 2  **Input Screen:** Aerosols

**Valid selections**

*Determined by Model* = 0 = use default season determined by Model Atmosphere

- **Fall-Winter** is the default for MIDLATITUDE WINTER (MODEL = 3)
  - SUBARCTIC WINTER (MODEL = 5)
- **Spring-Summer** is the default for METEOROLOGICAL DATA INPUT (MODEL = 0)
  - TROPICAL (MODEL = 1)
  - MIDLATITUDE SUMMER (MODEL = 2)
  - SUBARCTIC SUMMER (MODEL = 4)
  - 1976 U.S. STANDARD ATMOSPHERE (MODEL = 6)
  - NEW MODEL ATMOSPHERE (MODEL = 7)

*Spring-Summer* = 1 = use SPRING-SUMMER profile

*Fall-Winter* = 2 = use FALL-WINTER profile

**Description**

This is one of the four parameters that selects the altitude and season dependent aerosol profiles and aerosol extinction coefficients. This parameter selects the season-dependent modifications made to the profiles for the two middle layers of aerosols: the tropospheric layer (2 - 10 km) and the stratospheric layer (10 - 30 km). Part of the seasonal changes are caused by variations in average tropopause height. In mid-latitude applications, seasonal profiles should be generally used as named. In tropical regions, where the tropopause is generally higher, **Spring-Summer** should be generally used. In subarctic regions, where tropopause is generally lower, **Fall-Winter** should be used.

**Related variables**

Model Atmosphere
4.3.6.3 Upper Atmosphere Aerosols (30 - 100 km)

**MODTRAN Variable:** IVULCN  
**Card:** 2  
**Input Screen:** Aerosols

**Valid selections**
- *Background Stratospheric* = 0,1 = use BACKGROUND STRATOSPHERIC profile and extinction
- *Moderate/Aged Volcanic* = 2 = MODERATE profile and AGED VOLCANIC extinction
- *High/Fresh Volcanic* = 3 = HIGH profile and FRESH VOLCANIC extinction
- *High/Aged Volcanic* = 4 = HIGH profile and AGED VOLCANIC extinction
- *Moderate/Fresh Volcanic* = 5 = MODERATE profile and FRESH VOLCANIC extinction
- *Bkgd Strat/Moderate* = 6 = MODERATE profile and BACKGROUND STRATO extinction
- *Bkgd Strat/High Volcanic* = 7 = HIGH profile and BACKGROUND STRATO extinction
- *Extreme Volcanic Profile* = 8 = EXTREME profile and FRESH extinction

**Description**
This is one of the four parameters that selects the altitude and seasonal dependent aerosol profiles and aerosol extinction coefficients. This parameter chooses the type of extinction and aerosol profiles for the stratospheric region (10-30 km). It also selects the transition profiles above the stratosphere up to 100 km. Meteoric dust extinction coefficients are always used for altitudes above 30 km.

The major component of the stratospheric aerosols is taken to be a 75 percent solution of sulfuric acid in water. Thus the *Background Stratospheric* model was representative of typical conditions in 1980 prior to the eruption of Mt. St Helens (May 1980). This parameter allows you to modify this profile to model changes around the time of a major volcanic eruption. For the first few months following an eruption the *Fresh Volcanic* model extinction should be used, and for the next year or so the *Aged Volcanic* extinction profile is appropriate. The *Moderate* and *High* volcanic profiles allow you to approximate the amount of material added to the atmosphere by the eruption. For example, the Mt. St. Helens eruption added significant amounts of dust into the atmosphere. However, early analysis indicated most of the dust remained in the troposphere where it had a relatively short lifetime. Thus a best guess would be to use the *Moderate Volcanic* profile for MODTRAN modeling of the atmosphere around this period. Unlike the Mount St Helens eruption, the June 1991 eruption of Mount Pinatubo in the Philippines produced significantly more volcanic dust which remained in the stratospheric region until late 1993. Each volcanic eruption should be analyzed with this level of detail before deciding upon the proper volcanic aerosol profile. The major component of the normal upper-atmospheric aerosols is meteoric or cometary dust.

**Related variables**
None
4.3.6.4 Air Mass Character for Navy Maritime Aerosol

**MODTRAN Variable:** ICSTL  
**Card:** 2  
**Input Screen:** Aerosols

**Valid selections**
Values can range from 1 to 10
1 = open ocean
...
10 = strong continental influence
The default value is 3

**Description**
This parameter is only used when the *Navy Maritime* model is selected in *Aerosol Model Used*. It controls the amount of aerosols contributed by nearby continental land masses. The greater the influence of a land mass, the larger the value assigned to this parameter, which operates on a sliding scale from 1 to 10.

Three methods are presented for calculating this number. These 3 methods are: (1) Determine the elapsed time in days since the air mass left land. Then use the equation ICSTL = INT(9*exp[-t/4]+1), where t is the number of days. (2) If measurements of the current atmospheric Radon 222 concentrations are available, use ICSTL = INT(Rn/4)+1 where Rn is the concentration of radon 222 in picocuries/cubic meter. This approach is valid because radon 222 is introduced into the atmosphere only by processes occurring over land. (3) Simply estimate the amount of land influence that occurred, using 1 for pure oceanic air and 10 for air that has recently been ashore over a polluted industrial area. Use the intermediate values between 1 and 10 for air between these extremes.

If the *Navy Maritime* aerosol model is not selected under *Aerosol Model Used*, this parameter is ignored.

**Related variables**
*Aerosol Model Used*
4.3.6.5 Use Cloud / Rain Aerosol Extension

**MODTRAN Variable:** ICLD  **Card:** 2  **Input Screen:** Aerosols

**Valid selections**
- No Clouds or Rain = 0 = no cloud attenuation included
- Cumulus Clouds = 1 = cumulus cloud with base 0.66 km, top at 2.7 km
- Altostratus Clouds = 2 = altostratus cloud with base 2.4 km, top at 3.0 km
- Stratus Clouds = 3 = stratus cloud with base 0.33 km, top at 1.0 km
- Stratus/Strato-Cumulus = 4 = strato-cumulus cloud with base 0.66 km, top at 2 km
- Nimbostratus Clouds = 5 = nimbostratus cloud with base 0.16 km, top at 0.66 km
- 2.0 mm/hr Rain = 6 = simulate drizzle rain with stratus clouds
- 5.0 mm/hr Rain = 7 = simulate light rain with nimbostratus clouds
- 12.5 mm/hr Rain = 8 = simulate moderate rain with nimbostratus clouds
- 25.0 mm/hr Rain = 9 = simulate heavy rain with cumulus clouds
- 75.0 mm/hr Rain = 10 = simulate extreme rain with cumulus clouds
- User Input Cloud Ext & Absor = 11 = use user defined cloud extinction/absorption
- Cirrus Profile = 18 = use standard cirrus model
- Subvisual Cirrus Profile = 19 = use optically thin cirrus
- NOAA Cirrus Profile = 20 = cirrus profile from LOWTRAN 6

**Description**
This option allows use of a series of cloud extinction models that are provided as part of MODTRAN. These models are infinite (in X and Y directions) plane-parallel models that simulate particle and droplet concentrations found in real clouds. Low altitude clouds, different rain rates, and high altitude cirrus cloud models are provided, along with the ability to add your own cloud extinction, absorption, and scattering profiles.

Cumulus, Altostratus, Stratus, Strato-Cumulus, and Nimbostratus options select five different cloud types. The base and top cited for each model is the region where the air is considered saturated with 100% relative humidity. The humidity is still elevated around the cloud, so it will affect transmission and radiance calculations in paths that pass near the clouds. The average water droplet size distribution is assumed centered around a 10 micron droplet diameter. The drops are treated as aerosols.

Five different built-in rain rate models (2.0 mm/hr Rain, 5.0 mm/hr Rain, 12.5 mm/hr Rain, 25.0 mm/hr Rain, and 75.0 mm/hr Rain) allow the user the ability to simulate different rain rates in the boundary layer. The actual values used for each layer are echoed in the input cards at the beginning of the MODOUT1 (TAPE6) file.

User Input Cloud Ext/Absor lets the user specify your own cloud profile. The actual values are entered on input screens User Supplied Aerosols and User Supplied Extinction (MODTRAN cards 2D and 2D2).

Cirrus Profile and Subvisual Cirrus Profile simulate attenuation caused by cirrus clouds. The cirrus clouds are assumed to be made of ice particles and to occur at high altitudes.
The attenuation coefficients used are based on a combination of theoretical models and measured extinction of solar radiation. These models include realistic wavelength dependence to the scattering and absorption parameters used.

NOAA Cirrus Profile is the same cirrus model that was provided as an option in LOWTRAN 6 and 7. The attenuation applied by this model is independent of wavelength and related only to the thickness of the cirrus layers. The default cirrus thickness is 1 km, but you can set any value using the parameter Cirrus Thickness. The default base altitude for the cirrus layer is 11 km (TROPICAL), 10 km (MIDLATITUDE SUMMER), 8 km (MIDLATITUDE WINTER), 7 km (SUBARCTIC SUMMER), or 5 km (SUBARCTIC WINTER). These defaults can be overridden using the parameter Cirrus Base Altitude.

If you select any of the 10 water cloud models (5 clouds and 5 rain rate options), the screen Clouds is enabled. If you select any of the three cirrus models, screen Cirrus Clouds is enabled. These let you control additional parameters about the clouds. Starting with MODTRAN 3.7, extensive additional user control is provided with the standard cloud models.

**Related variables**
if this input is set as below, access to the screen Clouds is enabled
- Cumulus Clouds
- Altostratus Clouds
- Stratus Clouds
- Stratus/Strato-Cumulus
- Nimbostratus Clouds
- 2.0 mm/hr Rain
- 5.0 mm/hr Rain
- 12.5 mm/hr Rain
- 25.0 mm/hr Rain
- 75.0 mm/hr Rain

User Input Cloud Ext & Absor
if this input is set as below, access to the screen Cirrus Clouds is enabled
- Cirrus Profile
- Subvisual Cirrus Profile
- NOAA Cirrus Profile
4.3.6.6 Use Army (VSA) for Aerosol Extensions

**MODTRAN Variable:** IVSA  
**Card:** 2  
**Input Screen:** Aerosols

**Valid selections** [checkbox input]
- **Unchecked** = 0 = do not use Army VSA
- **Checked** = 1 = use VSA (vertical structure algorithm)

**Description**
The Army Vertical Structure Algorithm (VSA) is a model describing the vertical structure of aerosols for specialized conditions in the boundary layer (0 - 2 km altitude). VSA describes vertical structure detail that is physically small (hundreds to tens of meters thick) which plays an important role in atmospheric transmission near the ground.

The VSA can be used for 4 cases: (1) dense ground fog; (2) haze or light fog below low level cloud; (3) shallow radiation fog or haze layer without a low level cloud layer; and (4) shallow haze layer near surface in relatively clear atmosphere. A variant on case (2), called case 2' in the LOWTRAN 6 manual, allows the haze layer below the cloud to be moderate to light. The way the VSA models these 4 cases is covered in chapter 6 of the LOWTRAN 6 manual, and that discussion should be read carefully before using the VSA. The VSA is implemented in MODTRAN exactly the same as described in that manual for LOWTRAN 6.

These 4 cases are selected by the data values assigned to the variables **Surface Range for Boundary Layer**, **VSA Cloud Ceiling Height**, and **VSA Inversion/Boundary Layer Height**. The following table describes how to select each case:

<table>
<thead>
<tr>
<th>Condition</th>
<th>Selected By</th>
</tr>
</thead>
</table>
| Case 1 Fog                    | **Surface Range** < or = to 0.5 km  
VSA Cloud Ceiling Height > or = to 0 km |
| Case 2 Haze/light fog         | 0.5 km < **Surface Range** < or = to 10 km  
VSA Cloud Ceiling Height > or = to 0 km |
| Case 2' Moderate/high vis     | **Surface Range** > 10 km  
VSA Cloud Ceiling Height > or = to 0 km |
| Case 3 Radiation fog/haze     | **Surface Range** > 0.5 km  
VSA Cloud Ceiling Height < 0  
VSA Inversion/Boundary Layer Height > or = to 0 |
| Case 4 No boundary layer      | **Surface Range** > 0.5 km  
VSA Cloud Ceiling Height < 0  
VSA Inversion/Boundary Layer Height > or = to 0 |

In case 3, a radiation fog is assumed if **Surface Range** < 2 km or **Aerosol Model Used** is Radiation Fog; a haze is assumed if **Surface Range** > 2 km. The primary difference between case 3 and case 4 is the first 200 meters above ground (Figure 18, LOWTRAN 6 manual, p. 53).
Note that input screen VSA Cloud is not enabled unless you have checked the box for this variable.

**Related variables**
- Aerosol Model Used
- Surface Range for Boundary Layer
- VSA Cloud Ceiling Height
- VSA Cloud/Fog Thickness
- VSA Inversion/Boundary Layer Height
4.3.6.7 Surface Range for Boundary Layer

**MODTRAN Variable:** VIS  
**Card:** 2  
**Input Screen:** Aerosols

**Valid selections**  
numeric value > 0 in units of kilometers  
if value = 0, default values (depending upon specific profiles selected) will be used

**Description**  
This parameter defines the surface meteorological range. This parameter is related to but is not to be confused with surface visibility. Meteorological range is defined in MODTRAN using the following form of the Koschmieder formula: \( \text{met range} = \frac{3.912}{B} \), where \( B \) is the extinction coefficient evaluated at 0.55 micrometers. If, as is commonly true, only an observer visibility \( V_{\text{obs}} \) is available, the meteorological range can be estimated for MODTRAN using the approximation \( \text{met range} = 1.3 \times V_{\text{obs}} \), with an error around 25% in the approximation.

If this parameter is set greater than 0, it overrides the default meteorological range associated with each of the boundary layer (0 - 2 km) aerosol models that can be selected using Aerosol Model Used. A list of the default meteorological ranges for each model is found in the description of Aerosol Model Used.

This parameter provides one of the primary ways to increase or decrease the amount of aerosol extinction and absorption in the boundary layer. Aerosol extinction and absorption data is stored in MODTRAN normalized to 1 at 0.55 micrometers, in the heart of the visible band. The visibility, or surface range, provides a measure of the amount of attenuation at 0.55 micrometers, which is then used to compute the scaling factor applied to the extinction or absorption spectral curve. Larger values for surface meteorological range reduce aerosol effects, while smaller values increase aerosol effects. This parameter is thus very important in the aerosol calculation, even if your spectral bandpass does not include any part of the visible band.

If the vertical structure algorithm (VSA) has been enabled by checking Use of Army (VSA) for Aerosols, then this variable plays an important role in selecting which VSA case to use in the calculation. See the Army VSA model description for further discussion.

**Related variables**  
Aerosol Model Used  
Use of Army (VSA) for Aerosols
4.3.6.8 Wind Speed - Navy Maritime Aerosol (m/s)

**MODTRAN Variable:** WSS  
**Card:** 2  
**Input Screen:** Aerosols

**Valid selections**
0 or negative = a default value is chosen based on the model atmosphere selected in Model Atmosphere. The default values are:

<table>
<thead>
<tr>
<th>Model</th>
<th>Wind Speed (m/sec)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Meteorological data supplied</td>
<td>6.9</td>
</tr>
<tr>
<td>TROPICAL MODEL ATMOSPHERE</td>
<td>4.1</td>
</tr>
<tr>
<td>MIDLATITUDE SUMMER</td>
<td>4.1</td>
</tr>
<tr>
<td>MIDLATITUDE WINTER</td>
<td>10.29</td>
</tr>
<tr>
<td>SUBARCTIC SUMMER</td>
<td>6.69</td>
</tr>
<tr>
<td>SUBARCTIC WINTER</td>
<td>12.35</td>
</tr>
<tr>
<td>1976 US Standard Atmosphere</td>
<td>7.2</td>
</tr>
<tr>
<td>New model atmosphere</td>
<td>6.9</td>
</tr>
</tbody>
</table>

value > 0 = user supplied value in units of meters/sec

**Description**
This parameter is only used when either the Navy Maritime or Desert extinction aerosol models are selected in Aerosol Model Used. It controls the effect of the 'fresh' aerosol component in the Navy Maritime model. The size of this component is a function of the current wind speed and reflects the production of drops by the wind from whitewater on waves. If you know the actual value for the air mass you are modeling, you can input it here (in meters/second). If the actual value is not known, a set of default values for each model can be selected by inputting 0. The defaults, shown above, are based on average values measured in observations, except for the user-defined cases, which use a global mean average value. In the Desert Extinction model the amount entered for this variable determines the amount of air-borne dust obscuration. Wind blown desert aerosols are largely made up of crustal material that are representative of loose and finely grained soils.

If the Wind Speed is not specified in this parameter, it is set equal to the 24-Hr Average Wind Speed. If the Navy Maritime or Desert Extinction models are not selected in Aerosol Model Used, this parameter is ignored.

**Related variables**
Aerosol Model Used
24-Hr Average Wind Speed
4.3.6.9 24 - hr Average Wind Speed - Navy Maritime (m/s)

**MODTRAN Variable:** WHH       **Card:** 2       **Input Screen:** Aerosols

**Valid selections**
numeric value > 0 in units of meters/sec

**Description**
This parameter is only used when the Navy Maritime aerosol model is selected in Aerosol Model Used. It controls the effect of the "stationary" component of the maritime aerosol model, which represents the aerosols caused by high winds and whitewater that do not fall rapidly out of the atmosphere. The size of this component is proportional to the average wind speed over the past 24 hours, which is specified by this parameter.

Note that if the Wind Speed - Navy Maritime Aerosol has not been specified, the value for this parameter is used to calculate the fresh component of the Navy Maritime aerosol model. If the Navy Maritime model is not selected under Aerosol Model Used, this parameter is ignored.

**Related variables**
Aerosol Model Used
Wind Speed - Navy Maritime Aerosol
4.3.6.10 Rain Rate (mm/hr)

**MODTRAN Variable:** RAINRT  
**Card:** 2  
**Input Screen:** Aerosols

**Valid selections**
numeric value > 0 in units of millimeters/hour

**Description**
The extinction due to rain is modeled by relating the transmission over a given path to the most directly obtainable meteorological parameter, rain rate in mm/hr. The two main components of the Marshall-Palmer (M-P) raindrop size distribution are rain rate and drop diameter. The (M-P) equation used for transmittance over path length is \( t = \exp(-0.365*R^{0.63} * s) \), where \( s \) is the path length in km and \( R \) is the rain rate in mm/hour. The extinction due to rain in this model is independent of wavelength, since the average raindrop diameters (0.1 to 10 mm) are considerably larger than the infrared or visible/uv wavelengths under consideration.

The Marshall-Palmer raindrop size distribution is used in MODTRAN since it is widely accepted as the standard within the meteorological community. Several other distribution models are mentioned in the rain model description in the LOWTRAN 6 manual. These alternate models cannot be used without recompiling the MODTRAN program, and are thus unavailable to PCModWin users without obtaining the model source code.

This particular modeling of the rain is not connected with the 5 built in rain/cloud models available through the variable Use Cloud/Rain Aerosol Extensions. This model calculates rain attenuation continuously through the part of the line-of-sight path from 0 to 6 km altitude.

Units of millimeters/hour were selected for this parameter since rain rates are reported in these units by worldwide meteorological stations.

**Related variables**
none
4.3.6.11 Ground Altitude Above Sea Level

**MODTRAN Variable:** GNDALT  
**Card:** 2  
**Input Screen:** Aerosols

**Valid selections**
positive number between 0 and 6 kilometers

**Description**
This variable is the altitude of the surface relative to sea level in units of kilometers. It enables the use of modified aerosol profiles for the boundary layer for elevated ground surfaces (for example, a location such as Denver, where the ground is almost 1 mile above mean sea level). Aerosols below 6 km are changed. This parameter is useful for paths that start on ground significantly above sea level, where the pressure and temperature profiles reflect the higher altitude, but the presence of ground modifies the boundary layer aerosols. The change made is a linear interpolation between the aerosol values used in the selected profile for 0 km, which is now assigned to the elevated ground, and the value assigned at 6 km, above which the default aerosol profile is left unchanged.

If *No Aerosol Attenuation* is selected for **Aerosol Model Used**, this parameter is ignored.

**Related variables**
*Aerosol Model Used*
4.3.6.12 Use A+ card

**MODTRAN Variable:** APLUS  **Card:** 2  **Input Screen:** Aerosols

**Valid selections** [check box]
- checked = redefine the boundaries and scaling of the 4 MODTRAN aerosol regions
- unchecked = do not use the aerosol extensions

**Description**
This input enables use of the "A+" option with MODTRAN aerosols. This enables access to the Card A+ screen, which lets you re-define the four built-in aerosol regions with considerable flexibility.

Note that the A+ option is incompatible with use of the NOVAM aerosol option. Thus if this input is checked, you cannot have the Use NOVAM output input checked as well. It is also incompatible with the new user supplied spectra (the "USS" option), so the input User Supplied Spectra must also be unchecked.

**Related variables**
- access to Card A+ screen
- Use NOVAM output
- User Supplied Spectra
4.3.6.13 Use NOVAM Output

MODTRAN Variable: CNOVAM  Card: 2  Input Screen: Aerosols

**Valid selections** [check box]
- checked = use NOVAM aerosol option
- unchecked = do not use NOVAM option

**Description**
This input lets you use aerosol parameters calculated by the Navy Oceanic Vertical Aerosol Model (NOVAM) for the boundary layer aerosols. NOVAM is a stand-alone code that must be run separately before using its outputs. MODTRAN 4 can read the output files created by NOVAM and use the results in its calculations. PcModWin provides a user interface to assist in running and viewing NOVAM code outputs.

One of the important recent additions to MODTRAN is support for the NOVAM model. NOVAM stands for Navy Oceanic Vertical Aerosol Model. NOVAM provides significantly improved modeling of oceanic aerosols from shipboard surface to 6 km altitude, covering the spectral range of 0.2 to 40 micrometers. NOVAM is intended to serve as an upgrade to the Navy Aerosol Model that is already present in MODTRAN. It is based on extensive direct shipboard measurements carried out by several different agencies specializing in the marine environment. Inputs to the NOVAM code are radiosonde data consisting of temperature, pressure, and relative humidity as a function of altitude, as well as other surface observation parameters such as optical visibility, wind speeds and surface IR extinction at 10.6 micrometers.

NOVAM recognizes three types of meteorological profiles characterized by the existence or non-existence of temperature inversions. There are three cases:

1. No inversion (the free convection mode)
2. Two inversions (the weak convection mode)
3. One inversion (the developed boundary layer)

The model contains four classes of marine aerosols with three mode radii of 0.03, 0.24, and 2.0 micrometers, where the mode radius is the size of the most populous part (i.e., the peak) of the distribution at a relative humidity of 80%. The 0.03 micrometer aerosol consists of two classes: soluble and insoluble. The other two sizes consist of soluble aerosols only.

The distribution version of NOVAM from NRad outputs surface layer altitudes, and the net extinction, absorption and asymmetry coefficients by combining the effects of the four aerosols. The output of NOVAM consists of aerosol size distribution parameters, and total extinction, absorption and asymmetry values as a function of wavelength. For MODTRAN, NOVAM was modified to output this information as a function of wavelength for a series of altitudes beginning at the lowest "significant" radiosonde altitude (usually a few meters), extending into the lower troposphere. The NOVAM
model is claimed to be valid up to 6 km. However, as the result of numerous private communications between SSI (NOVAM integrator) and Stuart Gathman (primary point of contact for NOVAM at NRad), the NOVAM aerosol profiles are restricted to reach no higher than 2 km.

NOVAM is provided as a standalone code that was obtained from the Naval Command, Control and Ocean Surveillance Center (NRad) and modified by Spectral Sciences Inc for use with MODTRAN. In order to use NOVAM, you must run the standalone code separately (before running MODTRAN) and provide its output file in the PcModWin executables directory. Click here for instructions on how to do this. The PcModWin interface currently does not support creation of the NOVAM input files, so you must prepare these separately with a text editor prior to NOVAM execution.

For more details on NOVAM, you should consult the electronic version of the published report "The Navy Oceanic Vertical Aerosol Model", by S.G.Gathman and K.L.Davidson, Technical Report 1693, December 1993. This report is provided in PDF format on the PcModWin CDROM.

NOVAM is provided as a separate DOS executable program with PcModWin. In order to use NOVAM with MODTRAN, you must first prepare the NOVAM input files and execute NOVAM, prior to making the MODTRAN calculation. PcModWin provides a user interface to allow setup, execution, and plotting of NOVAM outputs. The results must end up in a file called NOVAM.OUT, located in the PcModWin executables directory (\PcModWin\bin). Then you must check this parameter when setting MODTRAN inputs.

The NOVAM option is incompatible with the "A+" option for aerosols, also new to MODTRAN 3.7. Thus if this input is checked, you cannot have the Use A+ card input checked as well.

**Related variables**

Use A+ card
4.3.6.14 User Supplied Spectra

**MODTRAN Variable:** USS  
**Card:** 2  
**Input Screen:** Aerosols

**Valid selections** [check box]

- **checked** = supply spectral extinction, absorption, asymmetry functions for aerosols
- **unchecked** = use built-in spectral functions for aerosols

**Description**

This variable controls use of one of the features added recently to MODTRAN: the ability for the user to specify the spectral aerosol behavior. Previous to this upgrade, users could only use the built-in spectral functions for extinction, absorption, and asymmetry for the various aerosol models. The provided spectra use a sparse grid, and for some purposes this was not adequate. With this option a user can provide a denser set of data, at wavelengths specifically of interest. You can also provide user-supplied spectral data for the default aerosol profiles.

Setting this input to checked enables the "USS" option, as it is referred to in the MODTRAN documentation. This enables access to the screen User Supplied Aerosols (MODTRAN card 2D). On that card, you enable the aerosol regions that you will be defining.

This "USS" option is not compatible with the "A+" option for aerosols. Thus, in order to use this, the input Use A+ card on the Aerosols screen must be unchecked.

**Related variables**

- **Use A+ card** provides access to User Supplied Aerosols screen
4.3.7 Screen “Card A+ Aerosol Layers”

This screen contains inputs for one of the aerosol upgrades made recently to MODTRAN. The four built-in aerosol models are no longer confined to fixed and essentially non-verlapping regions. Each can be independently moved to any region, and can be stretched, compressed, and scaled. They can also occupy overlapping regions. An important benefit of this feature is the ability to move the tropopause height. This screen is shown below:

This screen contains the “A+ card” MODTRAN variables. To access this screen, you must have Use A+ card on the Aerosols screen checked.
4.3.7.1 Bottoms A1+

**MODTRAN Variable:** ZAER\textsubscript{i1}  \hspace{1em} **Card:** 2A+  \hspace{1em} **Input Screen:** A+ Aerosol Layers

**Valid selections**
floating point number in kilometers

**Description**
This input sets the base or bottom of the current aerosol region.

The conventional MODTRAN definition of aerosol regions leads to some confusion on this and the Tops A1+ variable. A better definition of an aerosol region would be to refer to the contiguous region where the aerosol concentration is non-negative, and outside of which it is zero. Using this better definition, the region of aerosol 1 (the "boundary layer" aerosol) ranges from 0 to 3 km; the profile linearly decreases from a non-zero value at 2 km to zero at 3 km. In the past MODTRAN documentation, the boundary layer region is said to run from 0 to 2 km. Thus in the current (and future) versions of MODTRAN, this variable and the Tops A1+ variable refer to the bounding altitudes at which the aerosol concentration is non-negative. The table below lists the values in kilometers of this and Tops A1+ for each of the 4 default MODTRAN aerosol regions:

<table>
<thead>
<tr>
<th>Region</th>
<th>Bottom</th>
<th>Top</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0</td>
<td>3</td>
</tr>
<tr>
<td>2</td>
<td>2</td>
<td>11</td>
</tr>
<tr>
<td>3</td>
<td>10</td>
<td>35</td>
</tr>
<tr>
<td>4</td>
<td>30</td>
<td>100</td>
</tr>
</tbody>
</table>

Note that there are 4 of these variables, one for each aerosol region. The "i" in the variable name runs from 1 to 4; hence the MODTRAN variable names are ZAER11, ZAER21, ZAER31, and ZAER41.

**Related variables**
Tops A1+
4.3.7.2 Tops A1+

**MODTRAN Variable:** ZAERi2  
**Card:** 2A+  
**Input Screen:** A+ Aerosol Layers

**Valid selections**

- if $>$ **Bottoms A1+:** floating point number in kilometers
- if $=$ or $<$ **Bottoms A1+:** flag directing MODTRAN on how to translate the region

**Description**

This input determines the height of the current aerosol region. If its value is set greater than the **Bottoms A1+** input, then this value is used as the height of the current aerosol region in kilometers. If this value is set less than the **Bottoms A1+** input, then MODTRAN will translate the original profile for this altitude to the new base altitude, which is still set in **Bottoms A1+**. If this input is set equal to **Bottoms A1+**, then the values are set to defaults and the **Scales** input is ignored.

The conventional MODTRAN definition of aerosol regions leads to some confusion on this and the **Bottoms A1+** variable. A better definition of an aerosol region would be to refer to the contiguous region where the aerosol concentration is non-negative, and outside of which it is zero. Using this better definition, the region of aerosol 1 (the "boundary layer" aerosol) ranges from 0 to 3 km; the profile linearly decreases from a non-zero value at 2 km to zero at 3 km. In the past MODTRAN documentation, the boundary layer region is said to run from 0 to 2 km. Thus in the current (and future) versions of MODTRAN, this variable and the **Bottoms A1+** variable refer to the bounding altitudes at which the aerosol concentration is non-negative. The table below lists the values of this and **Bottoms A1+** in kilometers for each of the 4 default MODTRAN aerosol regions:

<table>
<thead>
<tr>
<th>Region</th>
<th>Bottom</th>
<th>Top</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0</td>
<td>3</td>
</tr>
<tr>
<td>2</td>
<td>2</td>
<td>11</td>
</tr>
<tr>
<td>3</td>
<td>10</td>
<td>35</td>
</tr>
<tr>
<td>4</td>
<td>30</td>
<td>100</td>
</tr>
</tbody>
</table>

Note that there are 4 of these variables, one for each aerosol region. The "i" in the variable name runs from 1 to 4; hence the MODTRAN variable names are ZAER12, ZAER22, ZAER32, and ZAER42.

**Related variables**

- **Bottoms A1+**
- **Scales**
4.3.7.3 Scales

**MODTRAN Variable:** SCALEi  **Card:** 2A+  **Input Screen:** A+ Aerosol Layers

**Valid selections**
if > 0.0, this is a multiplicative factor for the profile
if = 0.0, the vertical profile is not modified

**Description**
This input affects the scaling of the aerosol column densities as the profile is mapped into the new altitude regime. If this input is set to 0 (or 1), the aerosols are linearly mapped into the new region and the column densities are preserved. If this number is any other positive value, it is used as a scaling factor to modify the column densities.

**Related variables**
Bottoms A1+
Tops A1+
4.3.7.4 Layer Type

**MODTRAN Variable:** ZAERi2  **Card:** 2A+  **Input Screen:** A+ Aerosol Layers

**Valid selections**
- *General* = allow complete user control over aerosol region altitude definition
- *Translate Original* = translate original profile to new base altitude only
- *Use Default* = do not modify aerosol profile for this region

**Description**
This variable lets you select the aerosol translation operation you want to perform for each region, and enables only the variables relevant to that operation. Selecting *General* enables all three variables, and by following the MODTRAN rules you can in fact either redefine, translate, or leave alone the aerosol profile. Selecting *Translate Original* limits the inputs to translating the original profile to a new base altitude. The new base altitude is set in *Bottoms A1+*, and the other inputs for that aerosol region are not needed, and hence disabled. Selecting *Use Default* means that the aerosol default profile for this region will not be modified, and hence all three of the inputs for that region are disabled.

**Related variables**
- *Bottoms A1+
- *Tops A1+
- *Scales*
4.3.7.5 Aerosol Region x

**MODTRAN Variable:** None  
**Card:** 2A+  
**Input Screen:** A+ Aerosol Layers

**Description**

This label refers to the 4 possible regions for which aerosol profiles can be modified on the A+ Aerosol Layers screen. The conventional definitions of the 4 aerosol regions are:

- **Region 1**  Boundary Layer Aerosols  0 - 2 km altitude
- **Region 2**  Tropospheric Aerosols     2 - 10 km altitude
- **Region 3**  Stratospheric Aerosols   10 - 30 km altitude
- **Region 4**  Mesospheric Aerosols     30 - 100 km altitude

The boundary altitudes used on this screen to reproduce this are slightly different, due to a change in the definition of aerosol regions. The new and improved definition of an aerosol region is to refer to the contiguous region where the aerosol concentration is non-negative, and outside of which it is zero. Using this better definition, the region of aerosol 1 (the "boundary layer" aerosol) ranges from 0 to 3 km; the profile linearly decreases from a non-zero value at 2 km to zero at 3 km. In the past MODTRAN documentation, the boundary layer region is said to run from 0 to 2 km. Thus in the current (and future) versions of MODTRAN, the **Top A1+** and the **Bottoms A1+** variables refer to the bounding altitudes at which the aerosol concentration is non-negative. The table below lists the values of the **Bottoms A1+** and **Top A1+** for each of the 4 default MODTRAN aerosol regions:

<table>
<thead>
<tr>
<th>Region</th>
<th>Bottom</th>
<th>Top</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0</td>
<td>3</td>
</tr>
<tr>
<td>2</td>
<td>2</td>
<td>11</td>
</tr>
<tr>
<td>3</td>
<td>10</td>
<td>35</td>
</tr>
<tr>
<td>4</td>
<td>30</td>
<td>100</td>
</tr>
</tbody>
</table>

**Related variables**

- Bottoms A1+
- Top A1+
- Scales
- Layer Type
4.3.8 Screen “Cirrus Cloud”

This screen controls inputs for the cirrus cloud option that is enabled by selecting one of the cirrus models for Use Cloud/Rain Aerosol Extensions on the Aerosols screen. The cirrus cloud models are the following options:

- Cirrus Profile
- Subvisual Cirrus Profile
- NOAA Cirrus Profile

If one of the lower altitude cloud models is enabled, a different version of this input screen is displayed (see section 4.3.9). If a cirrus model is not selected for this input, this screen is disabled in the menu bar. This screen is shown below:
4.3.8.1  Cirrus Thickness (km)

**MODTRAN Variable:** CTHIK  
**Card:** 2A  
**Input Screen:** Cirrus Cloud

**Valid selections**
floating point value = or > than 0 in units of kilometers  
= 0 selects default of 1 km

**Description**
This parameter sets the thickness of the cirrus layer that will be modeled. If you leave this input at 0, a default thickness of 1.0 km will be used. Setting this parameter other than 0 lets you override the default with a value of your own choosing. If the cirrus extinction coefficient in [Extinction coefficient](#) is left at 0, this variable is also used to calculate the extinction coefficient using 0.14 * CTHIK.

If you wish to investigate the effects of many different layer thicknesses, to establish transmittance probability statistics, a random number generator is provided with this model so that a large number of random thicknesses can be generated. This generator is seeded using [Random Number Initialization](#).

This screen is only displayed if [Use Cloud/Rain Aerosol Extensions](#) is set to *Cirrus Profile*, *Subvisual Cirrus Profile*, or *NOAA Cirrus Profile*.

**Related variables**
- [Use Cloud/Rain Aerosol Extensions](#)
- [Extinction coefficient](#)
- [Random Number Initialization](#)
4.3.8.2  Cirrus Base Altitude (km)

**MODTRAN Variable:** CALT  **Card:** 2A  **Input Screen:** Cirrus Cloud

**Valid selections**
floating point value = or > than 0 in units of kilometers
= 0 selects default based on Model Atmosphere

**Description**
This input lets you specify the base altitude at which the cirrus starts for your calculation. If you leave this input at 0, a default altitude is selected, based on the atmospheric profile selected for Model Atmosphere. The table below shows the different defaults for each profile:

<table>
<thead>
<tr>
<th>Model Atmosphere selection</th>
<th>default base altitude (km)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tropical</td>
<td>11</td>
</tr>
<tr>
<td>MidLatitude Summer</td>
<td>10</td>
</tr>
<tr>
<td>MidLatitude Winter</td>
<td>8</td>
</tr>
<tr>
<td>SubArctic Summer</td>
<td>7</td>
</tr>
<tr>
<td>SubArctic Winter</td>
<td>5</td>
</tr>
</tbody>
</table>

If you are specifying your own atmospheric profile, with User Supplied ATM Profile, there is no default and you must provide a value here, or else the cirrus will start at 0 km.

This screen is only displayed if Use Cloud/Rain Aerosol Extensions is set to Cirrus Profile, Subvisual Cirrus Profile, or NOAA Cirrus Profile.

**Related variables**
Use Cloud/Rain Aerosol Extensions
Model Atmosphere
4.3.8.3 Extinction Coefficient

**MODTRAN Variable:** CEXT  
**Card:** 2A  
**Input Screen:** Cirrus Cloud

**Valid selections**
- $0$: use the default value of $0.14 \times \text{CTHIK}$
- $>0$: user supplied extinction coefficient in units of $\text{km}^{-1}$

**Description**
This parameter gives you the option of specifying your own extinction coefficient for the cirrus in your calculation. If you leave this parameter at 0, the extinction defaults to $0.14 \times \text{CTHIK}$, where CTHIK is the Cirrus Thickness. If you specify a value greater than 0, it is used directly as the extinction coefficient in inverse kilometers.

Note that this extinction coefficient is used across the entire wavelength band when the NOAA Cirrus Profile is selected for Use Cloud/Rain Aerosol Extensions. For the other two cirrus models, this value is assigned to the extinction at 0.55 micrometers, and the wavelength dependent scattering and absorption parameters are normalized to this value.

This screen is only displayed if Use Cloud/Rain Aerosol Extensions is set to Cirrus Profile, Subvisual Cirrus Profile, or NOAA Cirrus Profile.

**Related variables**
- Use Cloud/Rain Aerosol Extensions
- Cirrus Thickness
4.3.8.4 Random Number Initialization

**MODTRAN Variable:** ISEED  **Card:** 2A  **Input Screen:** Cirrus Cloud

**Valid selections**
- 0  use default mean values for cirrus
- > 0  use input integer as seed for random number generator

**Description**
This parameter is provided if you wish to investigate the effects of many different cirrus layer thicknesses in order to establish transmittance probability statistics. If this number is greater than 0, it seeds a random number generator that generates a random cirrus thickness. If you make many calculations, repeated calls will generate different thicknesses.

This screen is only displayed if Use Cloud/Rain Aerosol Extensions is set to Cirrus Profile, Subvisual Cirrus Profile, or NOAA Cirrus Profile.

**Related variables**
- Use Cloud/Rain Aerosol Extensions
- Cirrus Thickness
4.3.9 Cloud Properties

This screen lets you customize many of the properties of the standard MODTRAN cloud profiles. It is displayed when Use Cloud/Rain Aerosol Extensions is set to any of the following non-cirrus cloud options:

Cumulus Clouds = 1 = cumulus cloud with base 0.66 km, top at 3.0 km  
Altostratus Clouds = 2 = altostratus cloud with base 2.4 km, top at 3.0 km  
Stratus Clouds = 3 = stratus cloud with base 0.33 km, top at 1.0 km  
Stratus/Strato-Cumulus = 4 = strato-cumulus cloud with base 0.66 km, top at 2 km  
Nimbostratus Clouds = 5 = nimbostratus cloud with base 0.16 km, top at 0.66 km  
2.0 mm/hr Rain = 6 = simulate drizzle rain with stratus clouds  
5.0 mm/hr Rain = 7 = simulate light rain with nimbostratus clouds  
12.5 mm/hr Rain = 8 = simulate moderate rain with nimbostratus clouds  
25.0 mm/hr Rain = 9 = simulate heavy rain with cumulus clouds  
75.0 mm/hr Rain = 10 = simulate extreme rain with cumulus clouds  
User Input Cloud Ext & Absor = 11 = use user defined cloud extinction/absorption

This card is shown below:

Input boxes for all of the inputs are only displayed if the Use Default check box is unchecked. The default value in general for all of these inputs is –9.
4.3.9.1 Cloud Thickness

**MODTRAN Variable:** CTHIK  **Card:** 2A  **Input Screen:** Cloud Properties

**Valid selections**
floating point number > 0 in units of km
specifying -9 selects a default, based on Use Cloud/Rain Aerosol Extensions

**Description**
This input sets the cloud vertical thickness. The cloud vertical thickness is defined as the altitude difference between the highest and lowest cloud profile boundary altitude for whichever water droplet or ice particle density is positive. These altitudes are supplied on the User Supplied Cloud and Rain Profile screen.

The default thicknesses for the 5 cloud types in MODTRAN are:

<table>
<thead>
<tr>
<th>Type</th>
<th>Thickness (km)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cumulus</td>
<td>2.34</td>
</tr>
<tr>
<td>Altostratus</td>
<td>0.60</td>
</tr>
<tr>
<td>Stratus</td>
<td>0.67</td>
</tr>
<tr>
<td>StratoCumulus</td>
<td>1.34</td>
</tr>
<tr>
<td>Nimbostratus</td>
<td>0.50</td>
</tr>
</tbody>
</table>

This input can be set to use defaults by setting its value to -9. You can accomplish the same effect by checking the "default" check box next to its input box.

This screen is only enabled if Use Cloud/Rain Aerosol Extensions is set to one of the water cloud options.

**Related variables**
Use Cloud/Rain Aerosol Extensions
4.3.9.2 Cloud Base Altitude

**MODTRAN Variable:** CALT  
**Card:** 2A  
**Input Screen:** Cloud Properties

**Valid selections**
floating point number > 0 in units of km
specifying -9 selects a default, based on Use Cloud/Rain Aerosol Extensions

**Description**
This input sets the cloud base altitude relative to ground level. Note that this is different from the meaning of CALT in the cirrus cloud models, which define the base altitude relative to sea level. A value of 0 translates the cloud down to the ground; a value of -9 places the cloud automatically at the default altitude.

The default base altitudes for the 5 cloud types in MODTRAN are:

<table>
<thead>
<tr>
<th>Type</th>
<th>Base Altitude (km)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cumulus</td>
<td>0.66</td>
</tr>
<tr>
<td>Altostratus</td>
<td>2.40</td>
</tr>
<tr>
<td>Stratus</td>
<td>0.33</td>
</tr>
<tr>
<td>StratoCumulus</td>
<td>0.66</td>
</tr>
<tr>
<td>Nimbostratus</td>
<td>0.16</td>
</tr>
</tbody>
</table>

This input can be set to use defaults by setting its value to -9. You can accomplish the same effect by checking the "default" check box next to its input box.

If there is a non-constant rain profile below a cloud, that profile is stretched or compressed depending upon whether the base altitude is increased or decreased. If the cloud base is lowered too much, the predicted zero water particle altitude can drop below ground. In this case, the zero water particle altitude is defined to be the ground, and the rain rate is assumed to vary linearly from ground level to cloud base.

This screen is only enabled if Use Cloud/Rain Aerosol Extensions is set to one of the water cloud options.

**Related variables**
Use Cloud/Rain Aerosol Extensions
4.3.9.3 Extinction Coefficient

**MODTRAN Variable:** CEXT  **Card:** 2A  **Input Screen:** Cloud Properties

**Valid selections**
floating point number > 0 in units of km\(^{-1}\)
specifying 0 or -9 selects a default, based on **Use Cloud/Rain Aerosol Extensions**

**Description**
This input sets the cloud liquid water droplet and ice particle vertical extinction, in inverse kilometers. This value is used for the **Reference Wavelength**. It is used within MODTRAN to scale the extinction (and absorption) coefficient curves. The ratio of the input optical depth (CEXT * CTHIK) to the calculated optical depth (the product of column density and extinction coefficient at CWAVLN, summed for both liquid water droplets and ice particles) is determined. The extinction and absorption coefficients at all frequencies are multiplied by this ratio.

The default cloud extinction at 0.55 micrometers for the 5 cloud types in MODTRAN are:

<table>
<thead>
<tr>
<th>Type</th>
<th>Extinction at 0.55 um (km(^{-1}))</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cumulus</td>
<td>92.6</td>
</tr>
<tr>
<td>Altostratus</td>
<td>128.1</td>
</tr>
<tr>
<td>Stratus</td>
<td>56.9</td>
</tr>
<tr>
<td>StratoCumulus</td>
<td>38.7</td>
</tr>
<tr>
<td>Nimbostratus</td>
<td>92.0</td>
</tr>
</tbody>
</table>

This input can be set to use defaults by setting its value to -9. You can accomplish the same effect by checking the "default" check box next to its input box.

This screen is only enabled if **Use Cloud/Rain Aerosol Extensions** is set to one of the water cloud options.

**Related variables**
**Use Cloud/Rain Aerosol Extensions**
**Reference Wavelength**
4.3.9.4 Number of Layer Boundary Altitudes

**MODTRAN Variable:** NCRALT  **Card:** 2A  **Input Screen:** Cloud Properties

**Valid selections**
integer from 0 to 16
using -9 chooses a default value for this input (3)

**Description**
This input sets the number of layer boundary altitudes for a user-defined cloud/rain profile. If this variable is set less than 3, a default value of 3 is used, since a minimum of three altitudes are needed for a cloud/rain profile: the cloud base, the cloud top, and the highest boundary altitude for which the water droplet and ice particle densities must be zero. If this variable is > 3, then it sets the number of layer boundary altitudes that are displayed for inputs on input screen User Supplied Cloud Profiles. The maximum allowed value for this parameter is 16. It is generally recommended that the altitude below which the cloud densities are zero are also included in the cloud profile. If this altitude is not entered, MODTRAN assumes that the cloud densities drop to zero 1 meter below the cloud base.

You can also set this variable on the screen User Supplied Cloud Profiles, using the prompt Number of Layers.

This screen is only enabled if Use Cloud/Rain Aerosol Extensions is set to one of the water cloud options.

**Related variables**
access to screen User Supplied Cloud Profiles
Use Cloud/Rain Aerosol Extensions
Number of Layers
4.3.9.5 Number of Spectral Data Points

**MODTRAN Variable:** NCRSPC  **Card:** 2A  **Input Screen:** Cloud Properties

**Valid selections**
Integer ranging from 2 to 788
Specifying -9 (the default) disables this option

**Description**
This input sets the number of data points for which you will provide cloud spectral data. Each data point corresponds to a wavelength, and for each wavelength you can provide the extinction, absorption, and asymmetry parameters of both ice and water. This data is entered on the User Supplied Cloud Spectral Data input screen. On that screen, you can also modify this parameter again.

This screen is only enabled if Use Cloud/Rain Aerosol Extensions is set to one of the water cloud options.

**Related variables**
User Supplied Cloud Spectral Data (this variable provides access to this screen)
4.3.9.6 Reference Wavelength

**MODTRAN Variable:** CWAVLN  **Card:**  2A  **Input Screen:** Cloud Properties

**Valid selections**
floating point number between 0.2 and 200. in units of micrometers

**Description**
This input specifies the reference wavelength used in defining cloud vertical extinction. In the past, all extinction profiles in MODTRAN were defined relative to the extinction at 0.55 micrometers. This is now generalized so that you can use any wavelength between 0.2 and 200 micrometers as the reference wavelength to scale the spectral extinction function to.

If this input is set to a value outside of the range 0.2 to 200 micrometers, MODTRAN reverts back to the original definition of 0.55 micrometers.

This variable is only used if **Extinction Coefficient** is set to a value greater than 0. Furthermore, if this variable is set to a wavelength value outside the range of the user defined cloud spectral data (on the **User Supplied Cloud Spectral Data** screen), a fatal error message is displayed by MODTRAN and model execution will stop at that point.

This screen is only enabled if **Use Cloud/Rain Aerosol Extensions** is set to one of the water cloud options.

**Related variables**
**Extinction Coefficient**
**Use Cloud/Rain Aerosol Extensions**
**User Supplied Cloud Spectral Data** screen
4.3.9.7 Liquid Water Droplet Column Density

**MODTRAN Variable:** CCOLWD  **Card:** 2A  **Input Screen:** Cloud Properties

**Valid selections**
floating point number $> 0$ in units of km gm/m$^3$

**Description**
If equal to or greater than 0, this input is the water droplet cloud vertical column density. MODTRAN determines the ratio of this input water droplet vertical column density to the column density calculated from the input cloud base, thickness, and default water droplet densities. Then all the water droplet densities are scaled by this ratio so that the desired column amount results.

It should be noted that if the cloud being modeled only has liquid water and a positive cloud vertical extinction, Extinction Coefficient, is input, MODTRAN will change spectral extinction and absorption coefficients so that predicted path transmittances and radiances are independent of this variable. However, if the spectral data are not being scaled to give a particular vertical extinction, increasing column density will increase extinction. Furthermore, if the cloud consists of both liquid water droplets and ice particles, this variable can be used to customize the relative contribution from the two particle types. The default cloud water droplet densities for the five MODTRAN liquid water clouds are listed below.

<table>
<thead>
<tr>
<th>Type</th>
<th>Column Amt (km gm/m$^3$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cumulus</td>
<td>1.6640</td>
</tr>
<tr>
<td>Altostratus</td>
<td>0.3450</td>
</tr>
<tr>
<td>Stratus</td>
<td>0.2010</td>
</tr>
<tr>
<td>StratoCumulus</td>
<td>0.2165</td>
</tr>
<tr>
<td>Nimbostratus</td>
<td>0.3460</td>
</tr>
</tbody>
</table>

If this input is less than 0, MODTRAN does not scale the water droplet densities.

This screen is only enabled if Use Cloud/Rain Aerosol Extensions is set to one of the water cloud options.

**Related variables**
- Extinction Coefficient
- Use Cloud/Rain Aerosol Extensions
4.3.9.8 Ice Particle Column Density

**MODTRAN Variable:** CCOLIP  **Card:** 2A  **Input Screen:** Cloud Properties

**Valid selections**
floating point number > 0 in units of km gm/m$^3$

**Description**
This input is the ice particle cloud vertical column density. Generally, this input is used to scale the ice particle density in the same way that the Liquid Water Droplet Column Density is used. MODTRAN determines the ratio of this input ice particle vertical column density to the column density calculated from the input cloud base, thickness, and default ice particle densities. Then all the ice particle densities are scaled by this ratio so that the desired column amount results. However, two points should be noted: (1) The MODTRAN cumulus and stratus type clouds (Use Cloud/Rain Aerosol Extensions set to any value between 1 and 10) do not contain ice particles. Thus, only user defined cloud profiles can be scaled by this input. Secondly, if both this input and Liquid Water Droplet Column Density are zero, scaling is turned off for both, since it does not make sense to define a cloud with no liquid water droplets or ice particles.

This screen is only enabled if Use Cloud/Rain Aerosol Extensions is set to one of the water cloud options.

**Related variables**
Liquid Water Droplet Column Density
Use Cloud/Rain Aerosol Extensions
4.3.9.9 Relative Humidity at all Boundary Layers

**MODTRAN Variable:** CHUMID  **Card:** 2A  **Input Screen:** Cloud Properties

**Valid selections**
floating point number between 0. and 105 that is a percentage

**Description**
This input is the relative humidity at all layer boundaries with either a positive rain rate or a positive cloud density. As much as 5% supersaturation is permitted, and clouds with 0% relative humidity throughout the entire cloud region are forbidden. If this input is set to a value outside the range 0 to 105., MODTRAN assumes that the relative humidity at cloud/rain layer boundaries is 100%.

This screen is only enabled if Use Cloud/Rain Aerosol Extensions is set to one of the water cloud options.

**Related variables**
Use Cloud/Rain Aerosol Extensions
4.3.9.10 Liquid Water Henyey-Greenstein Phase Function

**MODTRAN Variable:** ASYMWD  **Card:** 2A  **Input Screen:** Cloud Properties

**Valid selections**
- if < 1 is the scattering phase function asymmetry factor to use
- if = or > than 1 use user-defined or default asymmetry factor

**Description**
This input sets the Henyey-Greenstein phase function asymmetry factor for scattering by liquid water cloud droplets. If this input is set less than 1, then it is used as the actual asymmetry factor in the calculation. If it is set to 1 or greater, then it directs MODTRAN to use the user-defined or model default asymmetry factors. User defined spectral asymmetry factors for water droplets can be provided on the input screen User Supplied Cloud Spectral Data, but those values for water are ignored if the absolute value of this input is less than 1.

The asymmetry factor is a measure of the asymmetry, or non-uniformity, of the angular scattering. It has a value of +1 for complete forward scattering, 0 for isentropic or symmetric scattering, and -1 for complete backscattering. Its value can range between these two extremes. Appropriate values depend upon the size and shape of the droplets, as well as their size relative to the wavelengths of light being considered.

This screen is only enabled if Use Cloud/Rain Aerosol Extensions is set to one of the water cloud options.

**Related variables**
User Supplied Cloud Spectral Data screen
4.3.9.11 Ice Particle Henyey-Greenstein Phase Function

**MODTRAN Variable:** ASYMIP   **Card:** 2A   **Input Screen:** Cloud Properties

**Valid selections**
if < 1
   * is the scattering phase function asymmetry factor to use
if = or > than 1
   * use user-defined or default asymmetry factor

**Description**
This input sets the Henyey-Greenstein phase function asymmetry factor for scattering by cloud ice particles. If this input is set less than 1, then it is used as the actual asymmetry factor in the calculation. If it is set to 1 or greater, then it directs MODTRAN to use the user-defined or model default asymmetry factors. User defined spectral asymmetry factors for ice can be provided on the input screen User Supplied Cloud Spectral Data, but those values for ice are ignored if the absolute value of this input is less than 1.

The asymmetry factor is a measure of the asymmetry, or non-uniformity, of the angular scattering. It has a value of +1 for complete forward scattering, 0 for isentropic or symmetric scattering, and -1 for complete backscattering. Its value can range between these two extremes. Appropriate values depend upon the size and shape of the ice particles, as well as their size relative to the wavelengths of light being considered.

This screen is only enabled if Use Cloud/Rain Aerosol Extensions is set to one of the water cloud options.

**Related variables**
User Supplied Cloud Spectral Data screen
4.3.10 Screen “User Supplied Cloud and Rain Profile”

This screen is used to set up user-defined cloud and/or rain profiles. It is possible, by setting negative numbers to 4 inputs on the Cloud Properties input screen, to run cloud calculations using the user-defined cloud rain profiles exactly as input. These inputs are Cloud Thickness, Cloud Base Altitude, Liquid Water Droplet Column Density, and Ice Particle Column Density. However, the Cloud Properties variables can be used to study the effect of changing the input cloud's thickness, altitude, or column amounts. One could perform the identical sensitivity analysis by explicitly altering the user-defined profiles, but it is clearly simpler to use the inputs on this screen than to modify the Cloud Properties inputs. This screen is shown below:

This screen contains the inputs for MODTRAN card 2E1.

This screen is only enabled if Number of Layer Boundary Altitudes on the Cloud Properties input screen is set equal to or greater than 3. You can also adjust that parameter on this screen, using the Number of Layers input. Note that the Cloud Properties input screen is only displayed if Use Cloud / Rain Aerosol Extension on the Aerosols screen is set to one of the non-cirrus cloud models.
4.3.10.1 Number of Layers

**MODTRAN Variable:** NCRALT  **Card:** 2A  **Input Screen:** User Cloud/Rain Profile

**Valid selections**
integer ranging from 3 to 16

**Description**
This input sets the number of layer boundary altitudes for a user-defined cloud/rain profile. If this variable is set less than 3, a default value of 3 is used, since a minimum of three altitudes are needed for a cloud/rain profile: the cloud base, the cloud top, and the highest boundary altitude for which the water droplet and ice particle densities must be zero. If this variable is > 3, then it sets the number of layer boundary altitudes that are displayed for inputs on this input screen. The maximum allowed value for this parameter is 16. It is generally recommended that the altitude below which the cloud densities are zero are also included in the cloud profile. If this altitude is not entered, MODTRAN assumes that the cloud densities drop to zero 1 meter below the cloud base.

Note that this variable can also be changed at **Number of Layer Boundary Altitudes** on the Cloud Properties input screen.

This screen is only enabled if **Number of Layer Boundary Altitudes** on the Cloud Properties input screen is set equal to or greater than 3. The Cloud Properties screen is only enabled if **Use Cloud/Rain Aerosol Extensions** is set to one of the water cloud options.

**Related variables**
**Number of Layer Boundary Altitudes**
4.3.10.2 Altitude

**MODTRAN Variable:** ZCLD(I,0)  **Card:** 2E1  **Input Screen:** User Cloud/Rain Profile

**Valid selections**
floating point number in kilometers

**Description**
This input sets the altitude above ground level of the layer boundary I for the user defined cloud/rain profile inputs. This input can be 0, and this is necessary if it is raining on the ground. This also allows the ground to actually sit on the ground.

The altitude inputs in this table must monotonically increase, or MODTRAN crashes may result. In addition, a fatal MODTRAN error will result if the highest cloud altitude specified here is above the top of the MODTRAN atmosphere. If you are using one of the built-in default profiles, the atmosphere top is at 100 km above sea level. If you are defining your own atmosphere (Model Atmosphere is set to New Model Atmosphere), then you must be careful to ensure that you have included at least one layer at or above any of the altitudes listed here.

This screen is only enabled if Number of Layer Boundary Altitudes on the Cloud Properties input screen is set equal to or greater than 3. The Cloud Properties screen is only enabled if Use Cloud/Rain Aerosol Extensions is set to one of the water cloud options.

**Related variables**
Water Droplet Density
Ice Particle Density
Rain Rate
4.3.10.3 Water Droplet Density

**MODTRAN Variable:** CLD(I,0)  **Card:** 2E1  **Input Screen:** User Cloud/Rain Profile

**Valid selections**
floating point number = or > than 0 in units of grams per cubic meter

**Description**
This input sets the liquid water droplet density, in grams per cubic meter, at the altitude set in Altitude. The liquid water droplet densities cannot be negative. If the profile is all ice at this altitude, this input can be set to zero. MODTRAN models the densities as varying linearly between altitudes.

Note that all of these inputs will be scaled if Liquid Water Droplet Column Density on the Cloud Properties screen is assigned a non-negative value. MODTRAN determines the ratio of the Liquid Water Droplet Column Density to the column density calculated from the input cloud base, thickness, and the default water droplet densities. Then all the water droplet densities are scaled by this ratio so that the desired column amount results.

This screen is only enabled if Number of Layer Boundary Altitudes on the Cloud Properties input screen is set equal to or greater than 3. The Cloud Properties screen is only enabled if Use Cloud/Rain Aerosol Extensions is set to one of the water cloud options.

**Related variables**
- Altitude
- Ice Particle Density
- Rain Rate
- Liquid Water Droplet Column Density
4.3.10.4 Ice Particle Density

**MODTRAN Variable:** CLDICE(I,0)  **Card:** 2E1  **Input Screen:** User Cloud/Rain Profile

**Valid selections**
Floating point number = or > than 0 in units of grams per cubic meter

**Description**
This input sets the ice particle density, in grams per cubic meter, at the altitude set in Altitude. The ice particle densities cannot be negative. If the profile is all water at this altitude, this input can be set to zero. MODTRAN models the densities as varying linearly between altitudes.

Note that all of these inputs will be scaled if Ice Particle Column Density on the Cloud Properties screen is assigned a non-negative value. MODTRAN determines the ratio of the Ice Particle Column Density to the column density calculated from the input cloud base, thickness, and the default ice particle densities. Then all the ice particle densities are scaled by this ratio so that the desired column amount results.

This screen is only enabled if Number of Layer Boundary Altitudes on the Cloud Properties input screen is set equal to or greater than 3. The Cloud Properties screen is only enabled if Use Cloud/Rain Aerosol Extensions is set to one of the water cloud options.

**Related variables**
Altitude
Water Droplet Density
Rain Rate
Ice Particle Column Density
4.3.10.5 Rain Rate

**MODTRAN Variable:** RR(I,0)  **Card:** 2E1  **Input Screen:** User Cloud/Rain Profile

**Valid selections**
floating point number equal to or greater than 0 in millimeters/hour

**Description**
This input sets the rain rate, in millimeters per hour, at the altitude set in Altitude. Rain rates cannot be negative.

Note that if the rain rate is specified in Rain Rate on the Aerosols screen, that constant rain rate will supercede this variable. Thus, if a user-defined rain rate profile is desired, the variable Rain Rate on the Aerosols screen should be set to 0.

This screen is only enabled if Number of Layer Boundary Altitudes on the Cloud Properties input screen is set equal to or greater than 3. The Cloud Properties screen is only enabled if Use Cloud/Rain Aerosol Extensions is set to one of the water cloud options.

**Related variables**
Altitude
Water Droplet Density
Ice Particle Density
Rain Rate (on Aerosols input screen)
### 4.3.11 Screen “User Supplied Cloud Spectral Data”

This screen lets the user provide their own spectral properties for the water and ice scattering parameters within a cloud: extinction, absorption, and asymmetry. This screen implements the inputs for MODTRAN card 2E2 (new starting with MODTRAN 3.7). It is shown below:

![User Supplied Cloud Spectral Data](image)

In order to access this screen, the variable **Number of Spectral Data Points** on the **Cloud Properties** screen must be set to a value between 2 and 788. You can modify the number of spectral data points on this input screen as well. In order to access the **Cloud Properties** screen, you must have one of the cloud models selected for **User Cloud/Rain Aerosol Extensions** on the **Aerosols** screen.
4.3.11.1 Number of Spectral Points

**MODTRAN Variable:** NCRSPC  **Card:** 2E2  **Input Screen:** User Cloud Spectral Data

**Valid selections**
integer ranging from 2 to 788

**Description**
This input sets the number of data points for which you will provide cloud spectral data. Each data point corresponds to a wavelength, and for each wavelength you can provide the extinction, absorption, and asymmetry parameters of both ice and water.

This input can also be set in Number of Spectral Data Points on the Cloud Properties screen.

In order to access this screen, the variable Number of Spectral Data Points on the Cloud Properties screen must be set to a value between 2 and 788. In order to access the Cloud Properties screen, you must have one of the cloud models selected for User Cloud/Rain Aerosol Extensions on the Aerosols screen.

**Related variables**
Number of Spectral Data Points
4.3.11.2 Wavelength

**MODTRAN Variable:** WAVLEN  **Card:** 2E2  **Input Screen:** User Cloud Spectral Data

**Valid selections**
floating point number in micrometers

**Description**
This input sets the current wavelength to provide cloud spectral data at in the wavelength grid. The first wavelength entered can be as low as 0.0 micrometers. Wavelengths must be entered in increasing order. Note that you must include a value at the reference wavelength for scaling the aerosol curves. If you are using a default reference wavelength, you must provide a value at 0.55 micrometers. If you have changed the reference wavelength, using the Reference Wavelength parameter on the Cloud Properties screen, then you must provide a value at that wavelength here.

The total number of points required is set in Number of Spectral Points.

In order to access this screen, the variable Number of Spectral Data Points on the Cloud Properties screen must be set to a value between 2 and 788. In order to access the Cloud Properties screen, you must have one of the cloud models selected for User Cloud/Rain Aerosol Extensions on the Aerosols screen.

**Related variables**
Reference Wavelength
Number of Spectral Points
4.3.11.3 Extinction Water

**MODTRAN Variable:** EXT(6,I)  **Card:** 2E2  **Input Screen:** User Cloud Spectral Data

**Valid selections**
- positive value: floating point number in km\(^{-1}\) * m\(^3\) / g
- negative value: interpolate value from selected cloud model

**Description**
The attenuation of radiant energy as it passes through the atmosphere is referred to as extinction. The extinction coefficient is defined in the following manner: the transmittance of a path through the atmosphere is expressed as an exponential relation
\[
\text{transmittance} = \exp(-\sigma \cdot x)
\]
where "\(\sigma\)" is called the extinction coefficient and "\(x\)" is the path length.

This input sets the liquid water droplet extinction coefficient at the micrometer specified in **Wavelength**. If a negative value is provided, a value for the extinction coefficient at this wavelength is interpolated from the default data for the cloud model selected in **Use Cloud/Rain Aerosol Extensions** on the **Aerosols** screen.

If a positive value is provided for **Extinction Coefficient** on the **Cloud Properties** card, then the coefficient input here is scaled by that value. If **Extinction Coefficient** specifies the use of defaults, then this value is used by MODTRAN exactly as input.

The total number of points required is set in **Number of Spectral Points**.

In order to access this screen, the variable **Number of Spectral Data Points** on the **Cloud Properties** screen must be set to a value between 2 and 788. In order to access the **Cloud Properties** screen, you must have one of the cloud models selected for **Use Cloud/Rain Aerosol Extensions** on the **Aerosols** screen.

**Related variables**
- **Wavelength**
- **Number of Spectral Points**
- **Extinction Coefficient**
- **Use Cloud/Rain Aerosol Extensions**
4.3.11.4 Absorption Water

**MODTRAN Variable:** ABSC(6,I)  **Card:** 2E2  **Input Screen:** User Cloud Spectral Data

**Valid selections**
- **positive value:** floating point number in km\(^{-1}\) m\(^3\) / g
- **negative value:** unitless floating point number from -1 to 0

**Description**
The attenuation of radiant energy as it passes through the atmosphere is referred to as extinction. The extinction coefficient is defined in the following manner: the transmittance of a path through the atmosphere is expressed as an exponential relation 
transmittance = EXP(-sigma * x)  where "sigma" is called the extinction coefficient and "x" is the path length. Typically several physical processes in the atmosphere cause extinction of the radiant energy. MODTRAN recognizes two processes: absorption by gaseous molecules of the atmosphere, and single scattering of energy out of the path. The water absorption coefficient is defined as a part of the extinction coefficient in the following manner: sigma = alpha + gamma , where alpha is the absorption caused by the aerosols and gamma is a scattering coefficient that expresses the scattering caused by the aerosols.

If this parameter is set to a positive value, it is used as the liquid water absorption coefficient at the wavelength in Wavelength, in units of km\(^{-1}\) * m\(^3\) / g. If this number is less than -1 or if it exceeds the extinction coefficient at Wavelength, that the absorption is calculated by first determining the default absorption to extinction ratio for the cloud model selected in Use Cloud/Rain Aerosol Extensions, and then multiplying the Extinction Water by this ratio. This is equivalent to assuming that the liquid water model cloud single scatter albedo should be used to determine the absorption coefficient.

If this parameter is set to a negative value between -1 and 0, it is used as the negative of one minus the liquid water droplet scattering albedo.

The total number of points required is set in Number of Spectral Points.

In order to access this screen, the variable Number of Spectral Data Points on the Cloud Properties screen must be set to a value between 2 and 788. In order to access the Cloud Properties screen, you must have one of the cloud models selected for Use Cloud/Rain Aerosol Extensions on the Aerosols screen.

**Related variables**
- Wavelength
- Number of Spectral Points
- Use Cloud/Rain Aerosol Extensions
- Extinction Water
4.3.11.5 Asymmetry Water

**MODTRAN Variable:** ASYM(6,I) **Card:** 2E2  **Input Screen:** User Cloud Spectral Data

**Valid selections**
floating point number ranging from -1 to 1

**Description**
This parameter determines the asymmetry factor to use with the Henyey-Greenstein aerosol phase function at *Wavelength*. This parameter is a measure of the asymmetry, or non-uniformity, of the angular scattering of the liquid water droplets. It has a value of +1 for complete forward scattering, 0 for isentropic or symmetric scattering, and -1 for complete backscattering. Its value can range between these two extremes.

This input is is ignored if the magnitude of Liquid Water Henyey-Greenstein Phase Function is less than one.

If the value specified here is not between -1 and 1, then the wavelength interpolated value from the currently selected cloud model in Use Cloud/Rain Aerosol Extensions is used.

The total number of points required is set in Number of Spectral Points.

In order to access this screen, the variable Number of Spectral Data Points on the Cloud Properties screen must be set to a value between 2 and 788. In order to access the Cloud Properties screen, you must have one of the cloud models selected for Use Cloud/Rain Aerosol Extensions on the Aerosols screen.

**Related variables**
- Wavelength
- Number of Spectral Points
- Liquid Water Henyey-Greenstein Phase Function
- Use Cloud/Rain Aerosol Extensions
4.3.11.6 Extinction Ice

**MODTRAN Variable:**  EXTC(7,I)  **Card:**  2E2  **Input Screen:**  User Cloud Spectral Data

**Valid selections**
- positive value: floating point number in km$^{-1}$ * m$^3$ / g
- negative value: interpolate value from the standard cirrus model (ICLD=18)

**Description**
The attenuation of radiant energy as it passes through the atmosphere is referred to as extinction. The extinction coefficient is defined in the following manner: the transmittance of a path through the atmosphere is expressed as an exponential relation transmittance = EXP(-sigma * x) where "sigma" is called the extinction coefficient and "x" is the path length.

This input sets the ice particle extinction coefficient at the micrometer specified in Wavelength. If a negative value is provided, a value for the extinction coefficient at this wavelength is interpolated from the standard cirrus model (Use Cloud/Rain Aerosol Extensions on the Aerosols screen = Standard Cirrus Profile).

If a positive value is provided for Extinction Coefficient on the Cloud Properties card, then the coefficient input here is scaled by that value. If Extinction Coefficient specifies the use of defaults, then this value is used by MODTRAN exactly as input.

The total number of points required is set in Number of Spectral Points.

In order to access this screen, the variable Number of Spectral Data Points on the Cloud Properties screen must be set to a value between 2 and 788. In order to access the Cloud Properties screen, you must have one of the cloud models selected for Use Cloud/Rain Aerosol Extensions on the Aerosols screen.

**Related variables**
- Wavelength
- Number of Spectral Points
- Extinction Coefficient
4.3.11.7 Absorption Ice

**MODTRAN Variable:** ABSC(7,I)  **Card:** 2E2  **Input Screen:** User Cloud Spectral Data

**Valid selections**
- positive value: floating point number in km⁻¹ m³ / g
- negative value: unitless floating point number from -1 to 0

**Description**
The attenuation of radiant energy as it passes through the atmosphere is referred to as extinction. The extinction coefficient is defined in the following manner: the transmittance of a path through the atmosphere is expressed as an exponential relation 
\[
\text{transmittance} = \exp(-\sigma \times x)
\]
where "\( \sigma \)" is called the extinction coefficient and "\( x \)" is the path length. Typically several physical processes in the atmosphere cause extinction of the radiant energy. MODTRAN recognizes two processes: absorption by gaseous molecules of the atmosphere, and single scattering of energy out of the path. The ice absorption coefficient is defined as a part of the extinction coefficient in the following manner: 
\[
\sigma = \alpha + \gamma
\]
where \( \alpha \) is the absorption caused by the aerosols and \( \gamma \) is a scattering coefficient that expresses the scattering caused by the aerosols.

If this parameter is set to a positive value, it is used as the ice particle absorption coefficient at the wavelength in **Wavelength**, in units of km⁻¹ * m³ / g. If this number is less than -1 or if it exceeds the extinction coefficient at **Wavelength**, that the absorption is calculated by first determining the default absorption to extinction ratio for the standard cirrus cloud model (ICLD=18) and then multiplying the **Extinction Ice** by this ratio. This is equivalent to assuming that the standard cirrus model single scatter albedo should be used to determine the absorption coefficient.

If this parameter is set to a negative value between -1 and 0, it is used as the negative of one minus the ice particle scattering albedo.

The total number of points required is set in **Number of Spectral Points**.

In order to access this screen, the variable **Number of Spectral Data Points** on the **Cloud Properties** screen must be set to a value between 2 and 788. In order to access the **Cloud Properties** screen, you must have one of the cloud models selected for **User Cloud/Rain Aerosol Extensions** on the **Aerosols** screen.

**Related variables**
- **Wavelength**
- **Number of Spectral Points**
- **Extinction Ice**
4.3.11.8 Asymmetry Ice

**MODTRAN Variable:** ASYM(7,I)  **Card:**  2E2  **Input Screen:** User Cloud Spectral Data

**Valid selections**
floating point number ranging from -1 to 1

**Description**
This parameter determines the asymmetry factor to use with the Henyey-Greenstein aerosol phase function at *Wavelength*. This parameter is a measure of the asymmetry, or non-uniformity, of the angular scattering of the ice particles. It has a value of +1 for complete forward scattering, 0 for isentropic or symmetric scattering, and -1 for complete backscattering. Its value can range between these two extremes.

This input is ignored if the magnitude of *Ice Particle Henyey-Greenstein Phase Function* is less than one.

If the value specified here is not between -1 and 1, then the wavelength interpolated value from the standard cirrus cloud model (ICLD=18) is used.

The total number of points required is set in **Number of Spectral Points**.

In order to access this screen, the variable **Number of Spectral Data Points** on the *Cloud Properties* screen must be set to a value between 2 and 788. In order to access the *Cloud Properties* screen, you must have one of the cloud models selected for *User Cloud/Rain Aerosol Extensions* on the *Aerosols* screen.

**Related variables**
*Wavelength*
*Number of Spectral Points*
*Ice Particle Henyey-Greenstein Phase Function*
4.3.12 Screen “VSA Cloud”

This screen controls inputs for the Army Vertical Structure Algorithm (VSA) option that is enabled by checking Use Army (VSA) for Aerosol Extension on the Aerosols screen. If the VSA has not been enabled, this screen will not be enabled in your input screen list. This screen is shown below:

The Army Vertical Structure Algorithm (VSA) is a model describing the vertical structure of aerosols for specialized conditions in the boundary layer (0 - 2 km altitude). VSA describes vertical structure detail that is physically small (hundreds to tens of meters thick) but that plays an important role in atmospheric transmission near the ground. It was developed initially to describe the vertical distribution of the atmospheric aerosols for conditions of limited visibility and beneath low-lying cloud decks. The formalism has been extended so it can also represent cases with no cloud ceiling and moderate to high visibility.

In low visibility situations, due either to haze or fog, increasing numbers of observations show that the measured visibility at the surface is not representative of conditions a few hundreds of meters, or even tens of meters, above the surface. Thus the "slant path visibility" can be significantly different from the "horizontal visibility". In a significant fraction of the cases the visibility becomes worse as the height above the surface increases. These cases are of special concern to the VSA.
4.3.12.1  VSA Cloud Ceiling Height (km)

**MODTRAN Variable:** ZCVSA  **Card:** 2B  **Input Screen:** VSA Cloud

**Valid selections**
- > 0  use number as known cloud ceiling height in km
- = 0  ceiling height unknown, use default (case 2)
- < 0  no cloud ceiling (case 3 or 4)

**Description**
This parameter defines the height above ground of the cloud layer in the Army Vertical Structure Algorithm (VSA) aerosol model. Several options, or cases, of the VSA are possible, depending upon the combined settings of several variables. These cases are summarized in a table below. The cloud ceiling height has physical meaning only for the first two cases.

The VSA can be used for 4 cases: (1) dense ground fog; (2) haze or light fog below low level cloud; (3) shallow radiation fog or haze layer without a low level cloud layer; and (4) shallow haze layer near surface in relatively clear atmosphere. A variant on case (2), called case 2' in the LOWTRAN 6 manual, allows the haze layer below the cloud to be moderate to light. The way the VSA models these 4 cases is covered in chapter 6 of the LOWTRAN 6 manual, and that discussion should be read carefully before using the VSA. The VSA is implemented in MODTRAN exactly the same as described in that manual for LOWTRAN 6.

These 4 cases are selected by the data values assigned to the variables **Surface Range for Boundary Layer**, **VSA Cloud Ceiling Height**, and **VSA Inversion/Boundary Layer Height**. The following table describes how to select each case:

<table>
<thead>
<tr>
<th>Condition</th>
<th>Selected By</th>
</tr>
</thead>
<tbody>
<tr>
<td>Case 1  Fog</td>
<td><strong>Surface Range</strong> &lt; or = to 0.5 km</td>
</tr>
<tr>
<td></td>
<td><strong>VSA Cloud Ceiling Height</strong> &gt; or = to 0 km</td>
</tr>
<tr>
<td>Case 2  Haze/light fog below cloud</td>
<td>0.5 km &lt; <strong>Surface Range</strong> &lt; or = to 10 km</td>
</tr>
<tr>
<td></td>
<td><strong>VSA Cloud Ceiling Height</strong> &gt; or = to 0 km</td>
</tr>
<tr>
<td>Case 2' Moderate/high vis below cloud</td>
<td><strong>Surface Range</strong> &gt; 10 km</td>
</tr>
<tr>
<td></td>
<td><strong>VSA Cloud Ceiling Height</strong> &gt; or = to 0 km</td>
</tr>
<tr>
<td>Case 3  Radiation fog/haze no cloud layer</td>
<td><strong>Surface Range</strong> &gt; 0.5 km</td>
</tr>
<tr>
<td></td>
<td><strong>VSA Cloud Ceiling Height</strong> &lt; 0</td>
</tr>
<tr>
<td></td>
<td><strong>VSA Inversion/Boundary Layer Height</strong> &gt; or = to 0</td>
</tr>
<tr>
<td>Case 4  No boundary layer no cloud layer</td>
<td><strong>Surface Range</strong> &gt; 0.5 km</td>
</tr>
<tr>
<td></td>
<td><strong>VSA Cloud Ceiling Height</strong> &lt; 0</td>
</tr>
<tr>
<td></td>
<td><strong>VSA Inversion/Boundary Layer Height</strong> &gt; or = to 0</td>
</tr>
</tbody>
</table>

In case 3, a radiation fog is assumed if **Surface Range** < 2 km or **Aerosol Model Used** is Radiation Fog; a haze is assumed if **Surface Range** > 2 km. The primary difference
between case 3 and case 4 is the first 200 meters above ground (Figure 18, LOWTRAN 6 manual, p. 53).

**Related variables**

- VSA Cloud/Fog Thickness
- VSA Inversion/Boundary Layer Height
- Surface Range for Boundary Layer
- Use of Army (VSA) for Aerosol Extension
4.3.12.2 VSA Cloud/Fog Thickness (km)

**MODTRAN Variable:** ZTVSA  **Card:** 2B  **Input Screen:** VSA Cloud

**Valid selections**
- 0  thickness unknown, use default of 0.2 km
- > 0  value of cloud thickness in kilometers

**Description**
This parameter defines the thickness of the cloud layer in the Army Vertical Structure Algorithm (VSA) aerosol model. Several options, or cases, of the VSA are possible, depending upon the combined settings of several variables. These cases are summarized in a table below. Case 1 of the VSA models a dense fog at ground level. Case 2 represents a fog or light haze below a low cloud layer. If Case 2 or 2' is being run, this parameter represents the thickness of the cloud. If Case 1 is selected, this value is the thickness of the fog at the surface.

The VSA can be used for 4 cases: (1) dense ground fog; (2) haze or light fog below low level cloud; (3) shallow radiation fog or haze layer without a low level cloud layer; and (4) shallow haze layer near surface in relatively clear atmosphere. A variant on case (2), called case 2' in the LOWTRAN 6 manual, allows the haze layer below the cloud to be moderate to light. The way the VSA models these 4 cases is covered in chapter 6 of the LOWTRAN 6 manual, and that discussion should be read carefully before using the VSA. The VSA is implemented in MODTRAN exactly the same as described in that manual for LOWTRAN 6.

These 4 cases are selected by the data values assigned to the variables Surface Range for Boundary Layer, VSA Cloud Ceiling Height, and VSA Inversion/Boundary Layer Height. The following table describes how to select each case:

<table>
<thead>
<tr>
<th>Condition</th>
<th>Selected By</th>
</tr>
</thead>
<tbody>
<tr>
<td>Case 1  Fog</td>
<td>Surface Range &lt; or = to 0.5 km</td>
</tr>
<tr>
<td>Case 2  Haze/light fog below cloud</td>
<td>VSA Cloud Ceiling Height &gt; or = to 0 km</td>
</tr>
<tr>
<td>Case 2' Moderate/high vis below cloud</td>
<td>0.5 km &lt; Surface Range &lt; or = to 10 km</td>
</tr>
<tr>
<td>Case 3  Radiation fog/haze no cloud layer</td>
<td>Surface Range &gt; 0.5 km</td>
</tr>
<tr>
<td>Case 4  No boundary layer no cloud layer</td>
<td>Surface Range &gt; 0.5 km</td>
</tr>
</tbody>
</table>

In case 3, a radiation fog is assumed if Surface Range < 2 km or Aerosol Model Used is Radiation Fog; a haze is assumed if Surface Range > 2 km. The primary difference
between case 3 and case 4 is the first 200 meters above ground (Figure 18, LOWTRAN 6 manual, p. 53).

**Related variables**
- VSA Cloud Ceiling Height
- VSA Inversion/Boundary Layer Height
- Surface Range for Boundary Layer
- Use of Army (VSA) for Aerosol Extension
4.3.12.3 VSA Inversion/Boundary Layer Height

**MODTRAN Variable:** ZINVSA  **Card:** 2B  **Input Screen:** VSA Cloud

**Valid selections**
- > 0 known height of inversion layer in km (case 3)
- = 0 height unknown, use default
- < 0 no inversion layer (case 4, if VSA Cloud Ceiling Height = 0 also)

**Description**
This parameter controls the height of the inversion layer above the ground for the Army Vertical Structure Algorithm (VSA) aerosol model. Several options, or cases, of the VSA are possible, depending upon the combined settings of several variables. These cases are summarized in a table below. If the inversion layer exists, its height in kilometers is set by this parameter, and the VSA will model case 3. If this parameter = 0, then the inversion layer is assumed to exist at a default height of 2 km, and the VSA uses case 3. If this parameter is less than 0, the inversion layer is assumed not to exist, and the VSA uses case 4.

This parameter will be ignored unless VSA Cloud Ceiling Height has been set less than 0.

The VSA can be used for 4 cases: (1) dense ground fog; (2) haze or light fog below low level cloud; (3) shallow radiation fog or haze layer without a low level cloud layer; and (4) shallow haze layer near surface in relatively clear atmosphere. A variant on case (2), called case 2' in the LOWTRAN 6 manual, allows the haze layer below the cloud to be moderate to light. The way the VSA models these 4 cases is covered in chapter 6 of the LOWTRAN 6 manual, and that discussion should be read carefully before using the VSA. The VSA is implemented in MODTRAN exactly the same as described in that manual for LOWTRAN 6.

These 4 cases are selected by the data values assigned to the variables Surface Range for Boundary Layer, VSA Cloud Ceiling Height, and VSA Inversion/Boundary Layer Height. The following table describes how to select each case:

<table>
<thead>
<tr>
<th>Condition</th>
<th>Selected By</th>
</tr>
</thead>
<tbody>
<tr>
<td>Case 1 Fog</td>
<td>Surface Range &lt; or = to 0.5 km</td>
</tr>
<tr>
<td></td>
<td>VSA Cloud Ceiling Height &gt; or = to 0 km</td>
</tr>
<tr>
<td>Case 2 Haze/light fog below cloud</td>
<td>0.5 km &lt; Surface Range &lt; or = to 10 km</td>
</tr>
<tr>
<td></td>
<td>VSA Cloud Ceiling Height &gt; or = to 0 km</td>
</tr>
<tr>
<td>Case 2' Moderate/high vis below cloud</td>
<td>Surface Range &gt; 10 km</td>
</tr>
<tr>
<td></td>
<td>VSA Cloud Ceiling Height &gt; or = to 0 km</td>
</tr>
<tr>
<td>Case 3 Radiation fog/haze no cloud layer</td>
<td>Surface Range &gt; 0.5 km</td>
</tr>
<tr>
<td></td>
<td>VSA Cloud Ceiling Height &lt; 0</td>
</tr>
<tr>
<td></td>
<td>VSA Inversion/Boundary Layer Height &gt; or = to 0</td>
</tr>
<tr>
<td>Case 4 No boundary layer no cloud layer</td>
<td>Surface Range &gt; 0.5 km</td>
</tr>
<tr>
<td></td>
<td>VSA Cloud Ceiling Height &lt; 0</td>
</tr>
</tbody>
</table>

MODTRAN Inputs
VSA Inversion/Boundary Layer Height $\geq 0$

In case 3, a radiation fog is assumed if Surface Range $< 2$ km or Aerosol Model Used is Radiation Fog; a haze is assumed if Surface Range $> 2$ km. The primary difference between case 3 and case 4 is the first 200 meters above ground (Figure 18, LOWTRAN 6 manual, p. 53).

**Related variables**
- VSA Cloud Ceiling Height
- VSA Cloud/Fog Thickness
- Surface Range for Boundary Layer
- Use of Army (VSA) for Aerosol Extension
4.3.13 Screen “New Model Atmosphere”

This screen controls inputs for a user supplied model atmosphere that is enabled by selecting New Model Atmosphere for Model Atmosphere on the first input screen. This option lets you supply specific atmospheric profiles so that MODTRAN can match experimental conditions. If you do not know all of the inputs needed by MODTRAN (for example, the ozone profile as a function of altitude), defaults for many variables can be selected from the provided MODTRAN standard model atmospheres. The format of this screen is shown below:

The new model atmosphere is first defined by a short screen that sets the number of layers, and generally determines if you will be supplying molecular concentrations and aerosols as a function of altitude. This screen is followed by a set of additional screens, one for each layer in your new model atmosphere. For each layer, you can supply temperature, pressure, height, molecular concentrations, and aerosol settings, mixing values that you know with defaults from the standard atmospheres. Many of the variables (particularly in the aerosols) are repeats of options present seen other places when using the standard profiles; the only significant difference is that these variable settings become specific to the layer you are defining.
4.3.13.1 Load Layer Data from a File

**MODTRAN Variable:** None  
**Card:** 2C  
**Input Screen:** New Model Atmosphere

**Valid selections**
pressing Browse and Load button starts this feature

**Description**
This parameter lets you import a user profile from a comma separated value (csv) file. This feature lets you set up a profile table independent of PcModWin (using a spreadsheet or other tool) and then import the profile in a single pass. An example file is provided with the PcModWin distribution. Any files you create should track this structure and follow the conventions noted in the example for ordering inputs and setting units.

Clicking on the Browse and Load button first displays a file dialog with which you select the csv file to use:

![Find File dialog](image)

After you select the file and click Open, it is imported in and you can edit the profile directly in PcModWin.

The user-specified atmospheric input cards (New Model Atmosphere and User Supplied Profile) are only displayed if Model Atmosphere is set to New Model Atmosphere.

**Related variables**
None
4.3.13.2  Go to Layer button

**MODTRAN Variable:** None  
**Card:** 2C  
**Input Screen:** New Model Atmosphere

**Valid selections**
integer from 1 to the value of **Number of Atmospheric Layers**

**Description**
This parameter lets you randomly access any layer in your user defined profile. The combo box displayed next to this button is loaded with a layer number from 1 up to the total number of layers defined in the profile. To use this feature, first change the layer number displayed in the combo box to the number of the layer that you want to move to. Then click the Go to Layer button to directly jump to that layer.

The user-specified atmospheric input cards (**New Model Atmosphere** and **User Supplied Profile**) are only displayed if Model Atmosphere is set to **New Model Atmosphere**.

**Related variables**
**Number of Atmospheric Layers**
4.3.13.3 Number of Atmospheric Layers

**MODTRAN Variable:** ML  **Card:** 2C  **Input Screen:** New Model Atmosphere

**Valid selections**
integer from 1 to 34

**Description**
This parameter sets the number of layers that your aerosol profile will have. Up to 34 separate layers, as a function of altitude, can be defined.

The user-specified atmospheric input cards (New Model Atmosphere and User Supplied Profile) are only displayed if Model Atmosphere is set to New Model Atmosphere.

**Related variables**
this variable controls how many User Supplied Profile screens are displayed Model Atmosphere
### 4.3.13.4 Supply Molecular Density by Layer

**MODTRAN Variable:** IRD1  
**Card:** 2C  
**Input Screen:** New Model Atmosphere

**Valid selections** [check box input]

- unchecked = 0 = use default molecular densities
- checked = 1 = user supplied molecular density profiles

**Description**

This parameter determines whether default values will be used for the molecular densities for each layer, or whether you will explicitly enter the densities. The molecular densities involved are those in the following list: water vapor (H\(_2\)O), carbon dioxide (CO\(_2\)), ozone (O\(_3\)), nitrous oxide (N\(_2\)O), carbon monoxide (CO), methane (CH\(_4\)), oxygen (O\(_2\)), nitric oxide (NO), sulphur dioxide (SO\(_2\)), nitrogen dioxide (NO\(_2\)), ammonia (NH\(_3\)), and nitric acid (HNO\(_3\)). If you plan to modify any of these profiles, or control the defaults that will be used, you must check this parameter. When this option is enabled, an additional list of inputs appears in the center of each atmospheric layer input card. These inputs allow you to either directly input the molecular density, or select a default model atmosphere value. Densities can be specified in the following units: volume mixing ratio (ppmv), number density (cm\(^{-3}\)), mass mixing ratio (gm/kg), mass density (gm/m\(^3\)), or partial pressure (mb). Water vapor molecular densities can additionally be specified by dew point temperatures or relative humidity. If you select one of the default model profiles, a linear interpolation will be made between the two closest layer values in the default profile to match the altitude of the layer that you are defining.

The user-specified atmospheric input cards (New Model Atmosphere and User Supplied Profile) are only displayed if Model Atmosphere is set to New Model Atmosphere.

**Related variables**

access to the upper part of User Supplied Profile screens is controlled by this variable Model Atmosphere
4.3.13.5 Supply Aerosol Information by Layer

**MODTRAN Variable:** IRD2  
**Card:** 2C  
**Input Screen:** New Model Atmosphere

**Valid selections** [check box input]
- unchecked = 0 = use default aerosol profiles
- checked = 1 = user supplied aerosol profile information

**Description**
This parameter controls whether you will explicitly specify aerosol information for the model atmosphere that you are defining, or whether you will use default settings for the aerosols. If you check this parameter, a series of additional input prompts will appear on the input card for each layer in the atmosphere you are defining. The additional inputs correspond to input card 2C3 that is described in the MODTRAN manual. If you want aerosols modeled in your new atmosphere, you must check this prompt, or else the default aerosol settings will all be set to 0. Once you have decided to supply the aerosol data for the layer, you will be able to use either default values for the parameters (which are based on the standard aerosol model profiles supplied in MODTRAN) or you will be able to explicitly enter your own values.

The user-specified atmospheric input cards (New Model Atmosphere and User Supplied Profile) are only displayed if Model Atmosphere is set to New Model Atmosphere.

**Related variables**
access to the lower half of the User Supplied Profile screen is controlled by this variable Model Atmosphere
4.3.13.6 Supply Up to Four Aerosol Profiles

**MODTRAN Variable:** IRD2  
**Card:** 2C  
**Input Screen:** New Model Atmosphere

**Valid selections** [check box input]
unchecked = 0 or 1 = do not enable aerosol option for IRD2 = 2  
checked = 2 = enable additional aerosol options for layers

**Description**
This parameter enables an alternate way of specifying the aerosols for each layer.

This option cannot be used with the "A+" aerosol option, so in order to use this, the Use A+ Card input must be unchecked. In addition, the Supply Aerosol Information by Layer input must be checked for this input to be enabled.

The user-specified atmospheric input cards (New Model Atmosphere and User Supplied Profile) are only displayed if Model Atmosphere is set to New Model Atmosphere.

**Related variables**
- Model Atmosphere
- Use A+ Card
- Supply Aerosol Information by Layer
4.3.13.7 Title

**MODTRAN Variable:** TITLE  **Card:** 2C  **Input Screen:** New Model Atmosphere

**Valid selections**
string of ASCII characters up to 72 characters in length

**Description**
This parameter lets you assign a text identifier string to your model atmosphere inputs. This string is echoed in the input parameters for MODTRAN to allow identification of the model atmosphere at a later date, and is also repeated in the MODOUT1 file (TAPE6) whenever it is used for a calculation.

The user-specified atmospheric input cards (New Model Atmosphere and User Supplied Profile) are only displayed if Model Atmosphere is set to New Model Atmosphere.

**Related variables**
Model Atmosphere
4.3.14 Screen “User Supplied Profile”

This screen sets the values for one layer of a user supplied model atmosphere that is enabled by selecting New Model Atmosphere for Model Atmosphere on input screen Model Atmosphere (1). This option lets you supply specific atmospheric profiles so that MODTRAN can match experimental conditions. If you do not know all of the inputs needed by MODTRAN (for example, the ozone profile as a function of altitude), defaults for many variables can be selected from the provided MODTRAN standard model atmospheres. This screen is shown below:

For each layer, you can supply temperature, pressure, height, molecular concentrations, and aerosol settings, mixing values that you know with defaults from the standard atmospheres. Many of the variables (particularly in the aerosols) are repeats of options present seen other places when using the standard profiles; the only significant difference is that these variable settings become specific to the layer you are defining.

Some parts of this screen become invisible, depending on the options selected on screen New Model Atmosphere. The default concentrations will be the value set on the Model Atmosphere (1) input screen. You are encouraged to use this option, if you want...
to use the default atmosphere for some molecules and user specified for others. It will save you considerable time in re-entering data.

If you set both Supply Aerosol Information by Layer and Supply Up to 4 Aerosol Profiles to checked on screen New Model Atmosphere, then the aerosol section of this screen is changed, as shown below:
4.3.14.1 Boundary Altitude of Layer #

**MODTRAN Variable:** ZMDL  
**Card:** 2C1  
**Input Screen:** User Supplied Profile

**Valid selections**
Numeric value from 0 to 100 kilometers

**Description**
This parameter defines the bottom altitude of the layer that you are defining in your new model atmosphere. The thickness of the layer is determined by the Boundary Altitude of the next layer that you input. The number next to Layer # reminds you of what number layer you are currently working on. A full screen card like this will be displayed for each layer in your model atmosphere, and the total number of layers has already been specified in Number of Atmospheric Layers, the first prompt on the first model atmosphere input card.

When a new layer is created, this variable is initialized to 0. The input program checks to make sure that the altitude of each succeeding layer is greater than the previous one. If you start paging through the newly initialized layer cards, you will see the error message at the bottom of the screen, and the input program will not let you leave this screen. Input a value for this variable larger than the previous layer. If you do not remember what the boundary altitude of the previous layer is, enter a very large number and then page back to see what it actually is. Because of this error checking, you should plan on setting up the altitude of each boundary layer first when you are inputting your own custom atmosphere.

Some of the parameters on the model atmosphere input card(s) are mandatory; others are optional (default values are used for optional inputs). This parameter is mandatory.

The user-specified atmospheric input cards (New Model Atmosphere and User Supplied Profile) are only displayed if Model Atmosphere is set to New Model Atmosphere.

**Related variables**
Number of Atmospheric Layers
4.3.14.2 Pressure

MODTRAN Variable: P        Card: 2C1        Input Screen: User Supplied Profile

Valid selections
numeric value > 0 in units defined in Pressure Units

Description
This parameter defines the average pressure of the atmospheric layer that you are specifying. The units for this parameter are defined in the input right below it on the screen labeled Pressure Units. Note that you can now specify the pressure of this atmospheric layer in two ways: (1) enter the value explicitly, or (2) use one of the default values from any of the standard atmospheric models supplied with MODTRAN. On the prompt immediately below this input, you select which method you will use. If you specify one of the model atmospheres, MODTRAN will interpolate (linearly) between the two closest values in the model atmosphere to derive the appropriate pressure for this layer.

Some of the parameters on this radiosonde input card are mandatory; others are optional (default values are used for optional inputs). If you specify one of the pressure units in Pressure Units, this parameter is mandatory; if you select one of the model atmospheres for Pressure Units, any value entered here will be ignored.

The user-specified atmospheric input cards (New Model Atmosphere and User Supplied Profile) are only displayed if Model Atmosphere is set to New Model Atmosphere.

Related variables
Pressure Units
4.3.14.3 Pressure Units

**MODTRAN Variable:** JCHAR  **Card:** 2C1  **Input Screen:** User Supplied Profile

**Valid selections**
- Units are (mb) = A = input layer pressure explicitly in millibars
- Units are (atm) = B = input layer pressure explicitly in atmospheres
- Units are (torr) = C = input layer pressure explicitly in torr
- Use Tropical = 1 = interpolate best match from Tropical atm
- Use Midlatitude Summer = 2 = interpolate best match from Midlatitude Summer
- Use Midlatitude Winter = 3 = interpolate best match from Midlatitude Winter
- Use Subarctic Summer = 4 = interpolate best match from Subarctic Summer
- Use Subarctic Winter = 5 = interpolate best match from Subarctic Winter

**Description**
This parameter controls how you will specify the average pressure of the layer. If you select one of the default atmospheric models, a value will be interpolated from that profile for the layer pressure, and any number in the Pressure prompt will be ignored. If you select one of the Units are ... prompts, you must explicitly enter the pressure for this layer in the units specified here into the Pressure parameter (immediately above on the screen).

This input is part of the MODTRAN control array JCHAR.

The user-specified atmospheric input cards (New Model Atmosphere and User Supplied Profile) are only displayed if Model Atmosphere is set to New Model Atmosphere.

**Related variables**
Pressure
4.3.14.4 Temperature

**MODTRAN Variable:** T  **Card:** 2C1  **Input Screen:** User Supplied Profile

**Valid selections**
any valid temperature value in units defined in Temperature Units

**Description**
This parameter defines the average temperature of the atmospheric layer that you are specifying. The units for this parameter are defined in the input right below it on the screen labeled Temperature Units. You can specify the temperature of this atmospheric layer in two ways: (1) enter the value explicitly, or (2) use one of the default values from any of the standard atmospheric models supplied with MODTRAN. On the prompt immediately below this input, you select which method you will use. If you specify one of the model atmospheres, MODTRAN will interpolate (linearly) between the two closest values in the model atmosphere to derive the appropriate temperature for this layer.

Some of the parameters on this radiosonde input card are mandatory; others are optional (default values are used for optional inputs). If you specify Units are (K) or Units are (C) for Temperature Units (in the prompt below), this parameter is mandatory; if you select one of the model atmosphere temperature profiles (in the prompt below), any value entered here will be ignored.

The user-specified atmospheric input cards (New Model Atmosphere and User Supplied Profile) are only displayed if Model Atmosphere is set to New Model Atmosphere.

**Related variables**
Temperature Units
4.3.14.5 Temperature Units

**MODTRAN Variable:** JCHAR  
**Card:** 2C1  
**Input Screen:** User Supplied Profile

- **Valid selections**
  - Units are (K) = A = input layer temperature explicitly in Kelvin
  - Units are (C) = B = input layer temperature explicitly in Centigrade
  - Use Tropical = 1 = interpolate best match from Tropical atmosphere profile
  - Use Midlatitude Summer = 2 = interpolate best match from Midlatitude Summer
  - Use Midlatitude Winter = 3 = interpolate best match from Midlatitude Winter
  - Use Subarctic Summer = 4 = interpolate best match from Subarctic Summer
  - Use Subarctic Winter = 5 = interpolate best match from Subarctic Winter

- **Description**
  
  This parameter determines how you will specify the average temperature of the layer. If you select one of the default atmospheric models here, a value will be interpolated from that profile for the layer temperature, and any number in the Temperature prompt will be ignored. If you select either of the Units are ... prompts, you must explicitly enter the temperature for this layer in the units specified here into the Temperature prompt (immediately above).

  This input is part of the MODTRAN control array JCHAR.

  The user-specified atmospheric input cards (New Model Atmosphere and User Supplied Profile) are only displayed if Model Atmosphere is set to New Model Atmosphere.

- **Related variables**
  - Temperature
4.3.14.6 Cross-Section Units

**MODTRAN Variable:** JCHARX  **Card:** 2C1  **Input Screen:** User Supplied Profile

**Valid selections**
- **Vol Mix Ratio (ppmv)** = A = enter explicitly as a volume mixing ratio
- **Number Density (cm⁻³)** = B = enter explicitly as a number per cubic cm
- **Mass Mix Ratio (gm/kg)** = C = enter explicitly as a ratio of grams of selected molecule per kilogram of layer atmosphere
- **Mass Density (gm/m³)** = D = enter explicitly as grams of molecule per cubic meter of layer
- **Partial Pressure (mb)** = E = enter explicitly as a partial pressure in mb

**Tropical** = 1 = interpolate best match from Tropical atm
**Midlatitude Summer** = 2 = interpolate best match from Midlatitude Summer
**Midlatitude Winter** = 3 = interpolate best match from Midlatitude Winter
**Subarctic Summer** = 4 = interpolate best match from Subarctic Summer
**Subarctic Winter** = 5 = interpolate best match from Subarctic Winter

**Description**
This parameter sets the units for the entire set of CFC's and other heavy molecules.

When the CFC's are being specified, an additional screen (User Supplied Xsections) is displayed for each layer.

The user-specified atmospheric input cards (New Model Atmosphere and User Supplied Profile) are only displayed if Model Atmosphere is set to New Model Atmosphere.
4.3.14.7 Individual Molecules (H₂O, CO₂, etc.)

**MODTRAN Variable:** WMOL  
**Card:** 2C1  
**Input Screen:** User Supplied

**Profile**

**Valid selections**
floating point number in units defined by Density Option/Units to the right

**Description**
This parameter lets you explicitly supply the density of any individual MODTRAN molecule for this layer in your model atmosphere. The units that you will use are shown immediately to the right of this prompt on the screen, under the column Density Option/Units. If the option/units selects one of the standard model atmospheric profiles supplied with MODTRAN, then any number you enter here for a density will be ignored, and the model will interpolate a value from the default profile selected. If a unit is shown in Density Option/Units, then you must enter the density explicitly in this unit. Densities can be specified in the following units: volume mixing ratio (ppmv), number density (cm⁻³), mass mixing ratio (gm/kg), mass density (gm/m³), or partial pressure (mb). Water vapor molecular densities can additionally be specified by dew point temperatures or relative humidity. Note that since this option is available for each molecule, you can mix and match default profile values (for molecules that you do not have explicit information on) with actual values that may have been measured or calculated from an experiment.

**Related variables**
Density Option/Units
4.3.14.8 Density Option/units (next to each molecule)

**MODTRAN Variable:** JCHAR  **Card:** 2C1  **Input Screen:** User Supplied Profile

**Valid selections**

- **Vol Mix Ratio (ppmv)** = A = enter explicitly as a volume mixing ratio
- **Number Density (cm-3)** = B = enter explicitly as a number per cubic cm
- **Mass Mix Ratio (gm/kg)** = C = enter explicitly as a ratio of grams of selected molecule per kilogram of layer atmosphere
- **Mass Density (gm/m3)** = D = enter explicitly as grams of molecule per cubic meter of layer
- **Partial Pressure (mb)** = E = enter explicitly as a partial pressure in mb
- **Tropical** = 1 = interpolate best match from Tropical atm
- **Midlatitude Summer** = 2 = interpolate best match from Midlatitude Summer
- **Midlatitude Winter** = 3 = interpolate best match from Midlatitude Winter
- **Subarctic Summer** = 4 = interpolate best match from Subarctic Summer
- **Subarctic Winter** = 5 = interpolate best match from Subarctic Winter

**Description**

This parameter determines how you will specify the individual molecular density for this layer. The molecule being specified is listed directly to the left of the current prompt. If you select one of the default atmospheric models here, a value will be interpolated from that profile for the layer concentration of this molecule, and any number in the input box to the left of this prompt will be ignored. If you select any of the units prompts, you must explicitly enter the molecule density for this layer in the units shown.

**Related variables**

specific molecule input box immediately to left of prompt
4.3.14.9 Aerosol Extinction at 0.55 \(\mu\text{m}\) (1/km)

**MODTRAN Variable:** AHAZE  \hspace{1cm} **Card:** 2C3  \hspace{1cm} **Input Screen:** User Supplied Profile

**Valid selections**
numeric value greater than 0 in km\(^{-1}\)

**Description**
The parameter is the aerosol scaling factor that is used to normalize the spectral values of the extinction coefficient for the aerosols in this layer. If used, it should be set equal to the extinction coefficient at 0.55 micrometers (in the visible band) at the altitude of this layer. The extinction coefficients at all other wavelengths for the aerosol model selected will be normalized to this value. The units for this parameter are inverse kilometers.

Note that either this parameter or the next one (Equivalent Liquid Water Content) should be used if you want to normalize this curve - both are not allowed.

This prompt (and the rest of the layer aerosol inputs) only appears if the Supply Aerosol Information by Layer box is checked on screen New Model Atmosphere.

**Related variables**
Equivalent Liquid Water Content
Supply Aerosol Information by Layer
4.3.14.10 Equivalent Liquid H2O Content (gm/m3)

**MODTRAN Variable:** EQLWCZ  **Card:** 2C3  **Input Screen:** User Supplied Profile

**Valid selections**
floating point value > 0 in units of gm/cm³

**Description**
This parameter selects a value for the equivalent liquid water content in gm/cm³ at a wavelength of 0.55 micrometers in the current layer altitude for the aerosol models. It is used to normalize the spectral variation in extinction coefficients for the aerosol at 0.55 micrometers.

Note that either this parameter or the previous one (Aerosol Extinction at 0.55 µm) should be used if you want to normalize this curve. Setting both inputs is not allowed, and if both are set, MODTRAN will use the value assigned to Aerosol Extinction at 0.55 µm.

This prompt (and the rest of the layer aerosol inputs) only appears if the Supply Aerosol Information by Layer box is checked on screen New Model Atmosphere.

**Related variables**
Aerosol Extinction at 0.55 µm
Supply Aerosol Information by Layer
4.3.14.11 Rain Rate (mm/hr)

**MODTRAN Variable:** RRATZ \hspace{1cm} **Card:** 2C3 \hspace{1cm} **Input Screen:** User Supplied Profile

**Valid selections**
any numeric value in units of mm/hr

**Description**
This parameter lets you specify a rain rate for the layer of model atmosphere that you are setting up. The extinction caused by rain is modeled by first making assumptions about the raindrop size distribution and then applying Mie theory. The equation used for transmittance over path length is \( t = \exp(-0.365R^{0.63}s) \), where \( s \) is the path length in km and \( R \) is the rain rate in mm/hour. The extinction due to rain in this model is independent of wavelength, since the average raindrop diameters (0.1 to 10 mm) are considerably larger than the infrared wavelengths under consideration.

The raindrop size distribution used in MODTRAN is the Marshall-Palmer one, which is widely accepted. Several other distribution models are mentioned in the rain model description in the LOWTRAN 6 manual. These alternate models cannot be used without recompiling the MODTRAN program, and are thus unavailable to PCModWin users.

The ability to specify different rain rates for different layers gives the user considerably more flexibility in setting up rain profiles than the single Rain Rate parameter on the Aerosols screen.

Units of millimeters/hour were selected for this parameter since rain rates are reported in these units by worldwide meteorological stations.

This prompt (and the rest of the layer aerosol inputs) only appears if the Supply Aerosol Information by Layer box is checked on screen New Model Atmosphere.

**Related variables**
Supply Aerosol Information by Layer
4.3.14.12 Aerosol Model Used

**MODTRAN Variable:** IHA1  **Card:** 2C3  **Input Screen:** User Supplied Profile

**Valid selections**

No Aerosol Attenuation = 0 = no aerosol effects included in the calculation  
Rural - VIS=23km = 1 = RURAL extinction, default VIS = 23 km  
Rural - VIS=5km = 2 = RURAL extinction, default VIS = 5 km  
Navy Maritime = 3 = NAVY MARITIME extinction, sets its own VIS  
Maritime - VIS=23km = 4 = MARITIME extinction, default VIS = 23 km  
Urban - VIS=5km = 5 = URBAN extinction, default VIS = 5 km  
Tropospheric - VIS=50km = 6 = TROPOSPHERIC extinction, default VIS = 50 km  
User Defined - VIS=23km = 7 = USER DEFINED extinction, default VIS = 23 km  
Fog advection - VIS=.5km = 8 = FOG1 (advection fog) extinction, default VIS = 0.2 km  
Fog radiation - VIS=.2km = 9 = FOG2 (radiation fog) extinction, default VIS = 0.5 km  
Desert extinction = 10 = DESERT extinction, sets its own VIS from WSS

**Description**

If the user sets New Model Atmosphere for Model Atmosphere, this parameter on input card 2C1 will select the default profile that will be used for the layer you are defining. The profile selected will be interpolated linearly to give the best fit value to the layer altitude. There are some complex rules regarding the use and priority of the aerosol input values when you are specifying your own model atmosphere. If either the Aerosol Extinction at 0.55 µm or Equivalent Liquid Water Content are set, then only one of the following parameters are needed: Aerosol Model Used (this parameter), Use Cloud/Rain Aerosol Extensions, or Upper Atmosphere Aerosols. If you specify this parameter, the other two will be ignored. If both the Aerosol Extinction at 0.55 µm and Equivalent Liquid Water Content are 0, then all three will be used to set the aerosol values for this layer.

The Rural, Maritime, and Urban models provide aerosol extinction characteristic of an air mass that has just moved through one of these types of areas. The Tropospheric model characterizes very clear conditions.

Option Navy Maritime (IHAZE = 3) selects use of the Navy Maritime Aerosol model. Aerosol population over the ocean is significantly different from continental aerosols, and this model attempts to model this difference. Three distinct types of aerosols are assumed: a 'continental' component contributed by nearby land mass (controlled by Air Mass Character); a 'stationary' component affected by the winds (controlled by the 24-hour Average Wind Speed); and a 'fresh' component caused by wind over the water (controlled by Wind Speed - Navy Maritime Aerosols).

If you select User Defined as the input here, the User Supplied Aerosols screen is enabled in the PcModWin list. This card displays a list of wavelength values and allows you to input an aerosol extinction and aerosol absorption coefficient for each wavelength.
Fog forms when the air is saturated with water vapor. This saturation can occur in two different ways: (1) the mixing of air masses with different temperatures and/or humidities (advection fogs), and (2) cooling of the air to the point where its temperature approaches the dew point temperature (radiation fogs). Thus two basic fog models are provided for use in the boundary layer. The first model, labeled Fog advection - VIS = .2 km, represents the advection fog, while the other, labeled Fog radiation - VIS = .5 km, is for radiation fogs. The extinction coefficients for radiation fogs are higher between 2 - 4 microns but significantly lower longer than 5 microns (compared to advection fogs). The absorption coefficients for radiation fogs are generally 10% - 20% lower than advection fogs.

*Desert extinction* is an aerosol profile that models particles over desert conditions. It contains a wind speed dependent parameter.

This prompt (and the rest of the layer aerosol inputs) only appears if the Supply Aerosol Information by Layer box is checked on screen New Model Atmosphere.

**Related variables**
- Aerosol Extinction at 0.55 µm
- Equivalent Liquid Water Content
- Use Cloud/Rain Aerosol Extensions
- Upper Atmosphere Aerosols
- Supply Aerosol Information by Layer
4.3.14.13 Use Cloud/Rain Aerosol Extensions

**MODTRAN Variable:** ICLD1  **Card:** 2C3  **Input Screen:** User Supplied Profile

**Valid selections**
- *No Clouds or Rain = 0* = no cloud attenuation included
- *Cumulus Clouds = 1* = cumulus cloud with base 0.66 km, top at 2.7 km
- *Altostratus Clouds = 2* = altostratus cloud with base 2.4 km, top at 3.0 km
- *Stratus Clouds = 3* = stratus cloud with base 0.33 km, top at 1.0 km
- *Stratus/Strato-Cumulus = 4* = strato-cumulus cloud with base 0.66 km, top at 2 km
- *Nimbostratus Clouds = 5* = nimbostratus cloud with base 0.16 km, top at 0.66 km
- *2.0 mm/hr Rain = 6* = simulate drizzle rain with stratus clouds
- *5.0 mm/hr Rain = 7* = simulate light rain with nimbostratus clouds
- *12.5 mm/hr Rain = 8* = simulate moderate rain with nimbostratus clouds
- *25.0 mm/hr Rain = 9* = simulate heavy rain with cumulus clouds
- *75.0 mm/hr Rain = 10* = simulate extreme rain with cumulus clouds
- *User Input Cloud Ext & Absor = 11* = use user defined cloud extinction/absorption
- *Cirrus Profile = 18* = use standard cirrus model
- *Subvisual Cirrus Profile = 19* = use optically thin cirrus
- *NOAA Cirrus Profile = 20* = cirrus profile from LOWTRAN 6

**Description**
This parameter will select the use of any cloud or rain aerosol modifications that should be made to the default aerosol profile selected in [Aerosol Model Used](#). The model selected will be interpolated linearly to give the best fit value to the layer altitude. There are some complex rules regarding the use and priority of the aerosol input values when you are specifying your own model atmosphere. If either the [Aerosol Extinction at 0.55 µm](#) or [Equivalent Liquid Water Content](#) are set, then only one of the following parameters are needed: Aerosol Model Used, this parameter, or [Upper Atmosphere Aerosols](#). If Aerosol Model Used has been specified, this parameter is ignored. If this parameter is specified, then Upper Atmosphere Aerosols will be ignored. However, if both the number [Aerosol Extinction at 0.55 µm](#) and Equivalent Liquid Water Content are 0, then all three will be used to set the aerosol values for this layer.

*Cumulus, Altostratus, Stratus, Strato-Cumulus, and Nimbostratus* options select five different cloud types. The base and top cited for each model is the region where the air is considered saturated with 100% relative humidity. The humidity is still elevated around the cloud, so it will affect transmission and radiance calculations in paths that pass near the clouds. The average water droplet size distribution is assumed centered around a 10 micron droplet diameter. The drops are treated as aerosols.

Five different built-in rain rate models (*2.0 mm/hr Rain, 5.0 mm/hr Rain, 12.5 mm/hr Rain, 25.0 mm/hr Rain, and 75.0 mm/hr Rain*) allow the user the ability to simulate different rain rates in the boundary layer. The actual values used for each layer are echoed in the input cards at the beginning of the MODOUT1 (TAPE6) file.
**Cirrus Profile** and **Subvisual Cirrus Profile** simulate attenuation caused by cirrus clouds. The cirrus clouds are assumed to be made of ice particles and to occur at high altitudes. The attenuation coefficients used are based on a combination of theoretical models and measured extinction of solar radiation. These models include realistic wavelength dependence to the scattering and absorption parameters used.

**NOAA Cirrus Profile** is the same cirrus model that was provided as an option in LOWTRAN 6 and 7. The attenuation applied by this model is independent of wavelength and related only to the thickness of the cirrus layers.

This prompt (and the rest of the layer aerosol inputs) only appears if the Supply Aerosol Information by Layer box is checked on screen **New Model Atmosphere**.

**Related variables**
- Aerosol Extinction at 0.55 µm
- Equivalent Liquid Water Content
- Aerosol Model Used
- Upper Atmosphere Aerosols
- Supply Aerosol Information by Layer
4.3.14.14 Upper Atmosphere Aerosol (30 - 100 km)

**MODTRAN Variable:** IVUL1  **Card:** 2C3  **Input Screen:** User Supplied Profile

**Valid selections**
- Background Stratospheric = 0,1 = use BACKGROUND STRATOSPHERIC profile and extinction
- Moderate/Aged Volcanic = 2 = MODERATE profile and AGED VOLCANIC extinction
- High/Fresh Volcanic = 3 = HIGH profile and FRESH VOLCANIC extinction
- High/Aged Volcanic = 4 = HIGH profile and AGED VOLCANIC extinction
- Moderate/Fresh Volcanic = 5 = MODERATE profile and FRESH VOLCANIC extinction
- Bkgd Strat/Moderate = 6 = MODERATE profile and BACKGROUND STRATO extinction
- Bkgd Strat/High Volcanic = 7 = HIGH profile and BACKGROUND STRATO extinction
- Extreme Volcanic Profile = 8 = EXTREME profile and FRESH extinction

**Description**
This parameter will select the use of any upper atmospheric modifications that should be made to the default aerosol profile selected in Aerosol Model Used. The profile selected will be interpolated linearly to give the best fit value to the selected profile. There are some complex rules regarding the use and priority of the aerosol input values when you are specifying your own model atmosphere. If either the Aerosol Extinction at 0.55 \( \mu m \) (2C1) or Equivalent Liquid Water Content are set, then only one of the following parameters are needed: Aerosol Model Used, Use Cloud/Rain Aerosol Extensions, or Upper Atmosphere Aerosols (2C1, this parameter). If either Aerosol Model Used or Use Cloud/Rain Aerosol Extensions have been specified, this parameter is ignored. However, if both the number Aerosol Extinction at 0.55 \( \mu m \) and Equivalent Liquid Water Content are 0, then all three will be used to set the aerosol values for this layer.

The major component of the stratospheric aerosols is taken to be a 75 percent solution of sulfuric acid in water. Thus the Background Stratospheric model was representative of typical conditions in 1980 prior to the eruption of Mt. St Helens (May 1980). This parameter allows you to modify this profile to model changes around the time of a major volcanic eruption. For the first few months following an eruption the Fresh Volcanic model extinction should be used, and for the next year or so the Aged Volcanic extinction profile is appropriate. The Moderate and High volcanic profiles allow you to approximate the amount of material added to the atmosphere by the eruption. For example, the Mt. St. Helens eruption added significant amounts of dust into the atmosphere. However, early analysis indicated most of the dust remained in the troposphere where it had a relatively short lifetime. Thus a best guess would be to use the Moderate Volcanic profile for MODTRAN modeling of the atmosphere around this period. Unlike the Mount St Helens eruption, the June 1991 eruption of Mount Pinatubo in the Philippines produced significantly more volcanic dust which remained in the stratospheric region until late 1993. Each volcanic eruption should be analyzed with this level of detail before deciding
upon the proper volcanic aerosol profile. The major component of the normal upper-atmospheric aerosols is meteoric or cometary dust.

This prompt (and the rest of the layer aerosol inputs) only appears if the Supply Aerosol Information by Layer box is checked on screen New Model Atmosphere.

Related variables
- Aerosol Extinction at 0.55 µm
- Equivalent Liquid Water Content
- Aerosol Model Used
- Use Cloud/Rain Aerosol Extensions
- Supply Aerosol Information by Layer
4.3.14.15 Seasonal Modifications to Aerosols

**MODTRAN Variable:** ISEA1  
**Card:** 2C3  
**Input Screen:** User Supplied Profile

**Valid selections**

_Determined by Model:_
- 0 = use default season determined by Model Atmosphere
- Fall-Winter is the default for MIDLATITUDE WINTER (MODEL = 3)
- SUBARCTIC WINTER (MODEL = 5)
- Spring-Summer is the default for METEOROLOGICAL DATA INPUT (MODEL = 0)
- TROPICAL (MODEL = 1)
- MIDLATITUDE SUMMER (MODEL = 2)
- SUBARCTIC SUMMER (MODEL = 4)
- 1976 U.S. STANDARD ATMOSPHERE (MODEL = 6)
- NEW MODEL ATMOSPHERE (MODEL = 7)

Spring-Summer = 1 = use SPRING-SUMMER profile  
Fall-Winter = 2 = use FALL-WINTER profile

**Description**

This parameter will select the use of the seasonal modifications that should be made to the default aerosol profile selected in Aerosol Model Used. The profile selected will be interpolated linearly to give the best fit value to the layer altitude. If a default aerosol profile is not selected through Aerosol Model Used, this input is ignored.

This prompt (and the rest of the layer aerosol inputs) only appears if the Supply Aerosol Information by Layer box is checked on screen New Model Atmosphere.

**Related variables**

Aerosol Model Used
Supply Aerosol Information by Layer
4.3.14.16 Change Profile Region

**MODTRAN Variable:** ICHR1  **Card:** 2C3  **Input Screen:** User Supplied Profile

**Valid selections** [check box input]
- unchecked $= 0 =$ no boundary change in user defined aerosol or cloud regions (regions are not adjacent)
- checked $= 1 =$ signifies the boundary change in adjacent user defined aerosol or cloud regions

**Description**
This parameter is used to indicate whether a boundary change is occurring between two or more adjacent user defined aerosol or cloud regions in the atmospheric layer you are setting up. Clearing the check box indicates that no such boundary change is occurring, while checking the box indicates that a change is occurring.

This variable is required only if you have selected *User Defined* for Aerosol Model Used or *User Input Cloud Ext/Abs* for Use Cloud/Rain Aerosol Extensions. If you have not selected either of these, it will internally default to a 0 value, since these boundaries are defined in the aerosol profiles provided in MODTRAN.

This prompt (and the rest of the layer aerosol inputs) only appears if the Supply Aerosol Information by Layer box is checked on screen New Model Atmosphere.

**Related variables**
- Aerosol Model Used
- Use Cloud/Rain Aerosol Extensions
- Supply Aerosol Information by Layer
4.3.14.17 First Aerosol Extinction at 0.55 um

**MODTRAN Variable:** AHAZE(1)  **Card:** 2C3  **Input Screen:** User Supplied Profile

**Valid selections**
floating point number not equal to 0 (unitless extinction at 0.55 um)

**Description**
This parameter is one of the upgrades added in MODTRAN 3.7. Prior to this upgrade, a user could define only one aerosol profile for a layer. With this upgrade, a user can have up to 4 aerosol profiles present in a single layer.

This parameter applies to the first aerosol profile being defined for this layer. The input is an altitude dependent aerosol extinction coefficient at 0.55 um.

This input is only enabled if Supply Up to 4 Aerosol Profiles is checked on the New Model Atmosphere screen.

Note that this upgrade cannot be combined with the "A+" option; the APLUS option is ignored if Atmospheric Model = New Model Atmosphere and Supply Aerosol Information by Layer is checked. The A+ option allows the built-in aerosols to be shifted around, whereas this upgrade allows the user to input aerosol profiles (up to all 4) with greater control.

**Related variables**
Supply Up to 4 Aerosol Profiles
4.3.14.18 Second Aerosol Extinction at 0.55 um

**MODTRAN Variable:** AHAZE(2)  **Card:** 2C3  **Input Screen:** User Supplied Profile

**Valid selections**
floating point number not equal to 0 (unitless extinction at 0.55 um)

**Description**
This parameter is one of the upgrades added in MODTRAN 3.7. Prior to this upgrade, a user could define only one aerosol profile for a layer. With this upgrade, a user can have up to 4 aerosol profiles present in a single layer.

This parameter applies to the second aerosol profile being defined for this layer. The input is an altitude dependent aerosol extinction coefficient at 0.55 um.

This input is only enabled if **Supply Up to 4 Aerosol Profiles** is checked on the **New Model Atmosphere** screen.

Note that this upgrade cannot be combined with the "A+" option; the APLUS option is ignored if **Atmospheric Model = New Model Atmosphere** and **Supply Aerosol Information by Layer** is checked. The A+ option allows the built-in aerosols to be shifted around, whereas this upgrade allows the user to input aerosol profiles (up to all 4) with greater control.

**Related variables**
**Supply Up to 4 Aerosol Profiles**
4.3.14.19  Third Aerosol Extinction at 0.55 um

**MODTRAN Variable:** AHAZE(3)  **Card:** 2C3  **Input Screen:** User Supplied Profile

**Valid selections**
floating point number not equal to 0 (unitless extinction at 0.55 um)

**Description**
This parameter is one of the upgrades added in MODTRAN 3.7. Prior to this upgrade, a user could define only one aerosol profile for a layer. With this upgrade, a user can have up to 4 aerosol profiles present in a single layer.

This parameter applies to the third aerosol profile being defined for this layer. The input is an altitude dependent aerosol extinction coefficient at 0.55 um.

This input is only enabled if Supply Up to 4 Aerosol Profiles is checked on the New Model Atmosphere screen.

Note that this upgrade cannot be combined with the "A+" option; the APLUS option is ignored if Atmospheric Model = New Model Atmosphere and Supply Aerosol Information by Layer is checked. The A+ option allows the built-in aerosols to be shifted around, whereas this upgrade allows the user to input aerosol profiles (up to all 4) with greater control.

**Related variables**
Supply Up to 4 Aerosol Profiles
4.3.14.20 Fourth Aerosol Extinction at 0.55 um

**MODTRAN Variable:** AHAZE(4)  **Card:** 2C3  **Input Screen:** User Supplied Profile

**Valid selections**
Floating point number not equal to 0 (unitless extinction at 0.55 um)

**Description**
This parameter is one of the upgrades added in MODTRAN 3.7. Prior to this upgrade, a user could define only one aerosol profile for a layer. With this upgrade, a user can have up to 4 aerosol profiles present in a single layer.

This parameter applies to the fourth aerosol profile being defined for this layer. The input is an altitude dependent aerosol extinction coefficient at 0.55 um.

This input is only enabled if Supply Up to 4 Aerosol Profiles is checked on the New Model Atmosphere screen.

Note that this upgrade cannot be combined with the "A+" option; the APLUS option is ignored if Atmospheric Model = New Model Atmosphere and Supply Aerosol Information by Layer is checked. The A+ option allows the built-in aerosols to be shifted around, whereas this upgrade allows the user to input aerosol profiles (up to all 4) with greater control.

**Related variables**
Supply Up to 4 Aerosol Profiles
4.3.15 Screen “User Supplied Xsections”

This screen is used to specify the cross section molecule concentrations for one layer of a user supplied model atmosphere that is enabled by selecting New Model Atmosphere for Model Atmosphere on the first input screen. This option lets you supply specific atmospheric profiles so that MODTRAN can match experimental conditions. This screen is shown below:

This screen is accessed by setting the following variables on the Model Atmosphere screen: Model Atmosphere to New Model Atmosphere, and the Other Gases Altitude Profile to Use CFCs. This screen is then displayed as a second input screen for each layer input. Use the Next button on the User Supplied Profile Screen to get to this window. For each layer, the altitude, temperature, and pressure of the layer is displayed at the top of the screen. You can then select either defaults (using the built-in profile) or explicitly specify concentrations of the species of interest.
4.3.15.1 Cross Section Units

**MODTRAN Variable:** JCHARX  **Card:** 2C1  **Input Screen:** User Supplied Xsections

**Valid selections**
- Vol Mix Ratio (ppmv) = A = enter explicitly as a volume mixing ratio
- Number Density (cm⁻³) = B = enter explicitly as a number per cubic cm
- Mass Mix Ratio (gm/kg) = C = enter explicitly as a ratio of grams of selected molecule per kilogram of layer atmosphere
- Mass Density (gm/m³) = D = enter explicitly as grams of molecule per cubic meter of layer
- Partial Pressure (mb) = E = enter explicitly as a partial pressure in mb
- Tropical = 1 = interpolate best match from Tropical atm
- Midlatitude Summer = 2 = interpolate best match from Midlatitude Summer
- Midlatitude Winter = 3 = interpolate best match from Midlatitude Winter
- Subarctic Summer = 4 = interpolate best match from Subarctic Summer
- Subarctic Winter = 5 = interpolate best match from Subarctic Winter

**Description**

This parameter sets the units for the entire set of CFC's and other heavy molecules. This single units selection applies to all the rest of the inputs on this screen. If you choose to interpolate from the default profile, then you do not need to supply any other inputs on this screen.

Although options are provided to section cross-section profiles for each model atmosphere, in fact there is only a single default altitude profile built into MODTRAN for each species. Thus choosing any of the default options will return the same profile. To see the default altitude profile stored in MODTRAN for each molecule, click on the help for that molecule in the PcModWin help file. The profile is given in volume mixing ratio, which is how it is stored internally in MODTRAN.

"Cross-section" molecules are so named in MODTRAN because their properties are stored in the form of absorption cross-sections instead of line parameters. This includes both complex molecules such as the CFC's and others for which line parameter data is not available. The absorption data for these molecules is stored in the MODTRAN data file "CFCBMP96.ASC". Complete data for these species, covering all spectral regions that they can impact, is not present; the data is limited to regions that have been measured and validated by researchers. Generally this data covers the 6 to 18 micrometer band. The most significant effects are observed in the atmospheric window band 8 - 12 micrometers.

This screen is accessed by setting the following variables on the Model Atmosphere screen: **Model Atmosphere** to New Model Atmosphere, and the **Other Gases Altitude Profile** to Use CFCs. This screen is then displayed as a second input screen for each
layer input. Use the Next button on the User Supplied Profile Screen to get to this window.
4.3.15.2 Cross Section Molecules

**MODTRAN Variable:** WMOLX(i)  **Card:** 2C2X  **Input Screen:** User Supplied Xsections

**Valid selections**
floating point value in units selected by Cross Section Units

**Description**
These parameter sets the amount of the specific molecule listed (CFC-11, CFC-12, etc.) for the current layer. Alternate names for each molecule are listed in the help file. The units are set by Cross Section Units. Possible choices for units are a volume mixing ratio (ppmv), a number density per cubic centimeter, a mass mixing ratio in gm/kg, a mass density in grams per cubic meter, or a partial pressure in millibars.

"Cross-section" molecules are so named in MODTRAN because their properties are stored in the form of absorption cross-sections instead of line parameters. This includes both complex molecules such as the CFC's and others for which line parameter data is not available. The absorption data for these molecules is stored in the MODTRAN data file "CFCBMP96.ASC". Complete data for these species, covering all spectral regions that they can impact, is not present; the data is limited to regions that have been measured and validated by researchers. Generally this data covers the 6 to 18 micrometer band. The most significant effects are observed in the atmospheric window band 8 - 12 micrometers.

If the default built-in cross-section profiles are selected for use, this input is disabled.

This screen is accessed by setting the following variables on the Model Atmosphere screen: Model Atmosphere to New Model Atmosphere, and the Other Gases Altitude Profile to Use CFCs. This screen is then displayed as a second input screen for each layer input. Use the Next button on the User Supplied Profile Screen to get to this window.

The help file contains the default altitude profile for each cross-section molecule stored in MODTRAN. The units are volume mixing ratio (ppmv). You can use these directly if you set Cross Section Units to Vol Mixing Ratio.

**Related Variables**
Cross Section Units
4.3.16 Screen “User Supplied Aerosols” (2D)

This screen lets you specify your own aerosol properties for any of the four aerosol altitude regimes supported in MODTRAN. On this screen, you specify which region you will supply aerosol properties for. For each region that you select, an additional screen User Supplied Extinction is displayed that lets you specify the properties. This screen is shown below:

A slightly modified form of this screen is displayed if the User Supplied Spectra option is selected on the Aerosols card. This screen is shown on the next page. The main difference between the two is the ability to control the wavelengths at which you provide the aerosol extinction, absorption, and asymmetry parameters. With the option shown above, you must populate a fixed array of 47 wavelengths with values. However, with the User Supplied Spectra option (new starting with MODTRAN 3.7), you can provide fewer wavelengths, and also specify exactly what they are. In this later case, you can also use different wavelengths for each of the 4 aerosols that are being defined.
These screens are accessed by setting either **Aerosol Model Used** to *User-Defined – VIS=23 km* or **Use Cloud/Rain Aerosol Extensions** to *User Input Cloud Ext/Abs*. The second version of this screen is accessed by setting **User Supplied Spectra** to *checked*. All of these inputs are on the **Aerosols** screen.
4.3.16.1 User input for Aerosol Region #1

**MODTRAN Variable:** \texttt{IREG(1)} \hspace{1cm} **Card:** 2D \hspace{1cm} **Input Screen:** User Supplied Aerosols

**Valid selections** [check box input]
- unchecked = 0 = use default values of aerosol extinction, absorption, and asymmetry for aerosols in this region
- checked = 1 = input explicit values for extinction, absorption, and asymmetry

**Description**
This parameter selects whether you will explicitly define the aerosol extinction, absorption, and asymmetry factors, or whether you will use one of the default sets supplied in MODTRAN. Region #1 refers to the boundary layer aerosols, located between 0 and 2 km.

These aerosol parameters are used to calculate both the absorption and scattering caused by aerosols in the path. All three of these parameters are functions of wavelength. If you wish to supply your own values for these parameters, check this box, and the additional screen User Supplied Extinction will be displayed for you to fill out. If the default functions built into MODTRAN are adequate, clear the box and they will be used. Remember that these curves are normalized at 0.55 micrometers using the value for the next prompt, Equivalent Liquid H2O Region #1.

**Related variables**
- Equivalent Liquid H2O Region #1
- Title Region #1

access to User Supplied Extinction screen (card 2D2) for this aerosol region is controlled by this input
4.3.16.2 Equivalent Liquid H2O Region #1

**MODTRAN Variable:** AWCON(1)  **Card:** 2D  **Input Screen:** User Supplied Aerosols

**Valid selections**
floating point value in units of km-gm/m³

**Description**
This parameter is used to convert from an equivalent liquid water content (in grams per cubic meter) to an extinction coefficient (in inverse kilometers). It is numerically equal to the equivalent liquid water content corresponding to an extinction coefficient of 1.0 km⁻¹ at a wavelength of 0.55 micrometers. It is used to normalize the aerosol extinction and absorption curves that either you supply on the screen User Supplied Extinction or are provided by default at 0.55 micrometers. This input applies to the boundary layer (0 to 2 km) aerosol values.

This input is only used if User Input for Aerosol Region #1 is checked.

**Related variables**
User Input for Aerosol Region #1
4.3.16.3 Title Region #1

**MODTRAN Variable:** TITLE  **Card:** 2D  **Input Screen:** User Supplied Aerosols

**Valid selections**
string of ASCII characters up to 72 in length

**Description**
This input lets you identify your custom aerosol profile with a line of descriptive text. This title goes with the boundary layer profile, and is echoed back with it in the MODOUT1 output (TAPE6 file).

This input is only used if User Input for Aerosol Region #1 is checked.

**Related variables**
User Input for Aerosol Region #1
4.3.16.4 User input for Aerosol Region #2

**MODTRAN Variable:** IREG(2)  **Card:** 2D  **Input Screen:** User Supplied Aerosols

**Valid selections** [check box input]
- unchecked = 0 = use default values of aerosol extinction, absorption, and asymmetry for aerosols in this region
- checked = 1 = input explicit values for extinction, absorption, and asymmetry

**Description**
This parameter selects whether you will explicitly define the aerosol extinction, absorption, and asymmetry factors, or whether you will use one of the default sets supplied in MODTRAN. Region #2 refers to the tropospheric layer aerosols, located between 2 and 10 km.

These aerosol parameters are used to calculate both the absorption and scattering caused by aerosols in the path. All three of these parameters are functions of wavelength. If you wish to supply your own values for these parameters, check this box, and the additional screen User Supplied Extinction will be displayed for you to fill out. If the default functions built into MODTRAN are adequate, clear the box and they will be used. Remember that these curves are normalized at 0.55 micrometers using the value for the next prompt, Equivalent Liquid H2O Region #2.

**Related variables**
- Equivalent Liquid H2O Region #2
- Title Region #2
access to User Supplied Extinction screen (card 2D2) for this aerosol region is controlled by this input
4.3.16.5 Equivalent Liquid H2O Region #2

**MODTRAN Variable:** AWCCON(2)  **Card:** 2D  **Input Screen:** User Supplied Aerosols

**Valid selections**
floating point value in units of km-gm/m³

**Description**
This parameter is used to convert from an equivalent liquid water content (in grams per cubic meter) to an extinction coefficient (in inverse kilometers). It is numerically equal to the equivalent liquid water content corresponding to an extinction coefficient of 1.0 km⁻¹ at a wavelength of 0.55 micrometers. It is used to normalize the aerosol extinction and absorption curves that either you input on the User Supplied Extinction screen or are provided by default at 0.55 micrometers. This input applies to the tropospheric layer (2 to 10 km) aerosol values.

This input is only used if User Input for Aerosol Region #2 is checked.

**Related variables**
User Input for Aerosol Region #2
4.3.16.6 Title Region #2

**MODTRAN Variable:** TITLE  
**Card:** 2D  
**Input Screen:** User Supplied Aerosols

**Valid selections**
string of ASCII characters up to 72 in length

**Description**
This input lets you identify your custom aerosol profile with a line of descriptive text.
This title goes with the tropospheric layer profile, and is echoed back with it in the MODOUT1 output (TAPE6 file).

**Related variables**
User Input for Aerosol Region #2
4.3.16.7 User input for Aerosol Region #3

**MODTRAN Variable:** IREG(3)  **Card:** 2D  **Input Screen:** User Supplied Aerosols

**Valid selections** [check box input]

- **unchecked** = 0 = use default values of aerosol extinction, absorption, and asymmetry for aerosols in this region
- **checked** = 1 = input explicit values for extinction, absorption, and asymmetry

**Description**

This parameter selects whether you will explicitly define the aerosol extinction, absorption, and asymmetry factors, or whether you will use one of the default sets supplied in MODTRAN. Region #3 refers to the stratospheric layer aerosols, located between 10 and 30 km.

These aerosol parameters are used to calculate both the absorption and scattering caused by aerosols in the path. All three of these parameters are functions of wavelength. If you wish to supply your own values for these parameters, check this box, and the additional screen **User Supplied Extinction** will be displayed for you to fill out. If the default functions built into MODTRAN are adequate, clear the box and they will be used. Remember that these curves are normalized at 0.55 micrometers using the value for the next prompt, **Equivalent Liquid H2O Region #3**.

**Related variables**

- **Equivalent Liquid H2O Region #3**
- **Title Region #3**

Access to **User Supplied Extinction** screen (card 2D2) for this aerosol region is controlled by this input.
4.3.16.8 Equivalent Liquid H2O Region #3

**MODTRAN Variable:** AWCCON(3)  **Card:** 2D  **Input Screen:** User Supplied Aerosols

**Valid selections**
floating point value in units of km-gm/m³

**Description**
This parameter is used to convert from an equivalent liquid water content (in grams per cubic meter) to an extinction coefficient (in inverse kilometers). It is numerically equal to the equivalent liquid water content corresponding to an extinction coefficient of 1.0 km⁻¹ at a wavelength of 0.55 micrometers. It is used to normalize the aerosol extinction and absorption curves that either you input on the User Supplied Extinction screen or are provided by default at 0.55 micrometers. This input applies to the stratospheric layer (10 to 30 km) aerosol values.

This input is only used if User Input for Aerosol Region #3 is checked.

**Related variables**
User Input for Aerosol Region #3
4.3.16.9 Title Region #3

**MODTRAN Variable:** TITLE  
**Card:** 2D  
**Input Screen:** User Supplied Aerosols

**Valid selections**
string of ASCII characters up to 72 in length

**Description**
This input lets you identify your custom aerosol profile with a line of descriptive text. This title goes with the stratospheric layer profile, and is echoed back with it in the MODOUT1 output (TAPE6 file).

This input is only used if User Input for Aerosol Region #3 is checked.

**Related variables**
User Input for Aerosol Region #3
4.3.16.10 User input for Aerosol Region #4


Valid selections [check box input]
unchecked = 0 = use default values of aerosol extinction, absorption, and asymmetry for aerosols in this region
checked = 1 = input explicit values for extinction, absorption, and asymmetry

Description
This parameter selects whether you will explicitly define the aerosol extinction, absorption, and asymmetry factors, or whether you will use one of the default sets supplied in MODTRAN. Region #4 refers to the upper atmospheric (or mesospheric) layer aerosols, located between 30 and 100 km.

These aerosol parameters are used to calculate both the absorption and scattering caused by aerosols in the path. All three of these parameters are functions of wavelength. If you wish to supply your own values for these parameters, check this box, and the additional screen User Supplied Extinction will be displayed for you to fill out. If the default functions built into MODTRAN are adequate, clear the box and they will be used. Remember that these curves are normalized at 0.55 micrometers using the value for the next prompt, Equivalent Liquid H2O Region #4.

Related variables
Equivalent Liquid H2O Region #4
Title Region #4
access to User Supplied Extinction screen (card 2D2) for this aerosol region is controlled by this input
4.3.16.11 Equivalent Liquid H2O Region #4

**MODTRAN Variable:** AWCCON(4)  **Card:** 2D  **Input Screen:** User Supplied Aerosols

**Valid selections**
floating point value in units of km-gm/m³

**Description**
This parameter is used to convert from an equivalent liquid water content (in grams per cubic meter) to an extinction coefficient (in inverse kilometers). It is numerically equal to the equivalent liquid water content corresponding to an extinction coefficient of 1.0 km⁻¹ at a wavelength of 0.55 micrometers. It is used to normalize the aerosol aerosol extinction and absorption curves that either you input on the User Supplied Extinction screen or are provided by default at 0.55 micrometers. This input applies to the mesospheric layer (30 to 100 km) aerosol values.

This input is only used if User input for Aerosol Region #4 is checked.

**Related variables**
User input for Aerosol Region #4
4.3.16.12 Title Region #4

**MODTRAN Variable:** TITLE  **Card:** 2D  **Input Screen:** User Supplied Aerosols

**Valid selections**
string of ASCII characters up to 72 in length

**Description**
This input lets you identify your custom aerosol profile with a line of descriptive text. This title goes with the mesospheric layer profile, and is echoed back with it in the MODOUT1 output (TAPE6 file).

This input is only used if User input for Aerosol Region #4 is checked.

**Related variables**
User input for Aerosol Region #4
4.3.17 Screen “User Supplied Extinction” (2D2)

This screen lets you specify the aerosol properties for one of the aerosol regions selected for user defined inputs on screen 2D. One of these screens will be displayed for each region selected by checking User Input for Aerosol Region #n on screen User Supplied Aerosols. If none of the 4 regions are checked, this screen is not accessible to the user. It’s screen layout is shown below:

A slightly modified form of this screen is displayed if the User Supplied Spectra option is selected on the Aerosols card. This screen is shown on the next page. The main difference between the two is the ability to control the wavelengths at which you provide the aerosol extinction, absorption, and asymmetry parameters.
These screens are accessed by setting either Aerosol Model Used to User-Defined – VIS=23 km or Use Cloud/Rain Aerosol Extensions to User Input Cloud Ext/Abs. The second version of this screen is accessed by setting User Supplied Spectra to checked. All of these inputs are on the Aerosols screen.
4.3.17.1 Wavelength

**MODTRAN Variable:** VX  **Card:** 2D2  **Input Screen:** User Supplied Aerosol Extinction

**Valid selections**
floating point numbers that are wavelengths in micrometers

**Description**
This array of values assigns the wavelengths at which you can define the aerosol properties of extinction, absorption, and asymmetry. If you have not enabled the "USS" option (by setting the User Supplied Spectra on the Aerosols card to checked), then these wavelengths are fixed in MODTRAN and cannot be changed by the user. If the User Supplied Spectra is checked, then you can define your own wavelength grid to supply aerosol scattering parameters for. In this case, the wavelengths can be arbitrary but must be in increasing order, and in micrometers.

This card (input card 2D2) only appears when you have checked the User Input for Aerosol Region #n, where n can be 1 to 4. It is repeated for each aerosol region that you are defining.

**Related variables**
Extinction
Absorption
Asymmetry
User Supplied Spectra
4.3.17.2 Extinction

**MODTRAN Variable:** EXTC  **Card:** 2D2  **Input Screen:** User Supplied Aerosol Extinction

**Valid selections**
numeric value greater than 0

**Description**
The attenuation of radiant energy as it passes through the atmosphere is referred to as extinction. The extinction coefficient is defined in the following manner: the transmittance of a path through the atmosphere is expressed as an exponential relation:

\[ \text{transmittance} = \exp(-\sigma \times x) \]

where "\(\sigma\)" is called the extinction coefficient and "\(x\)" is the path length.

This card allows you to input your own set of aerosol extinction coefficients for whatever aerosol layer you are specifying. A list of 47 wavelengths are printed in the first column on this card. You must provide a valid extinction coefficient for each wavelength in your band of interest. Note that the larger the extinction coefficient used, the lower the path transmission at that wavelength. For example, using a 2 km path length (looking straight up through the boundary layer), an extinction coefficient of 0 yields transmission = 1; an extinction coefficient of 0.5 yields a transmission of 0.368; and an extinction coefficient of 2 yields a transmission of 0.0183.

Note that MODTRAN expects these coefficients to be normalized so that the extinction = 1.0 at 0.55 micrometers.

This card (input card 2D2) only appears when you have checked the User Input for Aerosol Region #n, where n can be 1 to 4. It is repeated for each aerosol region that you are defining.

**Related variables**
User Input for Aerosol Region #n, where n can be 1 to 4
Absorption
Asymmetry
4.3.17.3 Absorption

**MODTRAN Variable:** ABSC  **Card:** 2D2  **Input Screen:** User Supplied Aerosol Extinction

**Valid selections**
numeric value greater than 0 but that cannot be greater than the aerosol Extinction at the same wavelength

**Description**
The attenuation of radiant energy as it passes through the atmosphere is referred to as extinction. The extinction coefficient is defined in the following manner: the transmittance of a path through the atmosphere is expressed as an exponential relation:

\[
\text{transmittance} = \text{EXP}(-\sigma \times x)
\]

where "\( \sigma \)" is called the extinction coefficient and "\( x \)" is the path length. Typically several physical processes in the atmosphere cause extinction of the radiant energy. MODTRAN recognizes two processes: absorption by gaseous molecules of the atmosphere, and single scattering of energy out of the path. The aerosol Absorption coefficient is defined as a part of the extinction coefficient in the following manner: \( \sigma = \alpha + \gamma \), where \( \alpha \) is the absorption caused by the aerosols and \( \gamma \) is a scattering coefficient that expresses the scattering caused by the aerosols.

This card allows you to input your own set of aerosol absorption coefficients for the aerosol region you are specifying. A list of 47 wavelengths are printed in card 2D2 on the left hand side. You must provide a valid absorption coefficient for each wavelength in your band of interest. Note that the absorption coefficient at each wavelength cannot be greater than the extinction coefficient at that same wavelength.

This card (input card 2D2) only appears when you have checked the User Input for Aerosol Region \( #n \), where \( n \) can be 1 to 4. It is repeated for each aerosol region that you are defining.

**Related variables**
- Extinction
- User Input for Aerosol Region \( #n \), where \( n \) can be 1 to 4
4.3.17.4 Asymmetry

**MODTRAN Variable:** ASYM  **Card:** 2D2  **Input Screen:** User Supplied Aerosol Extinction

**Valid selections**
numeric values equal to or between -1 and +1

**Description**
This parameter determines the asymmetry factor to use with the Henyey-Greenstein aerosol phase function at a particular wavelength. This parameter is a measure of the asymmetry, or non-uniformity, of the angular scattering. It has a value of +1 for complete forward scattering, 0 for isentropic or symmetric scattering, and -1 for complete backscattering. Its value can range between these two extremes.

This card allows you to input your own set of aerosol asymmetry coefficients for the aerosol region you are specifying. A list of 47 wavelengths are printed in card 2D2 on the left hand side. You must provide a valid asymmetry factor for each wavelength in your band of interest. Note that the asymmetry factor can range between -1 and 1.

This card (input card 2D2) only appears when you have checked the **User Input for Aerosol Region #n**, where n can be 1 to 4. It is repeated for each aerosol region that you are defining.

**Related variables**
- Extinction
- Absorption
- User Input for Aerosol Region #n, where n can be 1 to 4
4.3.18 Screen “Geometry and Spectral Band” (3)

This screen sets the geometry of the path, as well as the spectral interval and resolution of the calculation. Access to the built-in MODTRAN slit function is also provided on this screen. Its screen layout is shown below:

![Geometry and Spectral Band Screen](image)

The items displayed below the Path Type input change, depending upon the setting of Path Type and the geometry type selected in Type of Atmospheric Path on the Model Atmosphere screen.
4.3.18.1 Path Type

**MODTRAN Variable:** None  
**Card:** 3  
**Input Screen:** Geometry and Spectral Band

**Valid selections**
if **Type of Atmospheric Path** = Slant Path:
- *Observer Height, Zenith Angle and Final Height* = two heights, and zenith at start point
- *Observer Height, Zenith Angle, Range* = height, angle, and distance
- *Observer Height, Final Height, Range* = two heights and distance between
- *Observer Height, Final Height, and Earth Center Angle* = two altitudes and earth center angle (refraction path)

- *Final Height, Observer Height, and Final Angle* = two heights, and zenith at end point
- *Final Height, Final Angle, and Range* = one height, zenith at end point, and range to observer

if **Type of Atmospheric Path** = Slant Path to Space:
- *Observer Height, Zenith Angle* = one height and zenith angle
- *Observer Height, Tangent Height* = one height and a lower tangent height of path
- *Tangent Height, Tangent Angle* = provide minimum height and zenith at that point

**Description**
This input chooses the method that you will use to set up your atmospheric geometry. The possible options depend upon the setting of **Type of Atmospheric Path**. These options simplify setting of the MODTRAN path geometry by omitting the unused prompts and implementing the rules surrounding the various ways it is possible to define a path in MODTRAN. The prompts for each option are self-explanatory, and only those inputs are displayed in the input boxes below.

For a discussion and illustration of the various path geometry definitions possible in MODTRAN, see the manual section 3.1 Path Geometry.

You can check out your current geometry setting by reviewing the schematic drawing of it on the Visual Geometry input window.

This prompt is not displayed if **Type of Atmospheric Path** is set to Horizontal Path.

**Related variables**
- **Type of Atmospheric Path**
4.3.18.2 Observer Height

**MODTRAN Variable:** \( H_1 \)  \hspace{1cm} **Card:** 3  \hspace{1cm} **Input Screen:** Geometry and Spectral Band

**Valid selections**
floating point value = or > than 0.0 in units of kilometers

**Description**
This variable defines the initial altitude, or start, of the atmospheric path. \( H_1 \) is used for all the types of path specifications possible in Type of Atmospheric Path. Note that when MODTRAN is computing radiance results (when Mode of Execution is equal to Thermal Radiance or Radiance with Scattering) the initial altitude parameter always defines the position of the observer or sensor. In Transmittance mode this parameter simply defines one end of the path.

If a Horizontal Path was selected for Type of Atmospheric Path, then this screen serves as input card 3.2H as well, and this is one of the two inputs enabled for the horizontal path specification.

For a discussion and illustration of the various path geometry definitions possible in MODTRAN, see the manual section 3.1 Path Geometry.

**Related variables**
Type of Atmospheric Path
Mode of Execution
4.3.18.3 Final Height

**MODTRAN Variable:** H2  **Card:** 3  **Input Screen:** Geometry and Spectral Band

**Valid selections**
Floating point value = or > than 0.0 in units of kilometers

**Description**
This parameter defines one of the ends of the atmospheric path being modeled. Note that when MODTRAN is computing radiance results (when **Mode of Execution** is equal to **Thermal Radiance** or **Radiance with Scattering**) the final altitude parameter always defines the part of the path furthest from the observer or sensor. In **Transmittance** mode this parameter simply defines one end of the path.

This variable is only displayed if enabled in **Path Type**.

For a discussion and illustration of the various path geometry definitions possible in MODTRAN, see the manual section 3.1 Path Geometry.

**Related variables**
- **Type of Atmospheric Path**
- **Mode of Execution**
- **Observer Height**
- **Zenith Angle**
4.3.18.4 Tangent Height

**MODTRAN Variable:** H2  Card: 3  **Input Screen:** Geometry and Spectral Band

**Valid selections**
Floating point value = or > than 0.0 in units of kilometers

**Description**
For **Type of Atmospheric Path** set to *Slant Path to Space*, this parameter is used to describe a limb viewing path, when the observer is looking close enough to the horizon so that part of the path is lower than the initial or final altitude. This input is used to define the minimum altitude of the path, which is also sometimes referred to as the 'tangent height'. The path continues on until it reaches space (which is 100 km altitude for MODTRAN).

This variable is only displayed if enabled in **Path Type**.

For a discussion and illustration of the various path geometry definitions possible in MODTRAN, see the manual **section 3.1 Path Geometry**.

**Related Variables**
- Type of Atmospheric Path
- Observer Height
4.3.18.5 Zenith Angle

**MODTRAN Variable:** ANGLE  
**Card:** 3  
**Input Screen:** Geometry and Spectral Band

**Valid selections**  
numeric value between 0 and 180 degrees

**Description**  
This parameter defines the path zenith angle at the Observer Height in degrees. Straight uplook (zenith) paths have a value of 0 degrees; paths looking to the side (horizon) have a value of 90 degrees; straight downlook paths (nadir) have an angle of 180 degrees. This variable is used for some of the path possibilities, when Type of Atmospheric Path is set to Slant Path or Slant Path to Space. For the limb viewing case, where Slant Path to Space is selected and Path Length Type is set to Long, if Tangent Height is set to 0.0, then this variable must be specified and is used to determine the minimum path tangent height.

This variable is only displayed if enabled in Path Type.

For a discussion and illustration of the various path geometry definitions possible in MODTRAN, see the manual section 3.1 Path Geometry.

**Related variables**  
Type of Atmospheric Path  
Observer Height  
Final Height  
Tangent Height  
Range  
Path Length Type  
Earth Centered Angle
4.3.18.6 Final Angle

**MODTRAN Variable:** ANGLE  **Card:** 3  **Input Screen:** Geometry and Spectral Band

**Valid selections**
numeric value between 0 and 180 degrees

**Description**
This parameter defines the path zenith angle at the endpoint away from the observer. It is an alternate way of defining a path when Type of Atmospheric Path is set to Slant Path. You must also provide the Final Height and the Range.

This variable is only displayed if enabled in Path Type.

For a discussion and illustration of the various path geometry definitions possible in MODTRAN, see the manual section 3.1 Path Geometry.

**Related variables**
Type of Atmospheric Path
Final Height
Range
4.3.18.7 Range

MODTRAN Variable: RANGE Card: 3  
Input Screen: Geometry and Spectral Band

Valid selections
numeric value > 0 in kilometers

Description
This parameter defines the atmospheric path length in kilometers. As noted in the summary of geometry options, it is only used for some of the possible path definitions. This variable is the geometrical length of the path (i.e., the straight-line distance between the endpoints of the path). The actual path length traveled by the photons in the path will be longer, because of refraction by the earth's atmosphere. For very long paths, this additional path length can be significant. The refracted path length calculated by MODTRAN is reported in the geometry summary in the MODOUt1 (TAPE6) file.

This variable is only displayed if enabled in Path Type.

For a discussion and illustration of the various path geometry definitions possible in MODTRAN, see the manual section 3.1 Path Geometry.

Related variables
Type of Atmospheric Path
Observer Height
Final Height
Zenith Angle
Earth Centered Angle
4.3.18.8 Earth Centered Angle

**MODTRAN Variable:** BETA  
**Card:** 3  
**Input Screen:** Geometry and Spectral Band

**Valid selections**
numeric value greater than 0 and physically valid (depends on the geometry) in units of degrees

**Description**
The earth center angle is defined as the angle from the center of the earth subtended by each end of the atmospheric path. This parameter is only used in one of the four ways possible to specify a *Slant Path* (for **Type of Atmospheric Path**). This method is provided in MODTRAN for cases when the geometrical configuration of the source and receiver are known accurately, but the initial zenith angle is not known precisely because of atmospheric refraction. The parameters **Zenith Angle** and **Range** should be left at 0 when using this case, because MODTRAN will calculate these values internally.

This variable is only displayed if enabled in **Path Type**. This is only true when **Path Type** = *Observer Height, Final Height, and Earth Centered Angle*.

For a discussion and illustration of the various path geometry definitions possible in MODTRAN, see the manual section 3.1 Path Geometry.

**Related variables**
Path Type
Type of Atmospheric Path
Observer Height
Final Height
Zenith Angle
Range
4.3.18.9 Radius of Earth

**MODTRAN Variable:** RO  **Card:** 3  **Input Screen:** Geometry and Spectral Band

**Valid selections**
numeric value greater than or equal to 0
if 0, default is selected using Model Atmosphere

**Description**
This parameter is the radius of the earth in kilometers at the particular latitude at which the atmospheric path calculation is being done. If this parameter is left at 0, MODTRAN uses a series of default earth radii, depending on the atmospheric model selected in Model Atmosphere. The following table lists the default earth radius for each model:

<table>
<thead>
<tr>
<th>Model</th>
<th>default earth radius (km)</th>
</tr>
</thead>
<tbody>
<tr>
<td>New Model Atmosphere</td>
<td>6371.23</td>
</tr>
<tr>
<td>Tropical Model</td>
<td>6378.39</td>
</tr>
<tr>
<td>MidLatitude Summer</td>
<td>6371.23</td>
</tr>
<tr>
<td>MidLatitude Winter</td>
<td>6371.23</td>
</tr>
<tr>
<td>SubArctic Summer</td>
<td>6356.91</td>
</tr>
<tr>
<td>SubArctic Winter</td>
<td>6356.91</td>
</tr>
<tr>
<td>1976 U S Standard</td>
<td>6371.23</td>
</tr>
<tr>
<td>Meteorologic Data Input</td>
<td>6371.23</td>
</tr>
</tbody>
</table>

Inputting a number for this parameter overrides the default value.

This variable is only displayed if enabled in Path Type. This is only true when Path Type = Observer Height, Final Height, and Earth Centered Angle.

For a discussion and illustration of the various path geometry definitions possible in MODTRAN, see the manual section 3.1 Path Geometry.

**Related variables**
Path Type
Model Atmosphere
Earth Centered Angle
4.3.18.10 Path Length Type

MODTRAN Variable: LEN Card: 3 Input Screen: Geometry and Spectral Band

Valid selections
Short = 0 = use short path (default)
Long = 1 = use long path through the tangent height

Description
For a number of downward looking slant paths defined by Observer Height, Final Height, and Zenith Angle, two atmospheric paths are possible. This duplication is best visualized by considering the earth center angle, which is the angle from the center of the earth subtended by each end of the atmospheric path. A short path exists when the final altitude endpoint of the path is also the lowest part of the path. The earth center angle for a short path is always less than 90 degrees. A long path exists when the final altitude endpoint of the path is higher than the lowest part of the atmospheric path. The earth center angle is greater than 90 degrees for a long path.

The difference between short and long paths is easier seen with a diagram. An excellent set of diagrams can be found in section 3.1 Path Geometry.

MODTRAN defaults to the short path definition when two paths are possible.

For a discussion and illustration of the various path geometry definitions possible in MODTRAN, see the manual section 3.1 Path Geometry.

Related variables
Observer Height
Final Height
Zenith Angle
Earth Centered Angle
4.3.18.11 Initial Frequency

**MODTRAN Variable:** V1  **Card:** 4  **Input Screen:** Geometry and Spectral Band

**Valid selections**
numeric value between 0 and 50000 cm\(^{-1}\) (valid range of MODTRAN)

**Description**
This parameter is the lower end (in wavenumbers) of the spectral band over which the atmospheric path transmittance and/or radiance will be calculated. The value entered here should be less than the *Final Frequency*.

Wavenumbers (cm\(^{-1}\)) are related to more commonly used units of wavelength, micrometers (or microns), by the simple relation:

\[
\text{frequency in wavenumbers} = \frac{10000}{(\text{wavelength in micrometers})}
\]

You can specify this input either in wavenumbers or in micrometers or nanometers, using the input boxes over to the right. If you specify a micrometer value, PCModWin automatically converts it into appropriate wavenumber units and displays the result.

**Related variables**
- Final Frequency
- Frequency Increment
- FWHM of Slit Function
4.3.18.12 Final Frequency

**MODTRAN Variable:** V2  **Card:** 4  **Input Screen:** Geometry and Spectral Band

**Valid selections**
numeric value between 0 and 50000 cm\(^{-1}\) (valid range of MODTRAN)

**Description**
This parameter is the upper end (in wavenumbers) of the spectral band over which the atmospheric path transmittance and/or radiance will be calculated. The value entered here should be greater than the Initial Frequency.

Wavenumbers (cm\(^{-1}\)) are related to more commonly used units of wavelength, micrometers (or microns), by the simple relation:

\[
\text{frequency in wavenumbers} = \frac{10000}{\text{wavelength in micrometers}}
\]

You can specify this input either in wavenumbers or in micrometers or nanometers, using the input boxes over to the right. If you specify a micrometer value, PCModWin automatically converts it into appropriate wavenumber units and displays the result.

**Related variables**
Initial Frequency
Frequency Increment
FWHM of Slit Function
4.3.18.13 Frequency Increment

**MODTRAN Variable:** DV  **Card:** 4  **Input Screen:** Geometry and Spectral Band

*Valid selections*
any integer greater than or equal to 1

**Description**
This parameter sets the output step size of the MODTRAN calculation within the band defined by Initial Frequency and Final Frequency. The smallest step size allowed by MODTRAN is 1 cm\(^{-1}\). This limits the effective resolution of MODTRAN to 2 cm\(^{-1}\) (half the sampling frequency). Note that DV is really the 'output step frequency' of MODTRAN, not the resolution. MODTRAN internally always makes calculations in 1 cm\(^{-1}\) bins. MODTRAN's spectral resolution is controlled by the triangular slit function that is applied to the output, the width of which is set by the input FWHM of Slit Function. For example, if you set DV to 100, and IFWHM to 2, your output table will consist of 2 cm\(^{-1}\) resolution data sampled every 100 cm\(^{-1}\). Any strong atmospheric absorption or emission that falls between the sampling channels set by DV will not be contained in your calculation.

**Related variables**
Initial Frequency
Final Frequency
FWHM of Slit Function
4.3.18.14 FWHM of Slit Function

**MODTRAN Variable:** IFWHM  **Card:** 4  **Input Screen:** Geometry and Spectral Band

**Valid selections**
Integer slit widths from 1 to 50 cm⁻¹

**Description**
This parameter sets the full width, half maximum of a triangular slit which is applied to the spectral bins to degrade the resolution. MODTRAN always makes its internal calculations at 1 cm⁻¹ resolution. This slit function will convolve a triangular function (of the full width at half maximum specified by this parameter) with the 1 cm⁻¹ calculation to arrive at any lower spectral resolution that your needs require. The minimum useful value of this function is 2 cm⁻¹, which is the limiting resolution of MODTRAN. You can set the full-width to 1 cm⁻¹, but the output may look jagged, which shows the 1 cm⁻¹ bins used internally by MODTRAN. This may be useful for diagnostic purposes. The maximum size of the slit function is 50 cm⁻¹. If you want to reduce the resolution further, you must apply the scanning function separately to your output file.

If you set **FWHM Type** to Relative %, this is then treated as a percentage instead of a wavenumber width.

This variable only applies to MODTRAN. If you select LOWTRAN from MODTRAN at the prompt **Calculation Option** at the top of the first input screen, this prompt is disabled.

**Related variables**
Initial Frequency
Final Frequency
Frequency Increment
Calculation Option
FWHM Type
4.3.18.15 Slit Function Type

**MODTRAN Variable:**  FLAGS(2:2)  **Card:**  4  **Input Screen:**  Geometry and Spectral Band

**Valid selections**

*Triangular* = apply triangular function to MODTRAN output  
*Rectangular* = apply rectangular function to MODTRAN outputs  
*Gaussian* = apply Gaussian function to MODTRAN outputs  
*Sinc* = apply sinc function to MODTRAN outputs  
*Sinc^2* = apply sinc-squared function to MODTRAN outputs  
*Hamming* = apply Hamming function to MODTRAN outputs

**Description**

This input sets the type of function that will be used for the slit function calculation in MODTRAN. A variety of spectral shapes are available. Some of the functions are more suitable for matching instrumental effects, such as slit diffraction or apodization. The functions are defined below. All built-in scanning functions are symmetrical about the central spectral wavelength (\(\delta_o = \lambda_o\)) or frequency (\(\delta_o = \nu_o\)) [the unit is specified by FLAGS (1:1)]. Let \(\Delta\) be the FWHM along the frequency-axis:

**Triangular**

\[
F_{\delta,\Delta}(\delta) = \frac{1}{\Delta} \left( 1 - \frac{|\delta - \delta_o|}{\Delta} \right) ; \quad |\delta - \delta_o| < \Delta \quad (= 0 \text{ elsewhere})
\]

**Square**

\[
F_{\delta,\Delta}(\delta) = \frac{1}{\Delta} ; \quad |\delta - \delta_o| < \frac{\Delta}{2} \quad (= 0 \text{ elsewhere})
\]

**Gaussian**

\[
F_{\delta,\Delta}(\delta) = \frac{s}{\sqrt{\pi}} e^{-\frac{(\delta - \delta_o)^2}{\Delta}} ; \quad s = \frac{2\sqrt{\ln 2}}{\Delta}
\]

**Sinc**  [ Sinc(x) \(\equiv\) sin (\(\pi x\)) / (\(\pi x\)) ]

\[
F_{\delta,\Delta}(\delta) = s \text{ Sinc}[s(\delta - \delta_o)] ; \quad s = \frac{1.2067}{\Delta}
\]

**Sinc^2**

\[
F_{\delta,\Delta}(\delta) = s \text{ Sinc}^2[s(\delta - \delta_o)] ; \quad s = \frac{0.88589}{\Delta}
\]
Hamming

\[ F_{\delta, \Delta} (\delta) = 0.230822 \, s \{ 2.33235 \, \text{Sinc}[s(\delta - \delta_o)] + \text{Sinc}[s(\delta - \delta_o) - 1] + \text{Sinc}[s(\delta - \delta_o) + 1] \} \; ; \]

\[ s = \frac{0.88589}{\Delta} \]

Related Variables

FWHM of Slit Function
4.3.18.16 FWHM Type

**MODTRAN Variable:** FLAGS(3:3)  **Card:** 4  **Input Screen:** Geometry and Spectral Band

**Valid selections**
*Absolute* = the FWHM is an absolute number
*Relative %* = the half-width is relative to the current value

**Description**
This input sets the way that MODTRAN will use the FWHM of Slit Function value. *Absolute* means that it will treat it as a value in wavenumbers that is constant for the entire spectral region. *Relative %* means that the value entered will be a relative percent; the slit function will use a full width at half-maximum of 100 * dv/v for wavenumbers, or 100 * dL/L for wavelength L.

**Related Variables**
FWHM of Slit Function
4.3.18.17 Type of Pltout Output

**MODTRAN Variable:** YFLAG  **Card:** 4  **Input Screen:** Geometry and Spectral Band

**Valid selections**

- *No plot file* = do not create output file pltout
- *Radiance* = create pltout file with radiance outputs
- *Transmittance* = create pltout file with transmission outputs

**Description**

This variable controls the creation and contents of the file "pltout". "Pltout" is a convenient file, created in the `\pcmodwin\bin` directory, that contains just two columns of numbers, which makes it very easy to import into other plotting or spreadsheet programs. If this is set to *No plot file*, then the file pltout is not created. If this is set to *Radiance*, then a two column file is created. The first column has the wavenumber or wavelength value (set in Pltout File units), and the second column has the radiances at each wavenumber or wavelength. If this is set to *Transmittance*, a similar file is created, but now the second column is populated with the total transmittance value at each wavenumber or wavelength.

**Related Variables**

- Pltout File Units
- Delimiter
4.3.18.18 Pltout File Units

**MODTRAN Variable:** XFLAG  **Card:** 4  **Input Screen:** Geometry and Spectral Band

**Valid selections**

*Wavenumber* = first column of pltout file is wavenumbers  
*Micrometers* = first column of pltout file is micrometers  
*Nanometers* = first column of pltout file is nanometers

**Description**

This sets the units used in the pltout file for wavelength or frequency. "Pltout" is a convenient file, created in the `\pcmodwin\bin` directory, that contains just two columns of numbers, which makes it very easy to import into other plotting or spreadsheet programs. If this is set to *Wavenumber*, the first column is the wavenumber, and radiances are reported as W/sr/cm²/cm⁻¹. If this is set to *Micrometers*, the first column is the micrometer, and radiances are reported as W/sr/cm²/um. The same pattern applies if it is set to *Nanometers*.

**Related Variables**

*Type of Pltout Output*
4.3.18.19 Delimiter

**MODTRAN Variable:** DLIMIT  **Card:** 4  **Input Screen:** Geometry and Spectral Band

**Valid selections**
character string up to 8 characters in length

**Description**
This input lets you specify a delimiting string up to 8 characters in length. This string is used in the output file selected by Type of Pltout Output to separate the scanned output from sequential MODTRAN runs. This can be used to rapidly search through a file and find the outputs of interest.

**Related Variables**
Type of Pltout Output
4.3.18.20 Degrade Type

**MODTRAN Variable:** FLAGS(4:4)  **Card:** 4  **Input Screen:** Geometry and Spectral Band

**Valid selections**
*Only Total Rad/Trans* = scan only total radiance and transmittance outputs  
*All Rad/Trans* = scan all components calculated by MODTRAN

**Description**
This input lets you choose which inputs will be scanned and placed into the scanning function output. Choosing *Only Total Rad/Trans* means that only the final, total path transmittance and radiance will be scanned and placed into the output file. This is useful if you are only working with the totals, and are not concerned with reduced resolution versions of the other MODTRAN outputs. *All Rad/Trans* applies the scanning function to all component outputs and reports this result to the output file.

**Related Variables**
*Type of Ploout Output*
4.3.18.21 Spectral Flux Table

**MODTRAN Variable:** FLAGS(7:7)  **Card:** 4  **Input Screen:** Geometry and Spectral Band

**Valid selections**
- Omit spectral flux table = blank = do not write a spectral flux table
- Create table, 80 chars/line = T = create file, 80 characters per line
- Create table, single line = F = create file, omit line feeds from file

**Description**
This input controls the creation of a spectral flux file during a MODTRAN solar run. The spectral flux stores the upwelling, downwelling, and direct solar flux at each wavenumber, at every atmospheric layer. The files can thus get quite large, but they provide valuable diagnostic information for understanding solar scattering results for some cases. *Omit spectral flux table* does not create this file. *Create table, 80 chars/line* creates a table that has line feeds every 80 characters and thus is more amenable to printing or screen display. *Create table, single line* creates the table and omits line feeds, which reduces the size of the file.

PcModWin provides an option to plot spectral flux files, under the menu item **Plot | Spec Flux**.

Spectral flux files can only be created when **Mode of Execution** is set to **Radiance w/ Scattering**.

**Related Variables**
**Mode of Execution**
4.3.19 Screen “Solar/Lunar Irradiance” (3A)

This screen sets the position of the sun (or moon) for the directly transmitted solar irradiance option. Access to this screen is controlled by the input Mode of Execution, which must be set to Direct Solar Irradiance for this screen to be enabled. Screens Geometry and Spectral Band and Solar/Lunar Geometry are disabled when this screen is being used. This screen is shown below:
4.3.19.1 Path Type

**MODTRAN Variable:** None   **Card:** 3A   **Input Screen:** Solar/Lunar Irradiance

**Valid selections**
Observer Height, Zenith Angle = height and zenith angle to space
Observer Height, Tangent Height = height and a path tangent height, to space

**Description**
This variable defines the type of geometry that you will use for your path. With the direct solar irradiance option, there are two possibilities. After specifying the Altitude of Observer, you can specify either a zenith angle to space (a short path) or a tangent height of the path (a long path). The setting of this variable affects what inputs are displayed for geometry on the following two prompts.

This screen is only enabled when you have selected *Direct Solar Irradiance* for **Mode of Execution**.

**Related variables**
Mode of Execution
Altitude of Observer
Apparent Solar Zenith Angle at H1
Tangent Height of Path to Sun
4.3.19.2 Altitude of Observer

**MODTRAN Variable:** H1  **Card:** 3A  **Input Screen:** Solar/Lunar Irradiance

**Valid selections**
Floating point value = or > than 0.0 in units of kilometers

**Description**
This variable defines the initial altitude, or start, of the atmospheric path. This is also the observer location that the solar irradiance will be transmitted to.

This screen is only enabled when you have selected *Direct Solar Irradiance* for **Mode of Execution**.

**Related variables**
- Mode of Execution
- Apparent Solar Zenith Angle at H1
4.3.19.3  Tangent Height of Path to Sun

**MODTRAN Variable:** H2  **Card:** 3A  **Input Screen:** Solar/Lunar Irradiance

**Valid selections**
floating point value = or > than 0.0 in units of kilometers

**Description**
This parameter is used to describe a limb viewing path, when the observer is looking close enough to the horizon so that part of the path is lower than the initial altitude. For this case this input is used to define the minimum altitude of the path, which is also sometimes referred to as the 'tangent height'. If this variable is equal to Altitude of Observer, the tangent case is not used.

This prompt is only displayed when Path Type is set to Observer Height, Tangent Height.

This screen is only enabled when Direct Solar Irradiance is selected for Mode of Execution.

**Related variables**
Altitude of Observer
Mode of Execution
Path Type
4.3.19.4 Apparent Solar Zenith Angle at H1

**MODTRAN Variable:** ANGLE     **Card:** 3A     **Input Screen:** Solar/Lunar Irradiance

**Valid selections**
numeric value between 0 and 180 degrees

**Description**
This parameter defines the apparent solar or lunar zenith angle at the Altitude of Observer. If the apparent solar zenith angle is not known for a particular case, then the solar scattering option (IEMSCT = 2) may be used along with, for instance, the observer's location, day of the year, and time of day to determine the solar zenith angle. Note that the apparent solar zenith angle is the zenith angle at H1 of the refracted path to the sun and is less than the astronomical solar zenith angle. The difference between the two angles is negligible for angles less than 80°.

This prompt is only displayed when Path Type is set to Observer Height, Zenith Angle.

This screen is only enabled when Direct Solar Irradiance is selected for Mode of Execution.

**Related variables**
Altitude of Observer
Mode of Execution
Path Type
4.3.19.5  Day of Year (1-365)

**MODTRAN Variable:** IDAY  **Card:** 3A  **Input Screen:** Solar/Lunar Irradiance

**Valid selections**
numeric value between 1 and 365

**Description**
This parameter is used to specify the day of the year for the MODTRAN calculation. The values can range from 1 (January 1) to 365 (December 31). This number is used to calculate the earth to sun distance. Small corrections are made to the magnitude of the solar source function to correct for annual variations in earth to sun distance.

This screen is only enabled when *Direct Solar Irradiance* is selected for **Mode of Execution**.

**Related variables**
**Mode of Execution**
4.3.19.6 Median Distance

**MODTRAN Variable:** IDAY  
**Card:** 3A  
**Input Screen:** Solar/Lunar Irradiance

**Valid selections** [check box input]
- unchecked = use Day of Year to calculate earth-to-sun distance
- checked = use median value distance

**Description**
This input lets you direct MODTRAN to use a single median distance for the earth-to-sun path, instead of selecting a value based on the Day of Year setting.

This screen is only enabled when Direct Solar Irradiance is selected for Mode of Execution.

**Related Variables**
- Day of Year
- Mode of Execution
4.3.19.7 Radius of Earth (km)

**MODTRAN Variable:** RO  
**Card:** 3A  
**Input Screen:** Solar/Lunar Irradiance

**Valid selections**
numeric value greater than or equal to 0
if 0, default is selected using Model Atmosphere

**Description**
This parameter is the radius of the earth in kilometers at the particular latitude at which the atmospheric path calculation is being done. If this parameter is left at 0, MODTRAN uses a series of default earth radii, depending on the atmospheric model selected in Model Atmosphere. The following table lists the default earth radius for each model:

<table>
<thead>
<tr>
<th>Model</th>
<th>default earth radius (km)</th>
</tr>
</thead>
<tbody>
<tr>
<td>New Model Atmosphere</td>
<td>6371.23</td>
</tr>
<tr>
<td>Tropical Model</td>
<td>6378.39</td>
</tr>
<tr>
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<td>6356.91</td>
</tr>
<tr>
<td>SubArctic Winter</td>
<td>6356.91</td>
</tr>
<tr>
<td>1976 U S Standard</td>
<td>6371.23</td>
</tr>
<tr>
<td>Meteorologic Data Input</td>
<td>6371.23</td>
</tr>
</tbody>
</table>

Inputting a number for this parameter overrides the default value.

This screen is only enabled when Direct Solar Irradiance is selected for Mode of Execution.

**Related variables**
Model Atmosphere
Mode of Execution
4.3.19.8 Extraterrestrial Source

**MODTRAN Variable:** ISOURC  **Card:** 3A  **Input Screen:** Solar/Lunar Irradiance

**Valid selections**
- Sun \(= 0\) = source of scattered radiance is the Sun
- Moon \(= 1\) = source of scattered radiance is the Moon

**Description**
This parameter specifies what the source of radiance for transmission through the atmospheric path is. The Moon irradiance is simply a scaled down version (by reflection off the moon's surface) of the solar source function.

This screen is only enabled when *Direct Solar Irradiance* is selected for **Mode of Execution**.

**Related variables**
- **Mode of Execution**
4.3.19.9 Moon Angle

**MODTRAN Variable:** ANGLEM   **Card:** 3A   **Input Screen:** Solar/Lunar Irradiance

**Valid selections**
numeric value between 0 and 180 degrees

**Description**
This parameter sets the phase angle of the moon, which is the angle formed by the sun, moon, and earth. Lunar radiance is modeled as a reflection of solar radiance. One term in the equation used to calculate the lunar intensity is a phase function giving the relative intensity of the lunar radiance as a function of the phase angle of the moon, as defined above.

This parameter is only used if the *Moon* is selected as the source of scattering radiance under *Extraterrestrial Source*.

This screen is only enabled when *Direct Solar Irradiance* is selected for *Mode of Execution*.

**Related variables**
*Extraterrestrial Source*  
*Mode of Execution*
4.3.19.10 Initial Frequency

**MODTRAN Variable:** V1  **Card:** 3A  **Input Screen:** Solar/Lunar Irradiance

**Valid selections**
numeric value between 0 and 50000 cm\(^{-1}\) (valid range of MODTRAN)

**Description**
This parameter is the lower end (in wavenumbers) of the spectral band over which the atmospheric path transmittance and/or radiance will be calculated. The value entered here should be less than the Final Frequency.

Wavenumbers (cm\(^{-1}\)) are related to more commonly used units of wavelength, micrometers (or microns), by the simple relation:

\[
\text{frequency in wavenumbers} = \frac{10000}{\text{wavelength in micrometers}}
\]

You can specify this input either in wavenumbers or in micrometers (or nanometers), using the input box over to the right. If you specify a micrometer value, PCModWin automatically converts it into appropriate wavenumber units and displays the result.

This screen is only enabled when Direct Solar Irradiance is selected for Mode of Execution.

**Related variables**
Final Frequency
Mode of Execution
4.3.19.11 Final Frequency

MODTRAN Variable: V2  Card: 3A  Input Screen: Solar/Lunar Irradiance

Valid selections
numeric value between 0 and 50000 cm\(^{-1}\) (valid range of MODTRAN)

Description
This parameter is the upper end (in wavenumbers) of the spectral band over which the atmospheric path transmittance and/or radiance will be calculated. The value entered here should be greater than the Initial Frequency.

Wavenumbers (cm\(^{-1}\)) are related to more commonly used units of wavelength, micrometers (or microns), by the simple relation:

\[
\text{frequency in wavenumbers} = \frac{10000}{(\text{wavelength in micrometers})}
\]

You can specify this input either in wavenumbers or in micrometers (or nanometers), using the input box over to the right. If you specify a micrometer value, PCModWin automatically converts it into appropriate wavenumber units and displays the result.

This screen is only enabled when Direct Solar Irradiance is selected for Mode of Execution.

Related variables
- Initial Frequency
- Mode of Execution
4.3.19.12 Frequency Increment

**MODTRAN Variable:** DV  **Card:** 3A  **Input Screen:** Solar/Lunar Irradiance

**Valid selections**
any integer greater than or equal to 1

**Description**
This parameter sets the output step size of the MODTRAN calculation within the band defined by Initial Frequency and Final Frequency. The smallest step size allowed by MODTRAN is 1 cm\(^{-1}\). This limits the effective resolution of MODTRAN to 2 cm\(^{-1}\) (half the sampling frequency). Note that DV is really the 'output step frequency' of MODTRAN, not the resolution. MODTRAN internally always makes calculations in 1 cm\(^{-1}\) bins. MODTRAN's spectral resolution is controlled by the triangular slit function that is applied to the output, the width of which is set by the input FWHM of Slit Function. For example, if you set DV to 100, and IFWHM to 2, your output table will consist of 2 cm\(^{-1}\) resolution data sampled every 100 cm\(^{-1}\). Any strong atmospheric absorption or emission that falls between the sampling channels set by DV will not be contained in your calculation.

This screen is only enabled when Direct Solar Irradiance is selected for Mode of Execution.

**Related variables**
Initial Frequency
Final Frequency
FWHM of Slit Function
Mode of Execution
4.3.19.13 FWHM of Slit Function

**MODTRAN Variable:** IFWHM  **Card:** 3A  **Input Screen:** Solar/Lunar Irradiance

**Valid selections**
integer slit widths from 1 to 50 cm⁻¹

**Description**
This parameter sets the full width, half maximum of a triangular slit which is applied to the spectral bins to degrade the resolution. MODTRAN always makes its internal calculations at 1 cm⁻¹ resolution. This slit function will convolve a triangular function (of the full width at half maximum specified by this parameter) with the 1 cm⁻¹ calculation to arrive at any lower spectral resolution that your needs require. The minimum useful value of this function is 2 cm⁻¹, which is the limiting resolution of MODTRAN. You can set the full-width to 1 cm⁻¹, but the output may look jagged, which shows the 1 cm⁻¹ bins used internally by MODTRAN. This may be useful for diagnostic purposes. The maximum size of the slit function is 50 cm⁻¹. If you want to reduce the resolution further, you must apply the scanning function separately to your output file.

This variable only applies to MODTRAN. If you select *LOWTRAN from MODTRAN* at the prompt *Calculation Option* at the top of the first input screen, this prompt is disabled.

This screen is only enabled when *Direct Solar Irradiance* is selected for *Mode of Execution*.

**Related variables**
- Frequency Increment
- Calculation Option
- Mode of Execution
4.3.20 Screen “Solar/Lunar Geometry” (3A1)

This screen sets the position of the sun for single scattering radiance calculations, as well as some aerosol scattering phase function options. Access to this screen is controlled by the input **Mode of Execution**, which must be set to **Radiance with Scattering** for this screen to be enabled. The screen layout of this screen is shown below:

Some of the prompts on the screen depend on the setting of the first input, **Solar/Lunar Geometry Type**. Unneeded inputs are not displayed.
4.3.20.1 Solar/Lunar Geometry Type

**MODTRAN Variable:** IPARM  \[ \text{Card: 3A1} \]  \[ \text{Input Screen: Solar/Lunar Geometry} \]

**Valid selections**
- **Obs and Source Lat/Long**  \( = 0 \) = use observer latitude/longitude and source latitude/longitude
- **Obs Lat/Long-Sun Day/Time**  \( = 1 \) = use observer latitude/longitude and day/time (solar scattering only)
- **Azimuth and Zenith Angle**  \( = 2 \) = use azimuthal angle of observer's line of sight and source zenith angle

**Description**
This parameter determines the method you will use to specify the geometry to be used for calculating single scattered radiance into the atmospheric path. If you set this to **Obs and Source Lat/Long** you must supply the following four parameters: **Observer Latitude**, **Observer Longitude**, **Sun Latitude**, and **Sun Longitude**. If you use option **Obs Lat/Long-Sun Day/Time** you must provide **Observer Latitude**, **Observer Longitude**, the **Day of Year (1-365)**, and the **Greenwich Time**. Note that this option can only be used with solar radiation and not lunar radiation. The sun/moon latitudes and longitudes are not used with this method. Option **Azimuth and Zenith Angle** requires the following two parameters: for the input labeled **Azimuthal Angle at Observer LOS to Sun** you must input the azimuthal angle between the observer's line-of-sight and the observer-to-sun path, measured from the line of sight, positive east of north, between -180 and 180 degrees. For the input labeled **Sun Zenith Angle** you must input the sun's zenith angle. Again the sun/moon latitude and longitude are not used with this option.

PcModWin displays only the prompts that are needed by the solar geometry option that you select with this option. If you have the moon chosen for **Extraterrestrial Source**, then the prompts with "sun" in them are changed to prompt for the equivalent "moon" item.

This optional screen is only enabled if you have selected **Radiance w/ Scattering** under **Mode of Execution**.

**Related variables**
- **Mode of Execution**
- **Day of Year (1-365)**
- **Greenwich Time**
- **Observer Latitude**
- **Observer Longitude**
- **Sun Latitude**
- **Sun Zenith Angle**
- **Sun Longitude**
- **Azimuthal Angle at Observer LOS to Sun**
### 4.3.20.2 Aerosol Phase Function

**MODTRAN Variable:** IPH  \hspace{1cm} **Card:** 3A1  \hspace{1cm} **Input Screen:** Solar/Lunar Geometry

**Valid selections**
- *Henyey-Greenstein* \( = 0 \) = use Henyey-Greenstein aerosol phase function
- *User Supplied* \( = 1 \) = use user supplied aerosol phase function
- *MIE Generated* \( = 2 \) = use MIE generated database of aerosol phase functions for MODTRAN

**Description**
A scattering phase function, as used in MODTRAN, expresses the differential probability of the scattered radiation going in a given angular direction. In MODTRAN the scattering caused by air molecules and aerosols is treated separately using different phase functions. Note that the phase functions are normalized so that the integral over all possible scattering directions = 1.

This parameter allows you to select which phase function should be used for aerosol scattering only. Air molecule scattering is treated using a Rayleigh phase function that is not user selectable. Three options exist for this parameter. *Henyey-Greenstein* uses a phase function of a special form (see LOWTRAN 6 manual pp. 35-36). *User Supplied* allows you to input your own phase functions for the different altitude regions. If you choose this option, an extra input screen **Phase Function** will appear that will allow you to define up to 50 angles for each of the four aerosol layers. *MIE Generated* uses the standard aerosol phase functions stored in MODTRAN corresponding to the different aerosol models available in the program. This last option is recommended by the authors of MODTRAN whenever the MODTRAN aerosol models are used for solar scattering. They are discussed in detail in Appendix D of the LOWTRAN6 manual.

This optional screen is only enabled if you have selected *Radiance w/ Scattering* under **Mode of Execution**.

**Related variables**
- **Mode of Execution**
- access to input screen **Phase Function** is controlled by this parameter
4.3.20.3 Day of Year (1-365)

MODTRAN Variable: IDAY  Card: 3A1  Input Screen: Solar/Lunar Geometry

Valid selections
numeric value between 1 and 365

Description
This parameter is used to specify the day of the year for the MODTRAN calculation. The values can range from 1 (January 1) to 365 (December 31). This number is used to calculate the earth to sun distance. In addition, if Solar/Lunar Geometry Type is set equal to Obs Lat/Long-Sun Day/Time, this day of the year is used (along with the Greenwich Time) to calculate the sun's location in the sky.

This optional screen is only enabled if you have selected Radiance w/Scattering under Mode of Execution.

Related variables
Solar/Lunar Geometry Type
Greenwich Time
Mode of Execution
4.3.20.4 Extraterrestrial Source

**MODTRAN Variable:** ISOURC  **Card:** 3A1  **Input Screen:** Solar/Lunar Geometry

**Valid selections**
- Sun = 0 = source of scattered radiance is the Sun
- Moon = 1 = source of scattered radiance is the Moon

**Description**
This parameter specifies what the source of radiance for single scattering into the atmospheric path is. Note that if you select Moon to model lunar radiance, you must use the Solar/Lunar Geometry Type of Obs and Source Lat/Long, since that is the only way provided in MODTRAN to specify lunar position.

This optional screen is only enabled if you have selected Radiance w/Scattering under Mode of Execution.

**Related variables**
- Solar/Lunar Geometry Type
- Mode of Execution
4.3.20.5 Observer Latitude

MODTRAN Variable: PARM1  Card: 3A1  Input Screen: Solar/Lunar Geometry

Valid selections
-90 to 90 degrees

Description
This is one of the four parameters used to specify the geometry for single scattering into the atmospheric path. The specific meaning of this parameter, called PARM1 in MODTRAN, depends on the value you have given to Solar/Lunar Geometry Type. If you specified Obs and Source Lat/Long or Obs Lat/Long-Sun Day/Time for the geometry type, this input is treated as the observer latitude, and can range in value from -90 to 90 degrees. Note that if the absolute value of the observer latitude is greater than 89.5 degrees, the observer is assumed to be at either the north or south pole. The Path Azimuth takes on a special meaning in this polar case.

This optional screen is only enabled if you have selected Radiance w/Scattering under Mode of Execution.

Related variables
Solar/Lunar Geometry Type
Path Azimuth
Mode of Execution
4.3.20.6 Azimuthal Angle of Observer LOS

**MODTRAN Variable:** PARM1  **Card:** 3A1  **Input Screen:** Solar/Lunar Geometry

**Valid selections**
-180 to 180 degrees

**Description**
This is one of the four parameters used to specify the geometry for single scattering into the atmospheric path. If you specified Azimuth and Zenith Angle for the Solar/Lunar Geometry Type, this input is the azimuthal angle between the observer's line-of-sight and the observer-to-sun path. This angle is measured from the line of sight and is positive east of north. It's value can range from -180 to 180 degrees.

This optional screen is only enabled if you have selected Radiance w/Scattering under Mode of Execution.

**Related variables**
Solar/Lunar Geometry Type
Mode of Execution
4.3.20.7 Observer Longitude

**MODTRAN Variable:** PARM2  **Card:** 3A1  **Input Screen:** Solar/Lunar Geometry

**Valid selections**
0 to 360 degrees

**Description**
This is one of the four parameters used to specify the geometry for single scattering into the atmospheric path. If you specified *Obs and Source Lat/Long* or *Obs Lat/Long-Sun Day/Time* for the Solar/Lunar Geometry Type, this input is the observer longitude, and can range in value from 0 to 360 degrees.

This optional screen is only enabled if you have selected *Radiance w/Scattering* under Mode of Execution.

**Related variables**
Solar/Lunar Geometry Type
Mode of Execution
4.3.20.8 Sun Zenith Angle

**MODTRAN Variable:** PARM2  **Card:** 3A1  **Input Screen:** Solar/Lunar Geometry

**Valid selections**
0 to 90 degrees

**Description**
This is one of the four parameters used to specify the geometry for single scattering into the atmospheric path. If you specified *Azimuth and Zenith Angle* for Solar/Lunar Geometry Type, this is the sun's zenith angle, and can range from 0 to 90 degrees.

This optional screen is only enabled if you have selected *Radiance w/Scattering* under Mode of Execution.

**Related Variables**
Solar/Lunar Geometry Type
Mode of Execution
**4.3.20.9 Sun/Moon Latitude**

**MODTRAN Variable:** PARM3  
**Card:** 3A1  
**Input Screen:** Solar/Lunar Geometry

**Valid selections**
-90 to 90 degrees

**Description**
This is one of the four parameters used to specify the geometry for single scattering into the atmospheric path. The specific meaning of this parameter, called PARM3 in MODTRAN, depends on the value you have given to Solar/Lunar Geometry Type. If you specified **Obs and Source Lat/Long** for the geometry type, PARM3 is treated as the scattered radiance source latitude, and can range in value from -90 to 90 degrees. The scattered radiance source is either the sun or the moon, depending on what you have selected for Extraterrestrial Source.

This optional screen is only enabled if you have selected Radiance w/Scattering under Mode of Execution.

**Related variables**
- Solar/Lunar Geometry Type
- Extraterrestrial Source
- Sun/Moon Longitude
- Mode of Execution
4.3.20.10 Sun/Moon Longitude

**MODTRAN Variable:** PARM4  **Card:** 3A1  **Input Screen:** Solar/Lunar Geometry

**Valid selections**
numeric value between 0 and 360 degrees

**Description**
This is one of the four parameters used to specify the geometry for single scattering into the atmospheric path. The specific meaning of this parameter, called PARM4 in MODTRAN, depends on the value you have given to Solar/Lunar Geometry Type. If you specified Obs and Source Lat/Long for the geometry type, PARM3 is treated as the scattered radiance source longitude, and can range in value from 0 to 360 degrees. The scattered radiance source is either the sun or the moon, depending on what you have selected for Extraterrestrial Source.

This optional screen is only enabled if you have selected Radiance w/Scattering under Mode of Execution.

**Related variables**
- Solar/Lunar Geometry Type
- Extraterrestrial Source
- Sun/Moon Latitude
- Mode of Execution
4.3.20.11 Greenwich Time

**MODTRAN Variable:** TIME  **Card:** 3A1  **Input Screen:** Solar/Lunar Geometry

**Valid selections**
numeric value between 0 and 24

**Description**
This parameter sets the Greenwich Time (or Universal Time) for the path calculation in decimal hours. For example, you would express 8:45 AM as 8.75; 5:20 PM is expressed as 17.33. This parameter is only used if the Solar/Lunar Geometry Type is set equal to Obs Lat/Long-Sun Day/Time. For this geometry definition, you must supply the observer's position in latitude and longitude, and the apparent solar zenith angle is determined using the Day of the Year and the Greenwich Time. Note that the apparent solar zenith angle is the zenith angle at the path start (Observer Height) of the refracted path of the sun and is less than the astronomical solar zenith angle.

This optional screen is only enabled if you have selected Radiance w/Scattering under Mode of Execution.

**Related variables**
Solar/Lunar Geometry Type
Day of the Year
Greenwich Time
Mode of Execution
4.3.20.12 Path Azimuth (degrees east of north)

**MODTRAN Variable:** PSIPO    **Card:** 3A1    **Input Screen:** Solar/Lunar Geometry

**Valid selections**
numeric value 0 to 360 degrees

**Description**
This parameter determines the path azimuth in units of degrees east of north. For example, using these units, due north is 0.0 degrees, and due east is 90.0 degrees. The meaning of this parameter depends on the value you have selected for Solar/Lunar Geometry Type. If the geometry type is set to Obs and Source Lat/Long or Obs Lat/Long-Sun Day/Time, this parameter is used as a path azimuth. Note that if the geometry type is Obs and Source Lat/Long and the absolute value of the Observer Latitude is greater than 89.5 degrees, the observer is assumed to be at either the north or south pole. For this special case the path azimuth is undefined, and the direction of the line of sight is instead specified as the longitude along which the path lies. For geometry type Azimuth and Zenith Angle, this parameter is not used.

This optional screen is only enabled if you have selected Radiance w/Scattering under Mode of Execution.

**Related variables**
- Solar/Lunar Geometry Type
- Observer Latitude
- Mode of Execution
4.3.20.13 Phase Angle of the Moon

**MODTRAN Variable:** ANGLEM   **Card:** 3A1   **Input Screen:** Solar/Lunar Geometry

**Valid selections**
numeric value between 0 and 180 degrees

**Description**
This parameter sets the phase angle of the moon, which is the angle formed by the sun, moon, and earth. Lunar radiance is modeled as a reflection of solar radiance. One term in the equation used to calculate the lunar intensity is a phase function giving the relative intensity of the lunar radiance as a function of the phase angle of the moon, as defined above.

This parameter is only used if the *Moon* is selected as the source of scattering radiance under **Extraterrestrial Source**.

This optional screen is only enabled if you have selected *Radiance w/Scattering* under **Mode of Execution**.

**Related variables**
**Extraterrestrial Source**
**Mode of Execution**
4.3.20.14 Asymmetry Factor

**MODTRAN Variable:** G  **Card:** 3A1  **Input Screen:** Solar/Lunar Geometry

**Valid selections**
numeric value ranging between -1 and +1

**Description**
This parameter determines the asymmetry factor to use with the Henyey-Greenstein aerosol phase function. This parameter is a measure of the asymmetry, or non-uniformity, of the angular scattering. It has a value of +1 for complete forward scattering, 0 for isentropic or symmetric scattering, and -1 for complete backscattering. Its value can range between these two extremes.

This parameter only has use when *Henyey-Greenstein* is selected as the input for *Aerosol Phase Function*.

This optional screen is only enabled if you have selected *Radiance w/Scattering* under *Mode of Execution*.

**Related variables**
*Aerosol Phase Function*  
*Mode of Execution*
4.3.21 Screen “Phase Function” (3B)

This screen provides inputs for a user defined phase function to be used for single scattering of solar/lunar radiation. Access to this screen is controlled by the input Aerosol Phase Function, which must be set to User Supplied for this screen to be enabled. The screen layout of this screen is shown below:
4.3.21.1 Number of Angles

**MODTRAN Variable:** NANGLS  **Card:** 3B1  **Input Screen:** Phase Function

**Valid selections**
number from 1 to 50

**Description**
This parameter determines the number of angles to be input for the user defined phase function. The maximum number of angles that can be defined is 50. After you input a number here, 0's will appear on the rest of this input card, indicating the angles you must supply for your phase function. A detailed description of how MODTRAN/LOWTRAN phase functions work can be found in Appendix D of the LOWTRAN 6 manual.

This input screen is only enabled if you have selected *User Defined* under Aerosol Phase Function.

**Related variables**
Aerosol Phase Function

Aerosol Phase Function
4.3.21.2 Use Wavelength Grid

**MODTRAN Variable:** NWLF  **Card:** 3B2  **Input Screen:** Phase Function

**Valid selections**
- *checked* = supply wavelength dependence of phase function for each scattering angle
- *unchecked* = no wavelength dependence in phase function

**Description**
This input allows the specification of a wavelength dependence for the user supplied aerosol phase function for each scattering angle. If it is checked, the button Phase Tables in the lower left of this input window is enabled. Clicking on it displays the Phase Function Wavelength Dependence input screen.

The number of wavelengths that will be specified for each scattering angle is set on the input to the right, Number of Wavelengths.

This input screen is only enabled if you have selected *User Defined* under Aerosol Phase Function.

**Related variables**
- Aerosol Phase Function
- Phase Tables button
- Number of Wavelengths
4.3.21.3 Number of Wavelengths

**MODTRAN Variable:** NWLF  
**Card:** 3B2  
**Input Screen:** Phase Function

**Valid selections**
integer ranging from 1 to 50

**Description**
This input sets the number of wavelengths that will be used to input the wavelength dependence for the aerosol phase function, at each scattering angle.

This input screen is only enabled if you have selected *User Defined* under Aerosol Phase Function.

**Related variables**
Aerosol Phase Function
4.3.21.4 Scattering Angle

**MODTRAN Variable:** ANGF    **Card:** 3B    **Input Screen:** Phase Function

**Valid selections**
decimal degree value from 0.0 to 180.0 degrees

**Description**
This parameter is the angle at which you will define your own aerosol phase function. The actual function value can be defined for up to all four of the aerosol types, and is defined on card 3A to the right of this parameter (in the 4 columns of 0's).

It is important to use phase functions that are normalized properly. MODTRAN expects phase functions to be normalized so that the integral over all directions (i.e., a sphere) is equal to 1. This is different than some of the conventions used in much of the other literature on aerosol phase functions. The most common alternate normalization factor is $4\pi$ (pi = 3.14159...).

This input screen is only enabled if you have selected *User Defined* under **Aerosol Phase Function**.

**Related variables**
- Number of Angles
- Aerosol Phase Function
4.3.21.5 Region 1 (0-2 km)

**MODTRAN Variable:** F(1)  
**Card:** 3B  
**Input Screen:** Phase Function

**Valid selections**
numeric value greater than or equal to 0

**Description**
This input parameter is part of an array of phase function values for each of the four aerosol types at the user supplied phase angle. This entry refers to region 1, which is the aerosols in the boundary layer (0 - 2 km).

It is important to use phase functions that are normalized properly. MODTRAN expects phase functions to be normalized so that the integral over all directions (i.e., a sphere) is equal to 1. This is different than some of the conventions used in much of the other literature on aerosol phase functions. The most common alternate normalization factor is $4\pi$ (pi = 3.14159...).

This input screen is only enabled if you have selected *User Defined* under Aerosol Phase Function.

**Related variables**
Number of Angles  
Scattering Angle  
Aerosol Phase Function
4.3.21.6 Region 2 (2-10 km)

**MODTRAN Variable:** F(2)  
**Card:** 3B  
**Input Screen:** Phase Function

**Valid selections**
numeric value greater than or equal to 0

**Description**
This input parameter is part of an array of phase function values for each of the four aerosol types at the user supplied phase angle. This entry refers to region 2, which is the aerosols in the upper troposphere (2 - 10 km).

It is important to use phase functions that are normalized properly. MODTRAN expects phase functions to be normalized so that the integral over all directions (i.e., a sphere) is equal to 1. This is different than some of the conventions used in much of the other literature on aerosol phase functions. The most common alternate normalization factor is 4*π (π = 3.14159...).

This input screen is only enabled if you have selected *User Defined* under *Aerosol Phase Function*.

**Related variables**
- Number of Angles
- Scattering Angle
- Aerosol Phase Function
4.3.21.7 Region 3 (10-30 km)

**MODTRAN Variable:** F(3)  
**Card:** 3B  
**Input Screen:** Phase Function

**Valid selections**
numeric value greater than or equal to 0

**Description**
This input parameter is part of an array of phase function values for each of the four aerosol types at the user supplied phase angle. This entry refers to region 3, which is the aerosols in the lower stratosphere (10 - 30 km).

It is important to use phase functions that are normalized properly. MODTRAN expects phase functions to be normalized so that the integral over all directions (i.e., a sphere) is equal to 1. This is different than some of the conventions used in much of the other literature on aerosol phase functions. The most common alternate normalization factor is $4\pi$ ($\pi = 3.14159...$).

This input screen is only enabled if you have selected *User Defined* under *Aerosol Phase Function*.

**Related variables**
- Number of Angles
- Scattering Angle
- Aerosol Phase Function
4.3.21.8  Region 4 (30-100 km)

**MODTRAN Variable:** F(4)  **Card:** 3B  **Input Screen:** Phase Function

**Valid selections**
numeric value greater than or equal to 0

**Description**
This input parameter is part of an array of phase function values for each of the four aerosol types at the user supplied phase angle. This entry refers to region 4, which is the aerosols in the upper atmosphere (30 - 100 km).

It is important to use phase functions that are normalized properly. MODTRAN expects phase functions to be normalized so that the integral over all directions (i.e., a sphere) is equal to 1. This is different than some of the conventions used in much of the other literature on aerosol phase functions. The most common alternate normalization factor is 4*pi (pi = 3.14159...).

This input screen is only enabled if you have selected *User Defined* under **Aerosol Phase Function**.

**Related variables**
- Number of Angles
- Scattering Angle
- Aerosol Phase Function
4.3.21.9 Phase Tables button

**MODTRAN Variable:** None  
**Card:** None  
**Input Screen:** Phase Function

**Valid selections**
clicking this button displays the Phase Tables input screen

**Description**
This button provides access to the Phase Function Wavelength Dependence screen that lets you input values for user defined aerosol phase functions at a grid of wavelengths you define. One of these tables is shown for each angle that the phase functions are being defined at.

This button is only enabled if Use Wavelength Grid is checked.

This input screen is only enabled if you have selected User Defined under Aerosol Phase Function.

**Related variables**
Aerosol Phase Function  
Use Wavelength Grid
4.3.22 Screen “Phase Function Wavelength Dependence” (3B)

This screen lets you specify a wavelength dependence for a user supplied aerosol phase function. The wavelength dependence can be independently set for each scattering angle; however, the wavelength grid and the angle grid is the same for each of the four aerosols. Furthermore, the phase function must be supplied either for all aerosols or for no aerosol. This feature was added starting in MODTRAN 4.

This screen is enabled if Use Wavelength Grid is checked on the Phase Function screen. You access this screen by clicking on the Phase Tables button at the lower left of the Phase Function screen. The scattering angle that inputs are being gathered for is shown at the top of the screen, and is selected by the input Angle Number. A separate input screen is used for every scattering angle. This implements MODTRAN cards 3C1 through 3C6. The screen layout of this screen is shown below:
4.3.22.1 Angle Number

**MODTRAN Variable:** indx into ANGF()  **Card:** 3C1  **Input Screen:** Phase Function

**Valid selections**
decimal degree value from 0 to 180 degrees

**Description**
This input selects the scattering angle for which the wavelength dependence will be input. The number of angles is specified in the Number of Angles input on the Phase Function screen. Each angle will have an entry generated in the combo input box for this variable. The actual scattering angle that this corresponds to is displayed to the right of this input.

It is important to use phase functions that are normalized properly. MODTRAN expects phase functions to be normalized so that the integral over all directions (i.e., a sphere) is equal to 1. This is different than some of the conventions used in much of the other literature on aerosol phase functions. The most common alternate normalization factor is 4*pi (pi = 3.14159...).

This screen is enabled if Use Wavelength Grid is checked on the Phase Function screen. You then access this screen by clicking on the Phase Tables button at the lower left of the Phase Function screen.

**Related variables**
Number of Angles
Use Wavelength Grid
4.3.22.2 Wavelength

**MODTRAN Variable:** WLF()  
**Card:** 3C2  
**Input Screen:** Phase Function

**Valid selections**  
Floating point number greater than 0.2 in units of micrometers

**Description**  
This input sets the wavelength at which the aerosol scattering value will be defined.

This screen is enabled if Use Wavelength Grid is checked on the Phase Function screen. You then access this screen by clicking on the Phase Tables button at the lower left of the Phase Function screen.

**Related variables**  
Use Wavelength Grid  
Phase Tables button
4.3.22.3 Region 1 (0-2 km)

**MODTRAN Variable:** F(1,I,J)  
**Card:** 3C3  
**Input Screen:** Phase Function

**Valid selections**  
numeric value greater than or equal to zero

**Description**  
This input parameter is part of an array of phase function values for each of the four aerosol types at the user supplied phase angle and wavelength. This entry refers to region 1, which traditionally is the aerosols in the boundary layer (0 - 2 km).

It is important to use phase functions that are normalized properly. MODTRAN expects phase functions to be normalized so that the integral over all directions (i.e., a sphere) is equal to 1. This is different than some of the conventions used in much of the other literature on aerosol phase functions. The most common alternate normalization factor is 4*pi (pi = 3.14159...).

This screen is enabled if Use Wavelength Grid is checked on the Phase Function screen. You then access this screen by clicking on the Phase Tables button at the lower left of the Phase Function screen.

**Related variables**  
Use Wavelength Grid  
Phase Tables button
4.3.22.4 Region 2 (2-10 km)

**MODTRAN Variable:** (F2,I,J)  
**Card:** 3C4  
**Input Screen:** Phase Function

**Valid selections**  
numeric value greater than or equal to zero

**Description**  
This input parameter is part of an array of phase function values for each of the four aerosol types at the user supplied phase angle and wavelength. This entry refers to region 2, which traditionally is the aerosols in the layer below the tropopause (2 - 10 km).

It is important to use phase functions that are normalized properly. MODTRAN expects phase functions to be normalized so that the integral over all directions (i.e., a sphere) is equal to 1. This is different than some of the conventions used in much of the other literature on aerosol phase functions. The most common alternate normalization factor is $4\pi$ ($\pi = 3.14159$...).

This screen is enabled if **Use Wavelength Grid** is *checked* on the **Phase Function** screen. You then access this screen by clicking on the **Phase Tables button** at the lower left of the **Phase Function** screen.

**Related variables**  
**Use Wavelength Grid**  
**Phase Tables button**
4.3.22.5 Region 3 (10-30 km)

**MODTRAN Variable:** \( F(3,I,J) \)  \hspace{1cm} **Card:** 3C5  \hspace{1cm} **Input Screen:** Phase Function

**Valid selections**
numeric value greater than or equal to zero

**Description**
This input parameter is part of an array of phase function values for each of the four aerosol types at the user supplied phase angle and wavelength. This entry refers to region 3, which traditionally is the aerosols in the upper stratosphere (10 - 30 km).

It is important to use phase functions that are normalized properly. MODTRAN expects phase functions to be normalized so that the integral over all directions (i.e., a sphere) is equal to 1. This is different than some of the conventions used in much of the other literature on aerosol phase functions. The most common alternate normalization factor is \( 4\pi \) (\( \pi = 3.14159... \)).

This screen is enabled if Use Wavelength Grid is checked on the Phase Function screen. You then access this screen by clicking on the Phase Tables button at the lower left of the Phase Function screen.

**Related variables**
- Use Wavelength Grid
- Phase Tables button

MODTRAN Inputs
4.3.22.6 Region 4 (30-100 km)

**MODTRAN Variable:** F(4,I,J)  
**Card:** 3C6  
**Input Screen:** Phase Function

**Valid selections**
numeric value greater than or equal to zero

**Description**
This input parameter is part of an array of phase function values for each of the four aerosol types at the user supplied phase angle and wavelength. This entry refers to region 4, which traditionally is the aerosols in the mesosphere (30 - 100 km).

It is important to use phase functions that are normalized properly. MODTRAN expects phase functions to be normalized so that the integral over all directions (i.e., a sphere) is equal to 1. This is different than some of the conventions used in much of the other literature on aerosol phase functions. The most common alternate normalization factor is $4\pi$ ($\pi = 3.14159...$).

This screen is enabled if Use Wavelength Grid is checked on the Phase Function screen. You then access this screen by clicking on the Phase Tables button at the lower left of the Phase Function screen.

**Related variables**
Use Wavelength Grid  
Phase Tables button
4.3.23 Screen “Surface Spectral Reflectance” (BRDF) (3B)

This screen provides inputs to specify the BRDF (Bidirectional Reflectance Distribution Function) properties of the surface at the start of the atmospheric path. It also supports the modeling of adjacency effects by providing the option to decouple the reflectance properties of the image-pixel surface (H2) and the ground surface used in the multiple scattering models.

This screen is only displayed if Surface Albedo Flag is set to Surface Spectral BRDF.

This screen is shown below:
4.3.23.1 Surface Temperature Type

**MODTRAN Variable:** NSURF  **Card:** 4A  **Input Screen:** Surface Reflectance (BRDF)

**Valid selections**
- Use Temp@Boundary = 1 = use same temperature for image pixel and area average
- Use Area-Average Ground Surface Temp = 2 = define separate area average temperature and reflectance

**Description**
This input supports the modeling of adjacency effects by providing the option to decouple the reflectance properties of the image-pixel surface (i.e., the surface at H2, or Final Height) and the ground surface used in the multiple scattering models. *Use Temp@Boundary* directs MODTRAN to use the reflectance properties of the image pixel for the 'area-averaged' ground surface in the multiple scattering models. If the line of sight intersects the earth, the area-averaged surface temperature is set to *Temperature at First Boundary*; otherwise, this temperature is determined from the atmospheric temperature profile.

*Use Area-Average Ground Surface Temp* defines the reflectance properties for an area-averaged ground surface that are independent of the image pixel. In this case the *Area Average Ground Surface Temp* is used to define the temperature of the surrounding surface, while the BRDF parameter inputs are repeated to get the reflectance of the surrounding area.

This input card only appears if you have selected *Surface Spectral BRDF* for the input *Surface Albedo Flag* on the *Surface Parameters at Start of Path* screen.

**Related variables**
- Surface Albedo Flag
- Temperature at First Boundary
- Area Average Ground Surface Temp
4.3.23.2 Area Average Ground Surface Temperature

**MODTRAN Variable:** AATEMP  **Card:** 4A  **Input Screen:** Surface Reflectance (BRDF)

**Valid selections**
floating point number > 0 in units of degrees Kelvin

**Description**
This input sets the average temperature of the area surrounding the image pixel at the end of the path. This allows you to model a case where the image pixel is surrounded by an extended surface with significantly different temperature and reflective properties. An example is a calibration tarp spread out on the ground and viewed from a distance. In MODTRAN, the difference will be in the multiple scattering calculations; this allows the multiple scattering contribution from the ground surface to be decoupled from the temperature and reflectance at the end of the atmospheric path.

This input is only used if **Surface Temperature Type** is set to *Use Area-Average Ground Surface Temperature*.

This input card only appears if you have selected *Surface Spectral BRDF* for the input **Surface Albedo Flag** on the **Surface Parameters at Start of Path** screen. To see any difference in the adjacency effect modeling, multiple scattering should be enabled by setting **Execute with Multiple Scattering** to either *MS on Flux at Observer* or *MS on Flux at H2*.

**Related variables**
- Surface Albedo Flag
- Surface Temperature Type
- Execute with Multiple Scattering
4.3.23.3 BRDF Parametrization Name

**MODTRAN Variable:** CBRDF  **Card:** 4B1  **Input Screen:** Surface Reflectance (BRDF)

**Valid selections**

- **Walthall = 2** = use Walthall empirical BRDF model
- **Walthall(a) = 51** = use Walthall model with analytically evaluated reflectance integrals
- **Sine-Walthall = 11** = use Sine-Walthall empirical model
- **Sine-Walthall(a) = 52** = use Sine-Walthall model with analytically evaluated reflectance integrals
- **Hapke = 4** = use Hapke semi-empirical BRDF model
- **Rahman** = use Rahman semi-empirical model
- **Roujeen** = use Roujeen semi-empirical model
- **Pinty-Verstraete** = use Pinty-Verstraete physical model
- **Ross-Li** = use Ross-Li semi-empirical model

**Description**

This input lets you select a BRDF parametrization to use for computing the reflectance of the surface at the end of the path. A variety of different models have been coded into MODTRAN. The BRDF's are numerically integrated to define surface albedo, directional (hemispheric) reflectivities and emissivities, and azimuth moments. The azimuth moments are required for interfacing to the DISORT multiple scattering routines. Negative values of the BRDF, which can result from angular extrapolation of the measurement-based parametrizations, are replaced by 0. For the simple empirical models, an option to use analytic representations of the reflectance quantities is also provided (i.e., the *Walthall(a)* and *Sine-Walthall(a)* input options).

Some of the BRDF parametrizations require one to four parameters to be specified as a function of wavelength. For those parameters, the table in the lower half of this screen is enabled. The meaning of the specific parameters changes for different BRDF formulations; these are defined in the summary of BRDF parametrizations provided here. This information is extracted from the MODTRAN 4 User's Manual.

**Walthall empirical BRDF Parametrization**

The Walthall option is defined below:

\[
\rho(\theta_v, \theta_s, \Delta \phi) = P_1 + P_2 \theta_v \theta_s \cos(\Delta \phi) + P_3 \theta_v^2 \theta_s^2 + P_4 (\theta_v^2 + \theta_s^2)
\]

where

- \( \theta_v \) is the view zenith angle from the surface to the sensor (H1);
- \( \theta_s \) is the source zenith angle at the surface; and
- \( \Delta \phi \) is the view-to-source relative azimuth angle from the surface.

The four parameters required to use this formulation are shown as P1 through P4.
**Walthall(a) empirical BRDF Parametrization**

This is the same as the previous option, except that analytically evaluated Walthall reflectance integrals are used.

**Sine-Walthall empirical BRDF Parametrization**

The Sine-Walthall option is defined as:

\[
\rho(\theta_v, \theta_s, \Delta \phi) = P_1' + P_2' \sin \theta_v \sin \theta_s \cos(\Delta \phi) + P_3' \sin^2 \theta_v \sin^2 \theta_s + P_4' \left( \sin^2 \theta_v + \sin^2 \theta_s \right)
\]

The sinusoidal Walthall form was introduced to facilitate Monte-Carlo sampling of photon trajectories. The sinusoidal Walthall parameters can be approximated from the Walthall parameters by equating zenith integrations, term-by-term. This lead to the following relationships:

\[
\begin{align*}
P_1' &= P_1' \\
P_3' &= (\pi^2 / 4 - 1)^2 P_3 \\
P_2' &= 9 \pi^2 P_2 / 64 \\
P_4' &= (\pi^2 / 4 - 1) P_4
\end{align*}
\]

The four parameters required to use this formulation are shown as P_1 through P_4.

**Sine-WaltHall(a) empirical BRDF Parametrization**

This is the same as the previous option, except that analytically evaluated sinusoidal Walthall reflectance integrals are used.

**Hapke semi-empirical BRDF Parametrization**

The Hapke option is defined as:

\[
\rho(\theta_v, \theta_s, \Delta \phi) = \frac{P_1 / 4}{\cos \theta_v + \cos \theta_s} \left\{ \left[ 1 + \frac{P_1 / P_1'}{B(\cos \phi, P_2, P_3)} \right] P_{HG}(\cos \phi, P_2) + H(\cos \theta_v, P_1) H(\cos \theta_s, P_1) - 1 \right\}
\]

where

\[
\begin{align*}
P_{HG}(\cos \phi, g) &= \frac{1 - g^2}{(1 + g^2 + 2g \cos \phi)^{3/2}} \\
B(\cos \phi, g, h) &= \frac{1 - g}{(1 + g)^2} \left[ 1 + \frac{\sqrt{(1 + \cos \phi) / (1 - \cos \phi)}}{h} \right]
\end{align*}
\]
\[ H(x, \omega) = \frac{1 + 2x}{1 + 2x \sqrt{1 - \omega}} \]

\( P_1 = \omega \) is the average single scattering albedo of the particles making up the surface.

\( P_2 = g \) is the Henyey-Greenstein asymmetry factor ranging from \(-1\) (backward scattering) to \(+1\) (forward scattering).

\( P_3 = h \) controls the width of the opposition effect (hot spot)

\( P_4 = S_H \) controls the magnitude of the opposition effect.

[Note that the atmospheric radiative transport convention for the Henyey-Greenstein variables has been adopted in these equations. The BRDF community generally represents the asymmetry factor with the symbol \( \Theta \) (instead of \( g \)) and represents the scattering angle with the symbol \( g \) (instead of \( \phi \)) – a confusing state of affairs to say the least.]

**Rahman semi-empirical BRDF Parametrization**

The Rahman option is defined as:

\[
\rho(\theta_v, \theta_s, \Delta \varphi) = P_1 [\cos \theta_v \cos \theta_s (\cos \theta_v + \cos \theta_s)]^{P_2 - 1} P_{HG}(\cos \varphi, P_2) [1 + \frac{1 - P_1}{1 + G(\theta_v, \theta_s, \Delta \varphi)}]
\]

where

\[ G(\theta_v, \theta_s, \Delta \varphi) = \sqrt{\tan^2 \theta_v + \tan^2 \theta_s - 2 \tan \theta_v \tan \theta_s \cos \Delta \varphi} \]

\( P_1 = \rho_o \geq 0 \) characterizes the reflectance of the surface cover

\( P_2 = g \) is the Henyey-Greenstein asymmetry factor ranging from \(-1\) (backward scattering) to \(+1\) (forward scattering)

\( P_3 = k \) indicates the level of anisotropy of the surface.

**Roujean semi-empirical BRDF Parametrization**

The Roujean option is defined as:

\[
\rho(\theta_v, \theta_s, \Delta \varphi) = P_1 + P_2 K_{geo}(\theta_v, \theta_s, \Delta \varphi) + \frac{4}{3\pi} P_3 K_{RT}(\theta_v, \theta_s, \Delta \varphi)
\]

where

\[
K_{geo} = \frac{(\pi - \Delta \varphi) \cos \Delta \varphi + \sin \Delta \varphi}{2\pi} \tan \theta_v \tan \theta_s - \frac{\tan \theta_v + \tan \theta_s + G(\theta_v, \theta_s, \Delta \varphi)}{\pi}
\]

\[
K_{RT} = \frac{(\pi / 2 - \phi) \cos \varphi + \sin \varphi - \pi}{\cos \theta_v + \cos \theta_s} - \frac{\pi}{4}
\]

\( P_1 = k_{Lamb} \) is the Lambertian scattering component and equal to the bidirectional reflectance for \( \theta_v = 0 \) and \( \theta_s = 0 \).

\( P_2 = k_{geo} \) is the coefficient of the geometric scattering kernel \( K_{geo} \).
$P_3 = k_{vol}$ is the coefficient for the RossThick volume scattering kernel $K_{RT}$, so called for its assumption of a dense leaf canopy.

**Pinty-Verstraete analytical BRDF Parametrization**

The Pinty-Verstraete option is defined as:

$$
\rho(\theta_v, \theta_s, \Delta \phi) = \frac{P_1}{4} \left( \frac{\cos \theta_v + \kappa_s(P_3)}{\kappa_s(P_3)} \right) \times \left\{ T(\theta_v, \theta_s, \Delta \phi, P_4) P_{HG}(\cos \phi, P_2) + H\left[ \left( \frac{\cos \theta_v}{\kappa_s(P_3)} \right) P_1 \right] H\left[ \left( \frac{\cos \theta_s}{\kappa_s(P_3)} \right) P_1 \right] - 1 \right\}
$$

where

$$
T(\theta_v, \theta_s, \Delta \phi, \chi_i, r\Lambda) = 1 + \frac{1}{1 + \left( \frac{4 - \frac{16}{3\pi}}{\kappa_s(\chi_i)} \left( \frac{G(\theta_v, \theta_s, \Delta \phi)}{r\Lambda} \right) \right)}
$$

$$
\kappa_s(\chi_i) = 1 - \Psi(\chi_i) + 1.754 \Psi(\chi_i) \cos \theta_v
$$

$$
\Psi(\chi_i) = (1.2666 + 0.66 \chi_i) \chi_i; \quad x = v \text{ or } s
$$

$P_1 = \omega$ is the average single scattering albedo of the particles making up the surface

$P_2 = g$ is the Henyey-Greenstein asymmetry factor ranging from −1 (backward scattering) to +1 (forward scattering)

$P_3 = \chi_i$ is most negative (-0.4) for an erectophile canopy (mostly vertical scatterers), 0. for a canopy with a uniform distribution (equal probability for all scatterer orientations), and most positive (0.6) for a planophile canopy (mostly horizontal scatterers); and parameter

$P_4 = r\Lambda$ is the product of $r$, the radius of the Sun flecks on the inclined scatterers, and $\Lambda$, the scatterer area density of the canopy (expressed as the scatterer surface per unit bulk area). Note that the functions describing the orientation distribution of the scatterers for the illumination and viewing angles, $\kappa_s$ and $\kappa_v$, are defined here as twice their normal value to be consistent with the definition of multiple scattering functions, $H(x, \omega)$.

**Ross-Li semi-empirical BRDF Parametrization**

The Ross-Li option is defined as:

$$
\rho(\theta_v, \theta_s, \Delta \phi) = P_1 + P_2 K_{LSR}(\theta_v, \theta_s, \Delta \phi, P_4, P_5) + P_3 K_{RT}(\theta_v, \theta_s, \Delta \phi)
$$

where
\[ K_{LSR} = \frac{1 + \sec \theta'_v \sec \theta'_s + \tan \theta'_v \tan \theta'_s \cos \Delta \varphi}{2} + \left( \frac{t - \sin t \cos t}{\pi} + 1 \right) (\sec \theta'_v + \sec \theta'_s) \]

\[ \cos^2 t = \min \left\{ \left( \frac{P_4}{\sec \theta'_v + \sec \theta'_s} \right)^2 \left[ G(\theta'_v, \theta'_s, \Delta \varphi)^2 + (\tan \theta'_v \tan \theta'_s \sin \Delta \varphi)^2 \right] , 1 \right\} \]

\[ \tan \theta'_x = P_3 \tan \theta'_s ; \quad x = v \text{ or } s \]

\[ P_1 = k_{Lamb} \] is the Lambertian scattering component and equal to the bidirectional reflectance for \( \theta_v = 0 \) and \( \theta_s = 0 \).

\[ P_2 = k_{geo} \] is the coefficient of the LiSparse-Reciprocal geometric scattering kernel \( K_{LSR} \), derived for a sparse ensemble of surface objects casting shadows on a Lambertian background.

\[ P_3 = k_{vol} \] is the coefficient for the RossThick volume scattering kernel \( K_{RT} \), so called for its assumption of a dense leaf canopy. The two constants, dimensionless crown relative height \( P_4 = h / b \) and shape \( P_5 = b / r \) parameters have been empirically obtained and should not be interpreted too literally. **The LiSparse-Reciprocal kernel has only been validated for \( h / b = 2 \) and \( b / r = 1 \). These are the recommended constant input values for parameters \( P_4 \) and \( P_5 \), and the values that will be used to invert the angular radiance data from NASA’s Moderate Resolution Imaging Spectroradiometer - MODIS (Justice et al., 1998).**

This input card only appears if you have selected *Surface Spectral BRDF* for the input *Surface Albedo Flag* on the *Surface Parameters at Start of Path* screen.

**Related variables**

*Surface Albedo Flag*
4.3.23.4 Number of BRDF Spectral Grid Points

MODTRAN Variable: NWVSRF  Card: 4B2  Input Screen: Surface Reflectance (BRDF)

Valid selections
integer ranging from 1 to 50

Description
This input sets the number of points of spectrally dependent BRDF information that will be input. The maximum number is 50. For each point, you must provide a wavelength and then the parameter values appropriate for the BRDF model selected in BRDF Parametrization Name.

This input card only appears if you have selected Surface Spectral BRDF for the input Surface Albedo Flag on the Surface Parameters at Start of Path screen.

Related variables
Surface Albedo Flag
BRDF Parametrization Name
4.3.23.5  Wavelength

**MODTRAN Variable:**  WVSURF  
**Card:**  4B3  
**Input Screen:**  Surface Reflectance (BRDF)

**Valid selections**  
floating point number greater than zero in units of micrometers

**Description**  
This input specifies the wavelength in micrometers at which the spectrally dependent BRDF parameters (columns to the right) are provided. The wavelength grid must be provided in order of increasing wavelength.

A maximum of 50 spectral points can be entered here. The number required is set in Number of BRDF Spectral Grid Points.

This input card only appears if you have selected Surface Spectral BRDF for the input Surface Albedo Flag on the Surface Parameters at Start of Path screen.

**Related variables**  
Surface Albedo Flag  
Number of BRDF Spectral Grid Points
4.3.23.6 Param 1

**MODTRAN Variable:** PARAMS(1)  
**Card:** Input Screen: Surface Reflectance (BRDF)

**Valid selections**
meaning depends on setting of BRDF Parametrization Name

**Description**
This is one of four parameters that can be specified to fully define the BRDF function being used to compute surface reflectance. The meaning of this parameter depends upon the BRDF function selected in BRDF Parametrization Name.

For Walthall, Walthall(a), Sine-Walthall, and Sine-Walthall(a), this parameter corresponds to the P1 in the equations shown on the BRDF Parametrization Name.

For Hapke, this parameter is the average single scattering albedo of the particles making up the surface.

For Rahman, this parameter characterizes the reflectance of the surface cover.

For Roujean, this parameter the Lambertian scattering component and equal to the bidirectional reflectance for $\theta_v = 0$ and $\theta_s = 0$.

For Pinty-Verstraete, this parameter is the average single scattering albedo of the particles making up the surface.

For Ross-Li, this parameter this parameter is the Lambertian scattering component and equal to the bidirectional reflectance for $\theta_v = 0$ and $\theta_s = 0$.

This input card only appears if you have selected Surface Spectral BRDF for the input Surface Albedo Flag on the Surface Parameters at Start of Path screen.

**Related variables**
Surface Albedo Flag  
BRDF Parametrization Name
4.3.23.7  Param 2

**MODTRAN Variable:** PARAMS(2)  
**Card:** Input Screen: Surface Reflectance (BRDF)

**Valid selections**  
meaning depends on setting of BRDF Parametrization Name

**Description**  
This is one of four parameters that can be specified to fully define the BRDF function being used to compute surface reflectance. The meaning of this parameter depends upon the BRDF function selected in BRDF Parametrization Name.

For Walthall, Walthall(a), Sine-Walthall, and Sine-Walthall(a), this parameter corresponds to the P2 in the equations shown on the BRDF Parametrization Name.

For Hapke, this parameter is the Henyey-Greenstein asymmetry factor. This ranges from -1 (complete back scattering) to +1 (complete forward scattering).

For Rahman, this parameter is the Henyey-Greenstein asymmetry factor. This ranges from -1 (complete back scattering) to +1 (complete forward scattering).

For Roujean, this parameter is the coefficient of the geometric scattering kernel.

For Pinty-Verstraete, this parameter is the Henyey-Greenstein asymmetry factor. This ranges from -1 (complete back scattering) to +1 (complete forward scattering).

For Ross-Li, this parameter is the coefficient of the LiSparseReciprocal geometric scattering kernel KLSR, derived for a sparse ensemble of surface objects casting shadows on a Lambertian background.

This input card only appears if you have selected Surface Spectral BRDF for the input Surface Albedo Flag on the Surface Parameters at Start of Path screen.

**Related variables**  
Surface Albedo Flag  
BRDF Parametrization Name
4.3.23.8  Param 3

**MODTRAN Variable:** PARAMS(3)  
**Card:** Input Screen: Surface Reflectance (BRDF)

**Valid selections**
meaning depends on setting of BRDF Parametrization Name

**Description**
This is one of four parameters that can be specified to fully define the BRDF function being used to compute surface reflectance. The meaning of this parameter depends upon the BRDF function selected in BRDF Parametrization Name.

For *Walthall*, *Walthall*(a), *Sine-Walthall*, and *Sine-Walthall*(a), this parameter corresponds to the P3 in the equations shown on the BRDF Parametrization Name.

For *Hapke*, this parameter controls the width of the opposition effect (hot spot).

For *Rahman*, this parameter is the level of anisotropy of the surface.

For *Roujean*, this parameter is the coefficient for the RossThick volume scattering kernel, so-called for its assumption of a dense leaf canopy.

For *Pinty-Verstraete*, this parameter is most negative (-0.4) for a canopy with mostly vertical scatterers, 0 for a canopy with a uniform distribution of vertical and horizontal scatterers, and most positive (0.6) for a canopy of mostly horizontal scatterers.

For *Ross-Li*, this parameter is the coefficient for the RossThick volume scattering kernel, so-called for its assumption of a dense leaf canopy.

This input card only appears if you have selected *Surface Spectral BRDF* for the input Surface Albedo Flag on the Surface Parameters at Start of Path screen.

**Related variables**
Surface Albedo Flag  
BRDF Parametrization Name
4.3.23.9 Param 4

**MODTRAN Variable:** PARAMS(4)  
**Card:** Input Screen: Surface Reflectance (BRDF)

**Valid selections**  
meaning depends on setting of BRDF Parametrization Name

**Description**  
This is one of four parameters that can be specified to fully define the BRDF function being used to compute surface reflectance. The meaning of this parameter depends upon the BRDF function selected in BRDF Parametrization Name.

For Walthall, Walthall(a), Sine-Walthall, and Sine-Walthall(a), this parameter corresponds to the P₄ in the equations shown on the BRDF Parametrization Name.

For Hapke, this parameter controls the magnitude of the opposition effect.

For Rahman, this parameter is not used (only 3 parameters needed).

For Roujean, this parameter is not used.

For Pinty-Verstraete, this parameter is the product of r (the radius of the sun flecks on the inclined scatterers) and delta, the scatterer density of the canopy (expressed as the scatterer surface per unit bulk area).

For Ross-Li, this parameter is not used.

This input card only appears if you have selected Surface Spectral BRDF for the input Surface Albedo Flag on the Surface Parameters at Start of Path screen.

**Related variables**  
Surface Albedo Flag  
BRDF Parametrization Name
4.3.24 Screen “Surface Spectral Reflectance” (Lambertian)

This screen is used to specify the directional reflectance properties of the surface at the start of the atmospheric path. It also supports the modeling of adjacency effects by providing the option to decouple the reflectance properties of the image-pixel surface (H2) and the ground surface used in the multiple scattering models.

This input card only appears if you have selected *Spectral Lambertian Surface* for the input [Surface Albedo Flag] on the [Surface Parameters at Start of Path] screen.

This input screen supports extensions in the modeling of the ground surface that are new starting with MODTRAN 4. These inputs correspond to the new cards 4A and 4Lx.

This screen is shown below:
4.3.24.1 Surface Temperature Type

MODTRAN Variable: NSURF  Card: 4A  Input Screen: Surface Reflectance (Lambertian)

Valid selections
Use Temp@Boundary = 1 = use same temperature for image pixel and area average
Use Area-Average Ground Surface Temp = 2 = define separate area average temperature and reflectance

Description
This input supports the modeling of adjacency effects by providing the option to decouple the reflectance properties of the image-pixel surface (i.e., the surface at H2, or Final Altitude) and the ground surface used in the multiple scattering models. Use Temp@Boundary directs MODTRAN to use the reflectance properties of the image pixel for the 'area-averaged' ground surface in the multiple scattering models. If the line of sight intersects the earth, the area-averaged surface temperature is set to Temperature at First Boundary; otherwise, this temperature is determined from the atmospheric temperature profile.

Use Area-Average Ground Surface Temp defines the reflectance properties for an area-averaged ground surface that are independent of the image pixel. In this case the Area Average Ground Surface Temp is used to define the temperature of the surrounding surface, while the BRDF parameter inputs are repeated to get the reflectance of the surrounding area.

This input card only appears if you have selected Spectral Lambertian Surface for the input Surface Albedo Flag on the Surface Parameters at Start of Path screen.

Related variables
Surface Albedo Flag
Area Average Ground Surface Temperature
4.3.24.2 Area Average Ground Surface Temp

**MODTRAN Variable:** AATEMP  **Card:** 4A  **Input Screen:** Surface Reflectance (Lambertian)

**Valid selections**  
floating point number > 0 in units of degrees Kelvin

**Description**  
This input sets the average temperature of the area surrounding the image pixel at the end of the path. This allows you to model a case where the image pixel is surrounded by an extended surface with significantly different temperature and reflective properties. An example is a calibration tarp spread out on the ground and viewed from a distance. In MODTRAN, the difference will be in the multiple scattering calculations; this allows the multiple scattering contribution from the ground surface to be decoupled from the temperature and reflectance at the end of the atmospheric path.

This input is only used if [Surface Temperature Type](#) is set to Use Area-Average Ground Surface Temperature. To see any difference in the adjacency effect modeling, multiple scattering should be enabled by setting [Execute with Multiple Scattering](#) to either MS on Flux at Observer or MS on Flux at H2.

This input card only appears if you have selected Spectral Lambertian Surface for the input [Surface Albedo Flag](#) on the Surface Parameters at Start of Path screen.

**Related variables**  
Surface Albedo Flag  
Surface Temperature Type  
Execute with Multiple Scattering
4.3.24.3 Spectral Albedo File Name

**MODTRAN Variable:** SALBFL  **Card:** 4L1  **Input Screen:** Surface Reflectance (Lambertian)

**Valid selections**
string containing valid path and filename of a file in the appropriate format

**Description**
This input lets you change the file that contains the spectral reflectance data function that will be used for the ground surface at the start of the path. The default value is "data\spec_alb.dat", which is the file provided with MODTRAN that contains a number of generic spectral reflectance functions. You can specify a different file either by typing the path and filename in directly, or using the Browse button to the right of this input to navigate to an appropriate file. You must choose a file in a format compatible with MODTRAN, or an error will result when your model calculation is run. The actual albedo function used is set in Spectral Albedo Function Name or Function Number.

Note that the file format for MODTRAN 4 has been changed from the format used for the "refbkg" file supplied with earlier versions of MODTRAN (3.5 and 3.7). The data provided in those files has been placed into the spec_alb.dat file provided with MODTRAN 4.

This input card only appears if you have selected Spectral Lambertian Surface for the input Surface Albedo Flag on the Surface Parameters at Start of Path screen.

**Related variables**
Surface Albedo Flag  
Spectral Albedo Function Name  
Function Number
4.3.24.4 Spectral Albedo Function Name

**MODTRAN Variable:** CSALB  **Card:** 4L2  **Input Screen:** Surface Reflectance (Lambertian)

**Valid selections**
Text name of function contained in current spectral albedo file

**Description**
This selects one of the spectral reflectance functions in the current reflectance file by name. The name must match one contained in the current file. The current file is set in the input Spectral Albedo File Name. You can either use the name of the function, or specify the function number in the input Function Number. The names or numbers of reflectance functions in this file can be determined by viewing the file with a text editor.

Note that the file format for MODTRAN 4 has been changed from the format used for the "refbkg" file supplied with earlier versions of MODTRAN (3.5 and 3.7). The data provided in those files has been placed into the spec_alb.dat file provided with MODTRAN 4.

This input card only appears if you have selected Spectral Lambertian Surface for the input Surface Albedo Flag on the Surface Parameters at Start of Path screen.

**Related variables**
Surface Albedo Flag
Spectral Albedo File Name
Function Number
4.3.24.5 Function Number

**MODTRAN Variable:** CSALB  **Card:** 4L2  **Input Screen:** Surface Reflectance (Lambertian)

**Valid selections**
number of function contained in current spectral albedo file

**Description**
This selects one of the spectral reflectance functions in the current reflectance file by name. The number must match one contained in the current file. The current file is set in the input Spectral Albedo File Name. You can either use the number of the function, or specify the function name in the input Spectral Albedo Function Name. The names or numbers of reflectance functions in this file can be determined by viewing the file with a text editor.

Note that the file format for MODTRAN 4 has been changed from the format used for the "refbkg" file supplied with earlier versions of MODTRAN (3.5 and 3.7). The data provided in those files has been placed into the spec_alb.dat file provided with MODTRAN 4.

This input card only appears if you have selected Spectral Lambertian Surface for the input Spectral Albedo Flag on the Surface Parameters at Start of Path screen.

**Related variables**
Surface Albedo Flag
Spectral Albedo File Name
4.4 Plotting Inputs

In addition to supporting MODTRAN model inputs, PcModWin also provides an extensive range of plotting options, to allow graphical display of the model outputs. You can configure a plot prior to a run, or edit a plot once it is displayed. PcModWin also lets you plot either multiple MODTRAN runs on the same plot, or the difference of two runs. These options are accessible from the PcModWin menus and have been described in chapter 2.

PcModWin plotting inputs can be accessed either from the MODTRAN inputs menu (the Plot Cards menu entry at the bottom of the list), or via the Plot menu options. The inputs are displayed on a single screen, with plotting components on the left, and plot configuration on the right. There are 4 general types of plot input screens, which are selected by the type of MODTRAN calculation that is made (controlled by the Mode of Execution input on the Model Atmosphere screen):

- Transmittance only calculation
- Thermal Radiance only (which includes the total transmission)
- Radiance with Scattering
- Direct Solar Irradiance

Each of these MODTRAN runs creates a different set of outputs. In Transmittance mode, the transmittance due to each component of the atmosphere (each molecule, aerosols, etc) is separately output, as well as the total path transmittance. This provides valuable insights into which components are playing an important role in the path transmittance. For the other three modes, only the total transmittance is output. The PcModWin plotting software adapts the available inputs so that you can fully access any of the important MODTRAN spectral outputs from any of these runs.
The plot input screen for a *Transmittance* calculation is shown below:

Because of the large number of transmittance outputs, there is a second screen, accessed by the More button near the bottom left of this screen. If you click the More button, the left side of the window changes, showing the additional outputs that can be plotted:
The plot input screen for a *Thermal Radiance* calculation is shown below:
The plot input screen for a *Radiance with Scattering* calculation is next:

![Plot Input Screen](image)

**Title**: TEST CASE #1

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Plot Type</th>
<th>Auto Scale</th>
<th>X Axis Type</th>
<th>Min X</th>
<th>Max X</th>
<th>Min Y</th>
<th>Max Y</th>
<th>X Height</th>
<th>Y Height</th>
<th>X Divisons</th>
<th>Y Divisions</th>
<th>X Decimal</th>
<th>Y Decimal</th>
<th>Grid</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trans Total</td>
<td>Not Plotted</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Path Thermal Radiance</td>
<td>Not Plotted</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Thermal Scat</td>
<td>Not Plotted</td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Surface Emission Radiance</td>
<td>Not Plotted</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Solar Scatter Radiance</td>
<td>Not Plotted</td>
<td></td>
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<tr>
<td>Single Scatter Radiance</td>
<td>Dashed</td>
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<td></td>
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</tr>
<tr>
<td>Total Ground Reflected Radian</td>
<td>Not Plotted</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Direct Ground Reflected Radiance</td>
<td>Not Plotted</td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Total Radiance</td>
<td>Solid</td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Reflected Solar</td>
<td>Not Plotted</td>
<td></td>
<td></td>
<td></td>
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<td></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Solar at Observer</td>
<td>Not Plotted</td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Optical Depth</td>
<td>Not Plotted</td>
<td></td>
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<td></td>
</tr>
</tbody>
</table>

**Options**:

- **Ok**: Finish and close the window.
- **Cancel**: Close the window without saving changes.
- **Next**: Proceed to the next screen.
- **Prev**: Return to the previous screen.
The plot inputs screen for a *Direct Solar Irradiance* calculation is shown below:
4.4.1 Plot Inputs

This section discusses the common plotting inputs displayed along the right of each plot screen. These input control the details of the plot such as the axes, tic marks, size, etc.

4.4.1.1 Title

Valid selections: ASCII string up to 72 characters in length

Description: This variable lets you place an ASCII title along the top of the plot.
4.4.1.2 Autoscale

**Valid selections:** [check box]  
*unchecked* = manually specify X and Y axis minimum and maximum values  
*checked* = automatically set X and Y axis endpoints, based on values of data

**Screen:** Plot Input Card

**Description:**  
This option allows the X and Y axis minimum and maximum values to be automatically determined from the actual data selected for plotting. This is a convenience if you have just made a calculation and do not know the full range of values that resulted from it. It is also handy for plotting previously calculated files, without having to first look in the file with a text editor and manually note the data range.

This option is enabled by checking this box. Once it is checked, the **Min X**, **Max X**, **Min Y**, and **Max Y** inputs are not used.

**Related variables:**  
Min X  
Max X  
Min Y  
Max Y
4.4.1.3 X Axis Type

**Valid selections:**
- *Wave Number*: plot lower X axis in wavenumbers (1/cm)
- *Microns*: plot lower X axis in micrometers

**Description:**
This selects the type of X axis that will be displayed along the bottom of the plot. You can plot results vs *Wave Number* (inverse centimeters), which is the normal unit that MODTRAN works in, or against *Microns*, a more commonly used unit for plotting. The opposite unit will be displayed along the upper X axis for reference.

If you are plotting radiance results, the results will be displayed using the units of the lower X axis. Thus if *Wave Number* is selected, the radiances plotted will be in units of watts.cm$^{-2}$.sr$^{-1}$ per wavenumber; if *Microns* is selected, the radiances will be plotted in units of watts.cm$^{-2}$.sr$^{-1}$ per micrometer.

Note that when you switch between micrometers and wavenumbers, the values of the *Min X* and *Max X* inputs are not automatically converted from one unit into another. It is up to you to adjust those values to be appropriate to the new units. For example, if you are plotting data between 9 and 10 micrometers, and then switch to wavenumber units, your plot will now want to run between 9 and 10 wavenumbers, which will likely result in an empty plot. You would have to change the plotting range to cover 1000 to 1111, to see the same region. The conversion between micrometers and wavenumbers is:

wavenumbers = 10000/micrometers

**Related variables:**
- *Min X*
- *Max X*
4.4.1.4 Y Axis Type

**Valid selections:**

*Linear* = use linear scale for Y axis

*Log* = use logarithmic scale for Y axis

**Screen:** [Plot Input Card](#)

**Description:**

This plotting option lets you span a very wide range of Y axis values in a single plot through logarithmic scaling. Selecting *Linear* gives a linear Y scale, while selecting *Log* gives a logarithmic scale. With a logarithmic scale, you lose some control over tic spacing and labeling; defaults are used that cannot be changed by the user.
4.4.1.5 Min X

**Valid selections:** Screen: Plot Input Card
floating point number >= 0 in units selected by X Axis Type

**Description:**
This sets the X value used for the left side of the lower X axis of the plot. The units of this input are either micrometers or wavenumbers, depending upon the setting of X Axis Type.

Note that when X Axis Type is changed, the value of this input is not converted from one unit to another. It remains unchanged, and it is up to you to input appropriate values.

**Related variables:**
X Axis Type

4.4.1.6 Max X

**Valid selections:** Screen: Plot Input Card
floating point number >= 0 in units selected by X Axis Type

**Description:**
This sets the X value used for the right side of the lower X axis of the plot. The units of this input are either micrometers or wavenumbers, depending upon the setting of X Axis Type.

Note that when X Axis Type is changed, the value of this input is not converted from one unit to another. It remains unchanged, and it is up to you to input appropriate values.

**Related variables:**
X Axis Type
4.4.1.7 Min Y

**Valid selections:** Screen: Plot Input Card
floating point number in units of the plot component selected

**Description:**
This input sets the minimum value of the Y axis for plotting. The units of this input depend upon the units of the component you have selected for plotting. If you are plotting a transmission result, the values can range from 0 to 1. You can also plot either radiance or irradiance results; these values can range in magnitude from 0 to just about any number.

If you are not sure what the appropriate values for the plot axes are, make an initial plot with the Auto Scale box checked. This directs PcModWin to determine min and max values for both axes from the selected data. You can always then redo the plot (using the Plot | Interactive menu option) with axes settings more appropriate to your requirements.

4.4.1.8 Max Y

**Valid selections:** Screen: Plot Input Card
floating point number in units of the plot component selected

**Description:**
This input sets the maximum value of the Y axis for plotting. The units of this input depend upon the units of the component you have selected for plotting. If you are plotting a transmission result, the values can range from 0 to 1. You can also plot either radiance or irradiance results; these values can range in magnitude from 0 to just about any number.

If you are not sure what the appropriate values for the plot axes are, make an initial plot with the Auto Scale box checked. This directs PcModWin to determine min and max values for both axes from the selected data. You can always then redo the plot (using the Plot | Interactive menu option) with axes settings more appropriate to your requirements.
4.4.1.9 X Height

**Valid selections:**
floating point number greater than 0 in inches

**Screen:** Plot Input Card

**Description:**
This sets the width of the plot, nominally in inches. However, not all print devices or recipients of the clipboard map these measurements exactly back into the inches you specify. Thus you can consider this number to be more of a relative measure than an absolute one. Its size relative to Y Height sets the aspect ratio of the plot.

Larger values of this parameter result in wider plots. Note that you may have to expand the size of the plotting window in order to see the entire plot.

**Related variables**
Y Height

4.4.1.10 Y Height

**Valid selections:**
floating point number greater than 0 in inches

**Screen:** Plot Input Card

**Description:**
This sets the height of the plot, nominally in inches. However, not all print devices or recipients of the clipboard map these measurements exactly back into the inches you specify. Thus you can consider this number to be more of a relative measure than an absolute one. Its size relative to X Height sets the aspect ratio of the plot.

Larger values of this parameter result in taller plots. Note that you may have to expand the size of the plotting window in order to see the entire plot.

**Related variables**
X Height
4.4.1.11 X Divisions

**Valid selections:** Screen: Plot Input Card
integer greater than 0

**Description:**
This input sets the number of labeled major divisions along the X axis. The major tic at the right side (maximum) of the X axis is included in this count (but the initial tic at the left is not).

You want to choose a number for this that results in clean, easy to read axes. To help achieve this, you can adjust the **Min X** and **Max X** to values larger than the calculation so that clean axes result. For example, if you have just completed a calculation between 2250 and 2450 wavenumbers, if you set the X axes endpoint to the start and stop of this calculation, setting **X Divisions** to 4 results in a major tic every 50 wavenumbers. You could also set the axis endpoints beyond the data, to run from 2000 to 2500 wavenumbers, and then set this input to 5 to result in a major tic every 100 wavenumbers.

**Related variables**
Min X
Max X

4.4.1.12 Y Divisions

**Valid selections:** Screen: Plot Input Card
integer greater than 0

**Description:**
This input sets the number of labeled major divisions along the Y axis. The major tic at the top (maximum) of the Y axis is included in this count (but the initial tic at the bottom is not).

You want to choose a number for this that results in clean, easy to read axes. To help achieve this, you can adjust the **Min Y** and **Max Y** to values larger than the calculation so that clean axes result. For example, if you have just completed a transmission calculation that ranges from 0.22 to 0.68, you can set the Y axes endpoints to 0.2 and 0.7, and then set this input to 5 for a clean major tic every 0.1 variation in transmission. wavenumbers.

**Related variables**
Min Y
Max Y
4.4.1.13 X Decimal

**Valid selections:** integer equal to or greater than 0

**Screen:** Plot Input Card

**Description:**
This input sets the number of digits that will be displayed to the right of the decimal point for labels of major tics on the X axis. Setting this input to 0 results in omission of the decimal point.

4.4.1.14 Y Decimal

**Valid selections:** integer equal to or greater than 0

**Screen:** Plot Input Card

**Description:**
This input sets the number of digits that will be displayed to the right of the decimal point for labels of major tics on the Y axis. Setting this input to 0 results in omission of the decimal point.

4.4.1.15 Grid

**Valid selections:** [check box input]

unchecked = omit grid from plot
checked = add major tic grid to plot

**Screen:** Plot Input Card

**Description:**
This input lets you connect the major tics of the X and Y axis with a grid of lines. Adding a grid can assist in reading specific values off the middle of a plot.
5 MODTRAN Outputs

MODTRAN is run from the Run Model | Run MODTRAN item on the main PCModWin menu. It reads the ASCII file MODIN (which is a TAPE5 file) and produces a number of output files:

**MODOUT1 or TAPE6** - This file is equivalent to the one described in the standard LOWTRAN/MODTRAN documentation. This file describes in detail the modeling calculations and documents the atmospheric profiles and geometry used in the modeling run. The model results, as a function of wavenumber, are then presented as lists of ASCII numbers in tabular form.

**MODOUT2 or Tape7** - This file echoes back the model inputs and then simply provides the final model calculations as a single table.

**MODOUT3 or Tape8** - (if enabled by the user) This file contains additional model results if it has been turned on (on screen Model Atmosphere). In transmittance mode, the transmittance of each molecule is shown. In radiance mode, it will contain either the differential transmittance results and radiance calculations for each layer, or the solar and thermal fluxes by layer.

The MODOUT1 or tape6 file (equivalent to the TAPE6 file referred to in the MODTRAN documentation) contains a large amount of information concerning each run that MODTRAN computes. This information is useful for a variety of purposes, ranging from diagnostic examination of why a particular case went wrong to understanding the assumptions that MODTRAN 7 makes as it calculates the properties of the atmospheric path. This chapter describes some of the outputs contained in the output file. A sample output file can be generated by running any of the input cases supplied with PCModWin. This file is an ASCII file, so it can easily be printed on a line printer that is capable of 132 column printing (which means you may need to enable a compressed font before printing one of these files on an 80 column printer).

**Echo back model inputs**

The first item in an output file is an echo of the inputs that were used to generate the calculation. This echo follows the input format rules defined in the section above. If you used PcModWin to generate your input case, this echo will show the inputs that it generated. If you input your own model atmosphere, or used one of the cloud models, all of the layer inputs will be echoed here as well. The inputs are described in some detail immediately after the input. For example, if multiple scattering is enabled, a test message appears "CALCULATIONS WILL BE DONE USING MULTIPLE SCATTERING". The atmospheric and aerosol models are described by their names. The geometry, scattering information (if any), and the frequency band are then shown. This second description helps those who are not completely familiar with the input values used in MODTRAN.
Atmospheric Profile tables

Next in the MODOUT1 file (TAPE6) is a series of tables showing the atmospheric profiles used in the model calculation. In general, three tables will be generated. The first shows the pressure, temperature, and absorber densities at each layer in the model atmosphere that you either selected or input. The following definitions of column headers may assist in sorting out the table:

<table>
<thead>
<tr>
<th>Column</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>layer number</td>
</tr>
<tr>
<td>Z</td>
<td>altitude of the layer base in kilometers</td>
</tr>
<tr>
<td>P</td>
<td>average pressure of the layer in millibars</td>
</tr>
<tr>
<td>T</td>
<td>temperature of the layer in degrees Kelvin</td>
</tr>
<tr>
<td>N2</td>
<td>nitrogen density for the layer (in scaled LOWTRAN units). This density is used to calculate the nitrogen continuum contributions.</td>
</tr>
<tr>
<td>CNTMSLF</td>
<td>this is the self-broadened water vapor continuum density factor</td>
</tr>
<tr>
<td>MOL SCAT</td>
<td>this is the total air density relative to 1013.25 millibars and 273.15 Kelvin. This number is used to calculate molecular scattering contributions.</td>
</tr>
<tr>
<td>N-1</td>
<td>this is the index of refraction - 1</td>
</tr>
<tr>
<td>O3(UV)</td>
<td>this is the actual density used for the ultraviolet ozone</td>
</tr>
<tr>
<td>O2(UV)</td>
<td>this is the actual density used for the ultraviolet oxygen</td>
</tr>
</tbody>
</table>

The second table contains additional information about each layer in the model atmosphere. The following definitions explain the table entries.

<table>
<thead>
<tr>
<th>Column</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>layer number</td>
</tr>
<tr>
<td>Z</td>
<td>altitude of the layer base in kilometers</td>
</tr>
<tr>
<td>P</td>
<td>average pressure of the layer in millibars</td>
</tr>
<tr>
<td>T</td>
<td>temperature of the layer in degrees Kelvin</td>
</tr>
<tr>
<td>CNTMFRN</td>
<td>the foreign-broadened water vapor continuum density factor</td>
</tr>
<tr>
<td>HNO3</td>
<td>the nitric acid density factor</td>
</tr>
</tbody>
</table>

AEROSOL 1 through AEROSOL 4 this presents the aerosol scaling factors (i.e., the densities in scaled LOWTRAN units) for each of the four regions of aerosol effects: the boundary layer (0 - 2 km), the tropospheric layer (2 - 10 km), the stratospheric layer (10 - 30 km), and the upper atmospheric layer (30 - 100 km). Note that the scaling factors are 0 for altitude regions outside of their valid range.

AER1*RH this is the log weighted relative humidity weighted by the boundary layer aerosol.

CIRRUS this is the cirrus cloud density profile in km$^{-1}$. If you have not selected one of the cirrus models, or put in your own, this variable is 0 everywhere.
RH  this is the path averaged relative humidity

In MODTRAN 3.7 and higher, two additional columns have been added: WAT DROP and ICE PART. These two columns show the column density for each layer of the water droplet and ice particle species that you have defined for any cloud in the layer, using the new MODTRAN 3.7 aerosol inputs. If you have not defined any cloud, these values are reported as 0’s.

The third table of the atmospheric profiles contains the column density of each molecular species that has a band model in MODTRAN.

I  layer number
Z  altitude of the layer base in kilometers
P  average pressure of the layer in millibars
T  temperature of the layer in degrees Kelvin
H2O  water density for the layer (in grams per square centimeter per kilometer)
O3  ozone density for the layer
CO2  carbon dioxide density for the layer
CO  carbon monoxide density for the layer
CH4  methane density for the layer
N20  nitrous oxide density for the layer
O2  oxygen density for the layer
NH3  ammonia density for the layer
NO  nitric oxide density for the layer
NO2  nitrogen dioxide density for the layer
SO2  sulfur dioxide density for the layer
HNO3  nitric acid density for the layer

The table then repeats with the column density of all the cross-section molecules’ column density for each layer.

**Slant Path Parameters in Standard Form**

This table contains the information used to calculate the geometry of the path being modeled. Some of the parameters are simply repeated from the input, while others have been calculated from them. The parameters are

H1  initial altitude of the path
H2  final altitude (or tangent height, depending upon geometry being used)
ANGLE  zenith angle for the calculation
PHI  the arrival angle at H2
HMIN  the altitude of the lowest point along the path
LEN  a flag that has the value of 1 if the path goes through a tangent height or 0 if it does not
Calculation of the Refracted Path through the Atmosphere

This table is a layer-by-layer description of the path through the atmosphere. It always starts at the lowest point on the path (given by HMIN shown in the previous table) and proceeds upwards in altitude. The title of this table has been changed in MODTRAN 3.7 and higher to use more descriptive titles. The table items are:

- **I**: layer number
- **Altitude**: the boundaries of the layer in kilometers
- **From/To**:
- **THETA**: zenith angle at the bottom of the layer
- **DRANGE**: curved path length through the layer
- **RANGE**: cumulative path length from HMIN to current layer
- **DBETA**: earth centered angle between the BETA angle for the path and local layer BETA angle
- **BETA**: path BETA angle
- **PHI**: arrival angle at the top of the layer
- **DBEND**: bending of the path within the layer
- **BENDING**: cumulative bending along the path (from HMIN to current layer)
- **PBAR**: average pressure of the layer in millibars
- **TBAR**: average temperature of the layer in degrees Kelvin
- **RHOBAR**: average total air density in grams per cubic centimeter

The new titles used in MODTRAN 3.7 are:

- **START ALTITUDE**: Altitude
- **END ALTITUDE**: Altitude
- **START TO END ZENITH**: THETA
- **DELTA RANGE**: DRANGE
- **TOTAL RANGE**: RANGE
- **DELTA EARTH ANGLE**: DBETA
- **EARTH CENTER ANGLE**: BETA
- **END TO START ZENITH**: PHI
- **DELTA BENDING**: DBEND
- **PATH BENDING**: BENDING
- **LAYER AVERAGE PRESSURE**: PBAR
- **LAYER AVERAGE TEMPERATURE**: TBAR
- **LAYER AVERAGE DENSITY**: RHOBAR
Layer Absorber Amounts for the Path Segment Ending at Z

This table shows the cumulative absorber amounts for each of the species in the atmospheric profile table from the observer to the different layer boundaries. This is different from the earlier profile table, because here the integrated absorber amount along the path is reported as the path goes through the layers. This table is split into three parts, because of the quantity of information that must be repeated. Most of the headings of these tables are equivalent to those defined earlier in the Atmospheric Profile Tables. One minor change are the columns CNTMSLF1 and CNTMSLF2, which present the self-broadened water vapor amount and the temperature correction factor. This table used to be called Cumulative Absorber Amounts for the Path from H1 to Z.

Summary of the Geometry Calculation

This small table resummarizes the geometry calculation after corrections for path bending caused by refraction. The additional items added to this summary are RANGE, which is the refracted path length, BETA, and BENDING.

Total Column Absorber Amounts for the Line-of-Sight Path

This table presents the total amounts for the entire path of each of the components that have been shown in the previous two sets of atmospheric profiles. The only item that is not for the entire path is the MEAN RH (mean relative humidity), which is the value for the boundary layer only. This table used to be titled Equivalent Sea Level Total Absorber Amounts.

Single Scattering Point to Source Paths

This table only appears if you are running in the Radiance with Scattering mode. It basically presents the path scattering geometry from each scattering point (one per atmospheric layer). The following definitions apply to this table:

SCTTR POINT layer number for scattering
SCTTR ALT altitude of layer that is scattering
SUBLTENDED the earth centered angle between the observer at H1 (theANGLE initial path altitude) and the scattering point
SOLAR ZENITH the astronomical or unrefracted zenith angle to the sun.

Note that if the refractive bending for the path to the sun is calculated to be greater than 0.1 degrees, then the solar zenith angle is corrected by the bending and the path is calculated again (up to four times) until the correction for refraction is less than 0.1 degrees.

PATH ZENITH layer path zenith angle
RELATIVE relative path azimuth in layer
AZIMUTH
SCTTR ANGLE  this is the scattering angle for this point (layer). A message will be printed if any scattering point is in the shade
MOLECULAR PHASE F  molecular phase function used for the calculation

At this point, the tables listed above will be repeated for the actual path being used in the calculation.

Results of the calculation

All MODTRAN outputs, with the exception of the direct solar irradiance option, are reported in terms of radiance, with units of watts per square centimeter per steradian per band. Two units of band interval are available: per wavenumber (frequency, or inverse centimeters) and per wavelength (in micrometers). Most radiance items are reported in terms of both of these intervals.

Radiance outputs

The radiance reported in this table is usually broken down by its source, which allows the model user to determine the relative importance of each component in the calculation. Note that if you do not use the scattering options in MODTRAN, some of these columns will be omitted.

Path Thermal:  radiance emitted by the atmosphere in the path. This will include the boundary emission, if you used TPTEMP and SURREF on input screen Surface at Start of Path. If multiple scattering is enabled, this will also include thermal radiation scattered by the atmosphere or reflected by the ground. The component used to be called Atmospheric Radiance.

Single Scatter:  this is the solar radiation scattered by the atmosphere. The single scattered component of this is shown separately under the heading S SCAT, and is reported per wavenumber only. This column used to be called Path Scattered Radiance.

Surface Emission:  this is the radiance emitted from the surface of specified temperature and albedo (emissivity).

Ground reflected radiance:  this is the solar radiance reflected by the ground. A separate component is shown here, called Direct, which is the solar radiation scattered within the atmosphere before reaching the ground.

Total radiance:  this is simply the sum of the three components of the radiance at the observer

Integral:  this is the integrated radiance from the initial frequency of the calculation to the current frequency.

Transmittance:  this is the total transmittance for the interval over the entire path.
At the end of the output table, some additional useful numbers are shown: the integrated absorption over the band, the average transmittance over the band, the integrated radiance, and the minimum and maximum values of the radiance in the band.

If MODTRAN is run in the radiance mode, only a single radiance, called ATMOS RADIANCE will be reported as the final output. This is true even if the multiple scattering option is enabled (i.e., the multiple scattering contributions are not reported separately).

**Transmitted Solar Irradiance**

In this mode, for each wavenumber MODTRAN returns the transmitted irradiance (both per micrometer and per wavenumber), the source solar irradiance, a running integral of both the transmitted and the top of the atmosphere solar irradiance, and the total path transmission.

**Transmittance outputs**

As in the radiance mode, the first two columns in the output section of transmittance runs are the wavenumber and wavelength at each interval (the spacing between these is set by the DV parameter, frequency increment, found at the bottom of inputs). Next the total transmittance over the entire path for the current spectral interval is reported. Then the transmission of each individual component over the entire path for the spectral band is shown. AER-HYD trans AER-HYD ABS Finally, the integrated absorption over the spectral band is reported in the rightmost column of the table.
6 PcModWin Scanning Function

PCModWin provides a scanning function that reduces the spectral resolution of a MODTRAN calculation by convolving a slit function with the MODTRAN calculated outputs. This is different from changing the Frequency Increment on input screen Geometry and Spectral Band. There the frequency resolution is reduced by simply sampling the calculation at a coarser spectral resolution which, if the undersampling is coarse enough, can miss out on important contributions of individual lines or bands. Calculating at the highest possible spectral resolution and then convolving down to the required lower resolution is more accurate. The scanning function build into MODTRAN (accessed through the FWHM of Triangular Slit input) does this, but its maximum range is 50 cm⁻¹. MODTRAN always operates internally using 1 cm⁻¹ bins. If you want to reduce the spectral resolution of a MODTRAN calculation to greater than 50 cm⁻¹, and if output undersampling is not satisfactory, then you should use the PCModWin scan function. If you are using the LOWTRAN within MODTRAN option, the FWHM of Triangular Slit input does not apply, and you must use the scanning function to convolve an output from the maximum 20 cm⁻¹ LOWTRAN resolution to a lower value.

MODTRAN 3.7 and higher adds a scanning function option as part of the basic run. This lets you apply a scanning function immediately after calculating an output. If you want to scan a file after the fact, you must still use the PcModWin scanning function. The two functions are extremely similar, both in inputs and final result. Inputs for the MODTRAN built-in scanning function can be found on the input screen Geometry and Spectral Band.

The scanning function is implemented as part of the PCModWin main program. A separate database file (with the extension .SCN) is maintained to hold scanning inputs. This lets you set up some generic scan functions and apply them across a range of MODTRAN outputs.

The scanning function is accessed using Scan from the main menu. Under Scan, you can specify the operation of the scanning function, save these inputs away to a separate database file (with filename extension .SCN), read in previously saved scan inputs, and run the scan function itself. The scanning function outputs are stored in an output file called MODSCAN or TAPE9. This file can be viewed from the PCModWin menu using the Edit | Edit File command, which runs a DOS based text file editor in a separate window. Alternately, you can use a Windows text editor to examine the outputs of the filter run. You can also plot the results (in MODSCAN or TAPE9) using the PCModWin Plot command.

6.1 Scanning Function Inputs

Inputs to the scan function are set with a single input screen, accessed by clicking Screen 1 in the Scan menu. The layout of this screen is shown below:
The function of the inputs is summarized briefly below.

### 6.1.1 Beginning Wavenumber

This sets the start of the spectral band to apply the scanning function to. Note that if the start of the spectral band is set lower than the actual start of data in the calculation, then the scan will simply start at the beginning of the data. Thus a useful default that covers all data in any file is to set the Beginning wavenumber to the lowest possible value, which is 0 cm\(^{-1}\). You can also specify the band endpoints in micrometers (um) or nanometers (nm).

### 6.1.2 Ending Wavenumber

This sets the end of the spectral band to apply the scanning function to. Again, if this input is set higher than the spectral endpoint of the calculation, the scan will apply to all the data in the file. Thus a simple way to ensure that the scan uses all the data in the file is to set this input to the highest possible wavenumber, which is 50000 cm\(^{-1}\). You can also specify the band endpoints in micrometers (um) or nanometers (nm).

### 6.1.3 Half Width Half Max

This input sets the half width of the scanning function that will be applied to the data. The half-width can be specified either in wavenumbers, micrometers, or nanometers. Increasing this number further reduces the spectral resolution of the scanned result, as more points are averaged together, weighted by the shape of the triangle function.
6.1.4 Slit Function Type

This input sets the shape of the function that will be scanned over the data. The choices are Triangular, Rectangular, Gaussian, Sinc, Sinc\(^2\), or a Hamming function.

6.1.5 Half Width Type

This input sets the way that the scan function will use the Half Width Half Max value. Absolute means that it will treat it as a value in wavenumbers that is constant for the entire spectral region. Relative % means that the value entered will be a relative percent; the slit function will use a full width at half-maximum of 100 * dv/v for wavenumbers, or 100 * dL/L for wavelength L.

6.1.6 Number of runs to scan

This input lets you select which output (from MODOUT2 or TAPE7) will be scanned. This item is useful only if you have multiple MODTRAN runs stored in a single calculation. Normally this value should be left at its default value of 1.

6.2 Scan Outputs

Once you have specified the scan inputs (either manually or by loading in a database file from disk), the scan can be applied using the Scan | Run Scan command. The scanning function operates on MODTRAN output files stored in the PCModWin \bin directory. If you want to apply the scanning function to a previously made run, you may first have to go into a DOS shell and copy the .FL7 file over into MODOUT2 or TAPE7. For example, to apply a scanning function to a previously calculated CASEM3 output, first execute the following command in a DOS shell:

```
copy casem3.fl7 tape7
```

Outputs of the scanning function are stored in a file called MODSCAN or TAPE9. A sample MODSCAN file, from a simple 25 cm\(^{-1}\) scan applied to the output of test case 3, is shown below:

```
T 6 2 0
Scan output file
Scan output file
Scan output file
Scan output file
Scan output file
Scan output file
Scan output file
Scan output file
990  1090   1
978.  0.0057  0.0059  0.0059  0.0059  0.0059  0.0058  0.0059  0.0059  0.0059  0.0059  0.0000  0.000262308     6.
0.0058  0.0059  0.0059/4lf  0.0059  0.0059  0.0059  0.0059  0.0059  0.0059  0.0059  0.0000
979.  0.0170  0.0177  0.0177  0.0177  0.0178  0.0178  0.0174  0.0178  0.0175  0.0178  0.0001  0.000782012    18.
0.0178  0.0177/4lf  0.0177  0.0177  0.0178  0.0178  0.0178  0.0178  0.0178  0.0178  0.0178  0.0000
980.  0.0340  0.0355  0.0354  0.0354  0.0355  0.0355  0.0348  0.0355  0.0349  0.0355  0.0003  0.00156136    35.
0.0355  0.0354/4lf  0.0354  0.0354  0.0355  0.0355  0.0355  0.0355  0.0355  0.0355  0.0355  0.0000
```
Comparison plots between the unscanned and scanned output of test case 3 are shown below. The data is plotted by selecting the **Plot | Interactive** option from the main PCModWin menu. The file selected for plotting is MODSCAN or TAPE9.

Notice that the edges of the scanned output drop rapidly towards zero. If you plan to apply the scanning function to a spectral region of interest, make sure that you run your MODTRAN calculation over a larger band, so that the region of interest is not affected by these edge effects of the scan function.
7 PcModWin Filter Function

PcModWin provides a filter function that can be used to calculate the effective atmospheric transmittance that would be measured by a filtered transmissometer or the effective radiance as seen by a radiometer with a bandpass filter. This capability simplifies the useful task of taking the spectral MODTRAN outputs and converting them into numbers measured by a typical banded imager. The filter function lets you specify the spectral shape of the instrument (detector + bandpass filter + optics) response and uses this shape as it computes the filtered value. It is very similar to the filter function provided in FORTRAN source form with older versions of the MODTRAN and LOWTRAN 7 distribution from the Air Force Research Laboratory.

The filter function is implemented in a standalone program called ONFIL.EXE. You can access this function from the PCModWin menu command Filter. Under Filter, you can specify the operation of the filter, save these inputs away to a separate database file (with filename extension .FLT), read in previously saved filter inputs, and run the filter function itself. The filter function outputs are essentially single numbers integrated across the filter you specify (i.e., no plotting is required). They are stored in an output file called MODFIL or LFILOUT. This file can be viewed from the PCModWin menu using the Edit | Edit File command, which runs a DOS based text file editor in a separate window. Alternately, you can use a Windows text editor to examine the outputs of the filter run.

Note that the database files created and used for MODTRAN inputs (.LTN) are different from the database files used to hold filter inputs (.FLT). This lets you specify several filter functions of interest (that match instrumentation in hand, for example) and then apply those filter functions to many separate MODTRAN calculations.

There are two methods available for selecting and setting the filter function inputs. The first is by using an existing database, similar to a MODTRAN database file. This has already been described in section 2.3.5 of this manual. The second is by specifying all of the parameters in the two input screens. The latter method is described in the next section.

7.1 Filter Function Inputs

The filter function inputs are spread across three input screens in PcModWin. The first screen specifies some general inputs and whether you plan to pass a blackbody source through the filter. The second screen specifies the spectral interval, number of filter points, and some title/labeling options. The third screen lets you specify each point of the filter. Each of these screens is described below.

7.1.1 Filter Screen 1

This initial filter input screen specifies some general inputs. It is shown below:
7.1.1.1  Number of Filters

This input specifies the number of filters that will be defined for this filter run. The maximum number of filters in a single filter run is 15.

7.1.1.2  Use Blackbody Source

This check-box input lets you enable or disable the blackbody option, which lets you compute the radiance measured by a radiometer using this filter function. If you check this box, you must supply a blackbody temperature in the input box immediately below.

7.1.1.3  Temp of Blackbody

This specifies the temperature of the blackbody, in degrees K, that is being used for the transmissometer calculation. The spectral distribution of emission at this temperature will be used as the source that the transmission is applied to.

7.1.1.4  Print Options

This input specifies the type of output that will be sent to the MDOFIL or LFILOUT file. There are three choices:

- Print All = print MODTRAN transmittances along with filter results
- Print Filter & Blackbody Fun = print filter function with blackbody folded in
- Print Filter transmittance = only print filter weighted transmittances

7.1.1.5  Runs to Filter

This input indicates which of the runs in the MODTRAN output file to which the filter is applied. For single MODTRAN calculations, this input must be 1. If you are working with a multiple run case, this input must be less than or equal to the total number of runs in the MODOUT2 or TAPE7 file.
7.1.2 Filter Screen 2

This screen specifies the title, type, and size of the filter function. It is shown below:

![Filter Screen 2: Filter Number 1 of 1](image)

**7.1.2.1 Filter Title**

This input specifies a title that you can associate with the filter for documentation in the output file.

**7.1.2.2 Filter ID number**

This input lets you assign an ID number to the filters being defined, again for documentation purposes.

**7.1.2.3 Wavenumber or Wavelength**

This input specifies how you will define the filter. You can work either in wavenumbers or wavelength. If you specify wavelength, the filter function will convert each point to wavenumbers, since the MODTRAN outputs are supplied per wavenumber.

**7.1.2.4 Number of Filter Points**

This input specifies the size of the filter being defined. Up to 80 wavenumber, response pairs can be defined for each filter.
7.1.3 Filter Screen 3

This screen specifies the actual filter function that will be applied to the MODTRAN outputs. The screen layout is shown below:

The screen consists of two columns, titled WAVE and FF. Each pair of WAVE and FF input boxes corresponds to a single filter function point. The WAVE column is where you specify the wavenumber value, while FF specifies the relative response value to apply at that point. Typically the relative response numbers range from 0 to 1.0. However, in order to get the proper area of the integral under the filter curve (to maintain radiometric calibration), you may want to specify some of the central points with values higher than 1.

The vertical scroll bar on the right side is used for input of more than 10 filter points. If you are specifying a larger filter, use the scroll bar to move up or down through the list of points being defined.

Inputting a filter function can be tedious for large or detailed filters. We strongly recommend saving the filters away to a database file (.FLT) so that you can reuse the filter on later runs without having to re-enter it manually. The filter inputs are saved away to a file using the Filter | Save menu command.
7.2 Filter Function Outputs

Once you have specified the filter function (either manually or by loading in a database file from disk), the filter can be applied using the Filter | Run Filter command. The filter function operates on the MODOUT2 or TAPE7 (MODTRAN output) file stored in the PCModWin \bin directory. If you want to apply the filter function to a previously made run, you may first have to go into a DOS shell and copy the .FL7 file over into TAPE7. For example, to apply a filter function to a previously calculated CaseM3 output, first execute the following command in a DOS shell:

copy casem3.fl7 tape7

Outputs of the filter function are stored in a file called MODFIL or LFILOUT. A sample MODFIL or LFILOUT file, from a simple filter applied to the output of test case 3, is shown below:

```
1 NUMBER OF FILTERS= 1  NEW= 1  IPT= 0  TEMPERATURE= 273.00  IPRINT= 0  NLOW= 1
FILTER NAME FILTER# IFWV NW
* 0 1 10
990.0 .00 1000.0 .20 1010.0 .40 1020.0 .80 1030.0 .60 1040.0 .90 1050.0 .50 1060.0 .50 1090.0 .10
1100.0 .00

0 **************************************** LOWTRAN CONTROL DATA ****************************************
6 2 0 0 6 6 6 6 6 1 0 0 .000 .000 0 1500 0.000 .000 .000 .000 -99 -99 -99 -99 -99 -99 -99 -99
331976 U.S STANDARDS
6 0.000 .000 .000 .000 .000 0
23.0 273.0 .000 .000 .000 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0
1 NUMBER OF FILTERS= -1  NEW= 0  IPT= 0  TEMPERATURE= .00  IPRINT= 0  NLOW= 0
```

The filter function inputs are echoed back first, including the spectral filter used. This is followed by the MODTRAN inputs used to compute CASEM3 calculation. Finally, the filter weighted results of the calculation are shown. Since CASEM3 is a transmittance calculation, the weighted transmission for each component is reported. It should be noted that while, in general, the spectral products of all the individual component transmittances sum to the total transmittance (at each wavenumber), the products of the inband transmittances of each component will not necessarily equal the weighted total transmittance reported by the filter function.
8 PcModWin Help

PCModWin is provided with a comprehensive on-line help system, based on the Microsoft Windows help file support that is provided with every Windows system. This on-line help system contains a wealth of information about MODTRAN and its inputs, as well as details on how to use PCModWin. Much of this information is reproduced in the printed documentation. This resource is always available on-line as you are working with PCModWin. If you are confused by a prompt, or curious about some aspect of MODTRAN, you can enter the help system and search for answers on your own. The information contained in this system is bound together though a series of hyperlinks, so that relevant facts can be quickly jumped to and retrieved.

The help system is loaded by first displaying any of the PcModWin input screens (under the Modtran Inputs menu), and then by clicking on any of the prompts. The help screen for the prompt that you click on is displayed. From this help screen, you can view help about the complete input screen, or any other inputs, or many other aspects of MODTRAN and PcModWin. You can also load the Help file in a stand-alone mode by clicking on it using the Windows Explorer.

When you call up help on a particular MODTRAN input, you will see a screen like the example below:
The help system adjusts the screen layout to the size of the window that you have available. You can run help in a very small window, but all the line wrapping makes the result difficult to read. We recommend use of a moderately large window (like the example shown above). To adjust the size of the window, place your mouse cursor over the outer edge of the window. When the cursor changes to a two-headed arrow cursor, hold the left button down and drag the window boundary to a larger size.

The top part of the screen describes the variable name, MODTRAN input card number, location within the PcModWin input screens, and allowed values. The following convention is adopted in the PCModWin help: text prompts that correspond to variable input values are displayed in blue, while variable prompts are all displayed in the underlined ‘help jump’ color for your system (usually green). The lower part of the screen describes the variable, its allowed values, and notes any related variables. If this section is too long to fit in the window, vertical scroll bars will be displayed to the right, and you can use this to navigate through the variable text. Any green underlined item is a jump to another topic in the help file. In the screen shown above, the model screen number of the variable is shown in underlined green text. You can jump to general information about this screen by positioning the mouse cursor over the text and clicking. When you are positioned over a jump spot, the cursor changes from an arrow pointer to a small hand with the index finger indicating the cursor location.

Along the top of the help screen is both a set of menus, as well as several command buttons. The function of the help system menus is summarized briefly below:

**File** Menu Commands
- **Open** Opens a Help file.
- **Print Topic** Sends current topic to Windows printer.
- **Exit** Quits Help and saves any annotations or bookmarks you created.

**Edit** Menu Commands
- **Copy** Copies current topic to Windows clipboard.
- **Annotate** Adds text to the current Help topic. Annotations are marked with a paper-clip icon, which appears in front of the topic heading.

**Bookmark** Menu Commands
- **Define** Places a bookmark in the current topic or removes a bookmark from any topic. The name you specify for the topic appears on the Bookmark menu.
- **List of Bookmark Names** Appears after you have defined a bookmark. From this list, you can choose the bookmark for the topic you want to display in the Help window.
- **More** Appears when you have defined more than nine bookmarks. Displays the complete list of bookmark names you have defined.

**Options** Menu Commands
- **Keep Help on Top** Option to keep the Help window on top of all other windows on the desktop.
**Display History Window**  
An optional listing of all the previous help topics you have visited  
**Font**  
Change Help system font size  
**Use System Colors**  
Control over colors used for Help display

**Help** Menu Commands (in Help)  
**Version**  
Displays version of help software.

In addition to the menu commands, there are also several buttons across the top of the screen. If a button feature is not available, its button name is dimmed (greyed). The functions of these buttons are summarized below:

<table>
<thead>
<tr>
<th>Button</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Contents</strong></td>
<td>Displays Help Contents for the application you are using.</td>
</tr>
<tr>
<td><strong>Index</strong></td>
<td>Lists all the words you can use to search for topics in the application's Help. By typing or selecting one of these words, you can search for and go to a specific Help topic.</td>
</tr>
<tr>
<td><strong>Back</strong></td>
<td>Displays the last topic you viewed. You move back one topic at a time in the order you viewed the topics.</td>
</tr>
<tr>
<td><strong>Print</strong></td>
<td>Displays the last 40 topics you have viewed in the Windows session. The most recent topic viewed is listed first. To revisit a topic, double-click it.</td>
</tr>
<tr>
<td><strong>&lt;&lt;</strong></td>
<td>Displays the previous topic in a series of related topics, until you reach the first topic in the series. The button is then dimmed.</td>
</tr>
<tr>
<td><strong>&gt;&gt;</strong></td>
<td>Displays the next topic in a series of related topics, until you reach the last topic in the series. The button is then dimmed.</td>
</tr>
</tbody>
</table>

To choose a Help button, either click the help button you want, or type the letter that is underlined in the help button.
9 PCModWin Test Cases

Sixteen test cases are supplied with PCModWin. The input databases are called CASE01 through CASE16, along with two others. The standard cases are the same as those supplied for many years with earlier versions of MODTRAN and LOWTRAN. Note that some of the test cases take a long time to execute (in particular, CASE01), but that the model calculations are fairly involved for those cases. A case that runs fairly quickly, and thus is a good example to get familiar with the software with, is CASE03. A brief description of each of the cases, as well as a sample hardcopy of the plot they are set up to generate, is contained below. The test cases are summarized in the table below.

<table>
<thead>
<tr>
<th>Case</th>
<th>Atmosphere</th>
<th>Path</th>
<th>Mode</th>
<th>Band</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Case01</td>
<td>US</td>
<td>SP</td>
<td>R w/s</td>
<td>Vis</td>
<td>illustrates multiple scattering</td>
</tr>
<tr>
<td>Case02</td>
<td>MdSum</td>
<td>SPS</td>
<td>R</td>
<td>8-13</td>
<td>slant path to space</td>
</tr>
<tr>
<td>Case03</td>
<td>US</td>
<td>SP</td>
<td>Tran</td>
<td>9-10</td>
<td>uses the elevated surface option</td>
</tr>
<tr>
<td>Case04</td>
<td>US</td>
<td>SPS</td>
<td>DSI</td>
<td>NIR</td>
<td>direct solar irradiance</td>
</tr>
<tr>
<td>Case05</td>
<td>US</td>
<td>SP</td>
<td>Trans</td>
<td>9-10</td>
<td>uses the volcanic aerosol option</td>
</tr>
<tr>
<td>Case06</td>
<td>Trop</td>
<td>SP</td>
<td>Trans</td>
<td>9-11</td>
<td>Navy Maritime aerosol option</td>
</tr>
<tr>
<td>Case07</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>omitted</td>
</tr>
<tr>
<td>Case08</td>
<td>MDH</td>
<td>Hor</td>
<td>Trans</td>
<td>8-11</td>
<td>User Supplied Atmosphere</td>
</tr>
<tr>
<td>Case09</td>
<td>US</td>
<td>SP</td>
<td>Trans</td>
<td>8-11</td>
<td>uses Army vertical structure algorithm</td>
</tr>
<tr>
<td>Case10</td>
<td>US</td>
<td>SP</td>
<td>Trans</td>
<td>100-2000</td>
<td>uses the cumulus cloud option</td>
</tr>
<tr>
<td>Case11</td>
<td>US</td>
<td>SP</td>
<td>Trans</td>
<td>100-2000</td>
<td>same as 10, but also uses the elevated surface option</td>
</tr>
<tr>
<td>Case12</td>
<td>NMA</td>
<td>SP</td>
<td>Trans</td>
<td>9-10</td>
<td>uses New Model Atmosphere option</td>
</tr>
<tr>
<td>Case13</td>
<td>US</td>
<td>SP</td>
<td>Trans</td>
<td>9-10</td>
<td>uses the desert aerosol option</td>
</tr>
<tr>
<td>Case14</td>
<td>MDH</td>
<td>Hor</td>
<td>R:w/s</td>
<td>4.6-4.7</td>
<td>how not to use the sun</td>
</tr>
<tr>
<td>Case15</td>
<td>ArcS</td>
<td>SP</td>
<td>R:w/s</td>
<td>1.5-2.5</td>
<td>sun scatter through cloud</td>
</tr>
<tr>
<td>Case16</td>
<td>US</td>
<td>SP</td>
<td>R:w/s</td>
<td>0.3-2.5</td>
<td>multiple runs, MODTRAN filter, 2 band models</td>
</tr>
</tbody>
</table>

1Atmospheric Model: US = US Standard, Trop = Tropical, MDH = meteorological data, NMA = new model atmosphere, ArcS = Subarctic Summer, Msum = Midlatitude Summer

2Path: SL = slant path, SPS = slant path to space, Hor = horizontal path

3Mode: Trans = transmittance, R w/s = radiance with scattering, DSI = direct solar irradiance

4Band: is the spectral band, Vis = visible, NIR = near infrared, others in micrometers.
9.1 CASE01

This case is the longest running of the sample cases provided as part of the MODTRAN distribution. It uses a slant path from an observer at 20 kilometers altitude looking straight down at the ground (surface albedo set to a value of 0.4). MODTRAN executes in the radiance with single-scattering mode, and **multiple scattering is enabled**. The program will report path radiance. The 1976 US Standard Atmosphere is used, and the Rural aerosol model (model #2) is specified for the boundary layer. The frequency band is from 14000 to 34000 cm\(^{-1}\), with a sampling interval half-width of 20 cm\(^{-1}\), so the calculation is taking place in the visible wavelength bands. The 15 cm\(^{-1}\) resolution band model is used to accelerate the calculation. The scattering geometry is specified by inputting the azimuthal angle of the observer's line of sight and the zenith angle of the source. Since the path is straight down, the actual azimuthal angle is set to 0 degrees, while the solar zenith angle is set at 60 degrees.

The two output plots of this case is shown below. In the first, the radiance per wavenumber is plotted vs wavenumber. Since wavenumber is the main x axis unit, a wavelength scale is plotted along the top of the plot for reference. Finally, the two elements plotted are the single scattered radiance from the path and the total radiance. This illustrates the relative importance of the single-scattered component to the total that MODTRAN calculates.

![Test Case CASE01](image)

The second plot shows the transmission of the path from the observer to the endpoint at the ground. The transmission to the ground is low, ranging from about 40 percent at...
the low wavenumber values (longest wavelength) to almost zero at the highest wavenumber values (shortest wavelength). This information indicates that the contribution of the ground to the path radiance is small compared to the single and multiple scattered solar radiance. This conclusion can be confirmed by examining the tabular outputs in the Modout1 and Modout2 files (or by making additional plots).
9.2 CASE02

Case02 illustrates a Slant Path to Space calculation. The Zenith Angle is set to 80 degrees, so the observer on the ground is looking towards the horizon but above it. The spectral band is 740 to 1250 cm\(^{-1}\) (8 to 13.5 micrometers).

The output plot from this case is shown below.
9.3 CASE03

This case illustrates the use of the elevated surface option of MODTRAN. The boundary layer aerosols are modified to reflect the fact that the ground for this case is 1.5 km above mean sea level. The path is a slant path between 1.5 and 6 kilometers. MODTRAN uses the value of 0 for the Zenith Angle and treat this as a vertical path looking straight up. This can be confirmed by looking in the MODOUT2 or tape7 output file, where the geometry calculations are summarized. The rural aerosol model is used, and the spectral band is 990 to 1090 wavenumbers with a sampling interval of 1 cm\(^{-1}\), which is then reduced using the slit function to 2 cm\(^{-1}\). The output plot, shown below, plots the total transmittance per wavenumber.

The difference introduced by the use of the elevated surface option can be seen buried in the table "Cumulative Absorber Amounts for the Path from H1 to Z" in the MODOUT2 or TAPE7 file. If you rerun this case, changing only the elevated surface parameter by setting it to 0, you will notice the absorber amounts for Aerosol 1 (the boundary layer aerosol) are decreased by more than a factor of 2 around 1.5 kilometers. The concentrations of Aerosol 2 are also reduced. This would be the result if you tried to simulate the elevated surface by simply increasing the initial altitude of the path above 0 km. If the aerosol contributions are important to the band you are working in, this can be a significant difference.
9.4 CASE04

This case demonstrates use of the direct solar irradiance option in MODTRAN. It uses a slant path from the ground to space with a solar zenith of 60 degrees, which means the sun is two thirds of the way to the horizon. The day of the year is also specified on screen Solar/Lunar Irradiance, and is set to March 15 (day 74). This parameter is ignored by MODTRAN because the Median Distance box is checked; if you clear this box, the Day of Year input is enabled to correct for annual variations in the earth to sun distance. The calculation uses the 1976 US Standard Atmosphere and the Rural aerosol model. The band specified is 6000 to 7500 wavenumbers with a resolution of 2 cm$^{-1}$. The plot from this case, shown below, compares the incident solar irradiance at the top of the atmosphere (solid line) with the transmitted solar irradiance (dashed line).
9.5 CASE05

This case illustrates use of the extreme volcanic aerosol profile for the stratospheric aerosols. The 1976 US Standard Atmosphere is specified. It also illustrates some interesting geometry. The initial and final altitudes of the path are both at 30 kilometers, and the zenith angle is slightly below horizontal. The height of the path at its closest point to the earth is 10 kilometers. This path is thus looking at another point at the same altitude, but the path is traveling through the denser atmosphere below because of the earth's curvature (a MODTRAN “tangent path”). If you look at the table called “Calculation of the Refracted Path Through the Atmosphere” in the MODOUT1 or TAPE6 file (using Edit | Edit File from the PCModWin main menu), you will notice that the path bending from refraction is only calculated for half the path, and then is doubled due to the symmetry of the geometry. The frequency band is 990 - 1090 wavenumbers (9.1 to 10.1 micrometers).

The results of this calculation are clearly being dominated by the stratospheric aerosols. This can be seen by examining the table of transmittances of the different components at the end of the MODOUT2 or TAPE7 file (use Edit | Edit File from the main PCModWin menu). The total transmittance is very small over this path. You may also notice that a strong ozone band is also playing an important role in this path, with zero transmittance from 1020 to 1060 wavenumbers. Two plots are created by this case. The first plot shows the total transmittance only, which is quite low (notice the values along the Y axis are scaled by 10^-2, which means the peak transmittance in this band is less than 1%). The second plot shows the ozone and total transmittance calculated over the band. The ozone-only transmittance is much higher than the total transmittance, and so the total component is buried along the bottom of the plot in this case.

![Test Case CASE05 - Total](image)
Second plot from Case05 showing ozone transmittance.
9.6 CASE06

This case illustrates use of the Navy Maritime aerosol model in the boundary layer. This is selected under Aerosol Model Used, which is the first input on PCModWin input screen Aerosols. No value is specified for the wind speed, so a default of 4.1 meters/sec is used. The airmass character is also left at 0, which means that a default value of 3 will be used. The path is a horizontal path 10 kilometers long at sea level, so it is contained entirely within the boundary layer. The spectral band for the calculation is 900 to 1145 wavenumbers (8.7 to 11.1 micrometers).

The average transmittance for this path is quite low, and is shown in the plot of total transmittance included with this case.
9.7 CASE07

Test Case07 is not included in the PcModWin distribution.
9.8 CASE08

This case illustrates entering your own atmospheric profile for a horizontal path case. This is selected by specifying Met Data (Hor Path Only) for the Model Atmosphere prompt at the top of screen Model Atmosphere. Since the geometry consists of a path length within a uniform layer (Horizontal Path), the Visual Geometry screen is disabled.

Some other items worthy of note in CASE08: rain is enabled with a rain rate of 10 mm/hour, which is a light rain. This is done by setting Rain Rate on the Aerosol screen to 10. The path is located at sea level, and is only 300 meters (0.3 kilometers) long. The spectral band for the calculation is 900 to 1145 wavenumbers (8.7 to 11.1 micrometers).

The output plot for this case is shown below. The only major component affecting the path transmittance is the rainfall present, which is reported under AER-HYD TRANS (the plot component is Trans Aerosols). Thus the total transmittance is plotted as a solid line, while the rain transmittance is plotted as a dotted line. To duplicate this plot, use the Plot | Interactive menu option to enable plotting of the Trans Aerosols component. Note that the plot boundaries are greater than the extent of the data, which allows you to select even wavenumber increments and tic values for readable plots.
9.9 CASE09

This case illustrates use of the Army Vertical Structure Algorithm (VSA), a model that modifies boundary layer aerosols. The model is enabled in the first input on screen Aerosols by checking Use Army (VSA) for Aerosol Extension, but all of the input values on screen VSA Cloud (2B) are set to 0, so a set of default values for the VSA inputs will be used. These defaults, incidentally, are all reported in the MODOUT1 or TAPE6 file, and can be viewed after the case is run by using Edit | Edit File from the main PCModWin menu. The path is contained entirely in the boundary layer, running from 0 to 1.8 kilometers at a zenith angle of 45 degrees. The spectral band for the calculation is 900 to 1145 wavenumbers (8.7 to 11.1 micrometers).

The path transmittance is dominated by the aerosols of the VSA and the water continuum. This is seen by examining the output tables of transmittance at the end of the MODOUT2 or TAPE7 output file (using Edit | Edit File from the main PCModWin menu). The total transmittance results are plotted below.
9.10 CASE10

This case illustrates the use of the cumulus cloud model. This cloud model is selected under Use Cloud/Rain Aerosol Extensions on screen Aerosols (2). All inputs on the Clouds screen are left at default values. The path is a vertical slant path running from 0 to 6 kilometers. The spectral band runs from 5 to 100 wavenumbers (2000 to 100 micrometers), which also shows the expanded spectral coverage of MODTRAN (valid down to 0 cm\(^{-1}\)). You can see the profile used for the cumulus model echoed at the start of the inputs in the MODOUT1 or TAPE6 output file. To see this, use Edit | Edit File from the main PCModWin menu.

At wavelengths shorter than 2000 micrometers, the path transmittance for this case is essentially 0. Looking at the transmittance tables in the output file reveals that the water band transmittance, the water continuum transmittance, and the cloud aerosol transmittance all rapidly drop to 0 with decreasing wavelength (increasing frequency). The sample plot, shown below, plots the total transmittance.

Test Case 10 - Cloud Example

![Test Case 10 - Cloud Example](image)
9.11 CASE11

This case is similar to case #10, with the addition of an elevated ground surface that is 1.5 kilometers above sea level. This is set in the last input on screen Aerosols (2). Unfortunately, the changes introduced by the elevated surface are swamped by the zero transmittances of the cloud, water band, and water continuum. The plot for case #11 is shown below.

![Test Case11 - Elevated Ground](image-url)
9.12 CASE12

This case illustrates the input of a new model atmosphere. A four layer atmosphere is specified over an elevated surface. You will see the initial screen New Model Atmosphere (2C), which specifies the number of layers and the title to be assigned to the new profile. Four screens follow, with inputs specified for each layer in the new atmosphere. Note that since Supply Aerosol Information by Layer is set to No, the cursor cannot travel down to the aerosol prompts at the bottom of each screen. This means that default values (set by the aerosol model selected at the top of screen Aerosols (2) ) will be used. Supply Molecular Densities by Layer is set to No which means that you only need to specify the concentrations of water, carbon dioxide, and ozone. The remaining gases use the default atmosphere set on screen Model Atmosphere (1). Setting this parameter to Yes (on the previous screen) allow you to specify the concentration of every gas.

The geometry for the case is a vertical path running from 1.5 to 6 kilometers. The spectral band is quite small: 1000 - 1005 wavenumbers (9.95 to 10 micrometers) and only a few points are generated by MODTRAN for it. This is shown in the plot below.
9.13 CASE13

This case illustrates use of the desert aerosol model. This is enabled by selecting *Desert Extinction* for *Aerosol Model Used* at the top of screen *Aerosols* (2). The wind speed used for the wind driven component of this model is set at *Wind Speed for Navy Maritime Aerosols*, the third prompt from the bottom on this screen. The value entered here is 10 meters/sec. The *US Standard Atmospheric* profile is selected. The path is a vertical path running from 0 to 6 kilometers. The spectral band is 990 to 1090 wavenumbers (9.1 to 10.1 micrometers). The sample case plot is shown below.
9.14 CASE14

This case illustrates setting up the sun for a Radiance with scattering calculation. Unfortunately, while the sun is turned on, the solar position values are all left at 0, leading to a poor example of configuring the sun. The observer latitude and longitude are zero, which puts the observer at the equator along the Prime Meridian, and the Greenwich mean time is set to 0 hours, which puts the sun below the horizon. Thus there is no solar scattering component to observe. Perhaps this is an example of things not to do when setting up a case. Reviewing the Modout1 file from this case clearly shows the solar position and the fact that the solar scattering component will be zero.

The plot from this case is shown below, with both total radiance and solar scattered radianc plotted.
9.15 CASE15

This case demonstrates use the multiple scattering option along a slant path through a cumulus cloud. This is a much better example of configuring the sun for solar scattering. The observer is at 3 km looking to the ground at a zenith angle of 104 degrees. The path is quite opaque and all the observer sees is solar scatter off the clouds along the path.

The path total and solar scattered radiance is plotted below.
9.16 CASE16

This case runs the MODTRAN correlation-k option along a downlooking path from 20 km straight to the ground. It also illustrates the use of the multiple run option provided with PcModWin. The first run uses the 15 cm\(^{-1}\) band model, while the second run uses the 1 cm\(^{-1}\) band model. Both components are plotted and the very close correlation of the plots shows that both models are returning essentially the same results in this case.

This case demonstrates using the MODTRAN filter function, with the AVIRIS.FLT provided with the distribution. It also increases the carbon dioxide concentration from the default 330 ppm to 355 ppm.

This test case takes much longer than any of the other cases to run, due to the use of the scattering models and the very large spectral bandpass. The spectral flux file created is over 6 Mb in size, while the MODTRAN output files are each almost 4 Mb, so make sure you have sufficient free disk space before running this case.

The output is plotted below. Due to the large number of points, this plot displays slowly, and if it remains as the window with focus it will repaint itself every time something is changed in the PcModWin window, leading to significant delays.
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