AURIC User's Guide
Version 1.2

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Chapter 1 - Introduction

1.1 Overview

Computational Physics, Inc. (CPI) has continued to develop the AURIC model (Atmospheric Ultraviolet Radiance Integrated Code) since Release 1.0. The earlier work leading to the first release was funded by the Air Force Phillips Laboratory Geophysics Directorate, now part of the Air Force Research Laboratory. The paper by Strickland et al. [Atmospheric ultraviolet radiance integrated code (AURIC): theory, software architecture, inputs, and selected results, *J. Quant. Spect. Rad. Transfer*, *62*, 689, 1999] documents the science and software as of that release. With this new release (1.2), AURIC now calculates thermospheric emission spectra in the 800 to 10000 Å wavelength region for dayglow and nightglow (see Appendix A for a complete listing of emission features). The software provides the capability to calculate emission spectra as a function of wavelength and viewing direction, and provides integrated radiances over specified wavelength intervals. AURIC is a powerful tool for computing optical backgrounds, analyzing optical data, and designing sensors.

1.2 Acknowledgments

Code RADTRANS was kindly provided by Dr. Randy Gladstone (referred to as code REDISTER in his publications).

1.3 Architecture

AURIC was designed with a modular approach as dictated by modern software engineering principles. Modularity provides system reliability, flexibility, and maintainability. AURIC consists of a collection of stand-alone programs written in Fortran 77. These programs communicate with each other via formatted data files. Each program reads a set of input files and writes one or more output files. Its output files then become input files to subsequent programs. This architecture works best when a module (i.e. a program or a group of programs that serve a single function collectively) is to be either deactivated or replaced in a given run. To illustrate, a user-specified atmosphere (measured or modeled) can be readily inserted, replacing the model atmosphere generated by the AURIC atmosphere module. As long as the AURIC file format specifications are met, the origin of its data files is irrelevant. Figures 1.1 and 1.2 delineate the flow of data between the AURIC programs. For a description of each program's specific function, see Chapter 4.

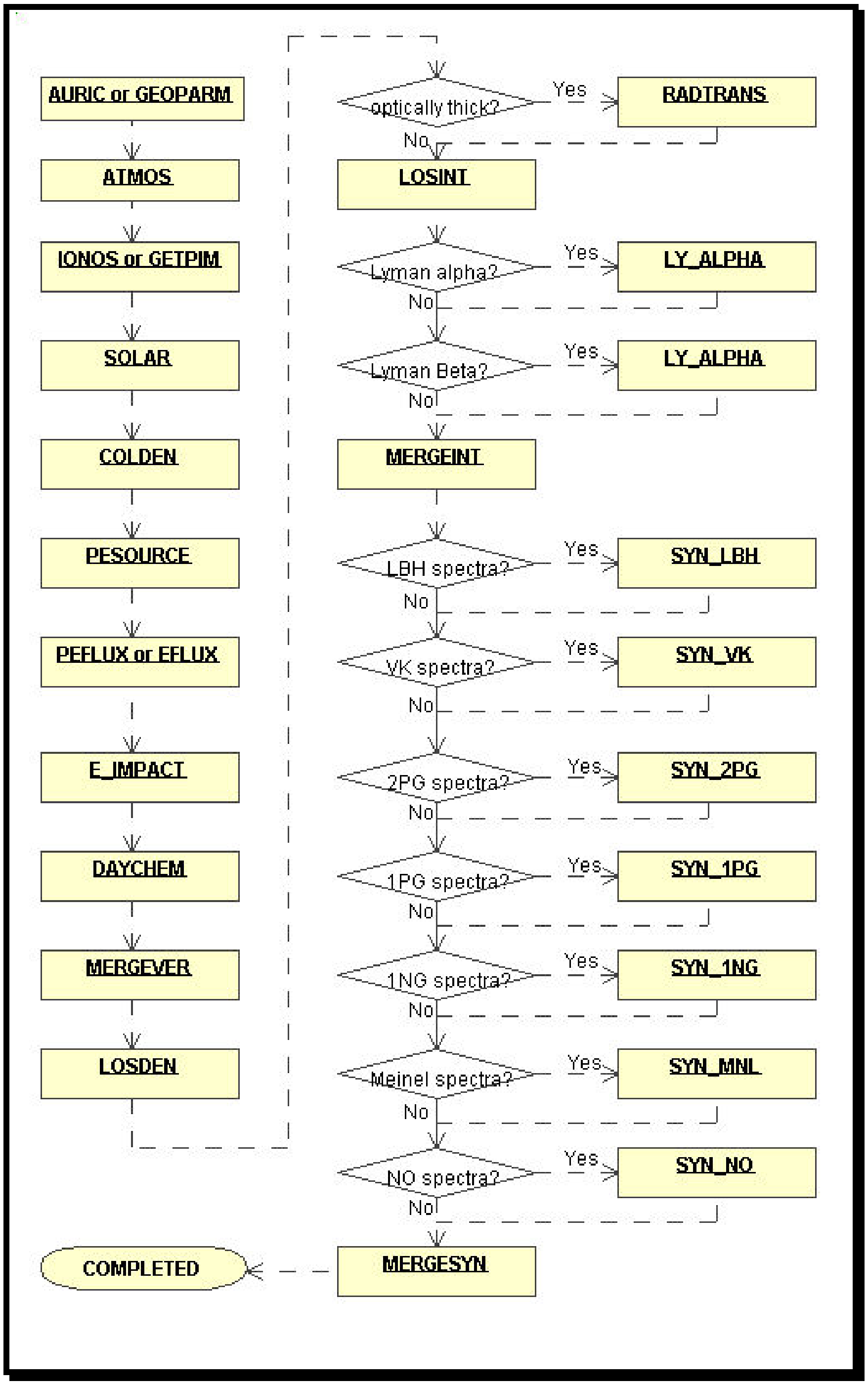

Figure 1.1 Dayglow execution flow chart

1.4 Inputs and Outputs

AURIC is input file driven. Once the input files are in place, it can be executed without any user intervention. This design enables the user to construct the input files, start the computationally intensive calculations, and leave the execution unattended until completed.

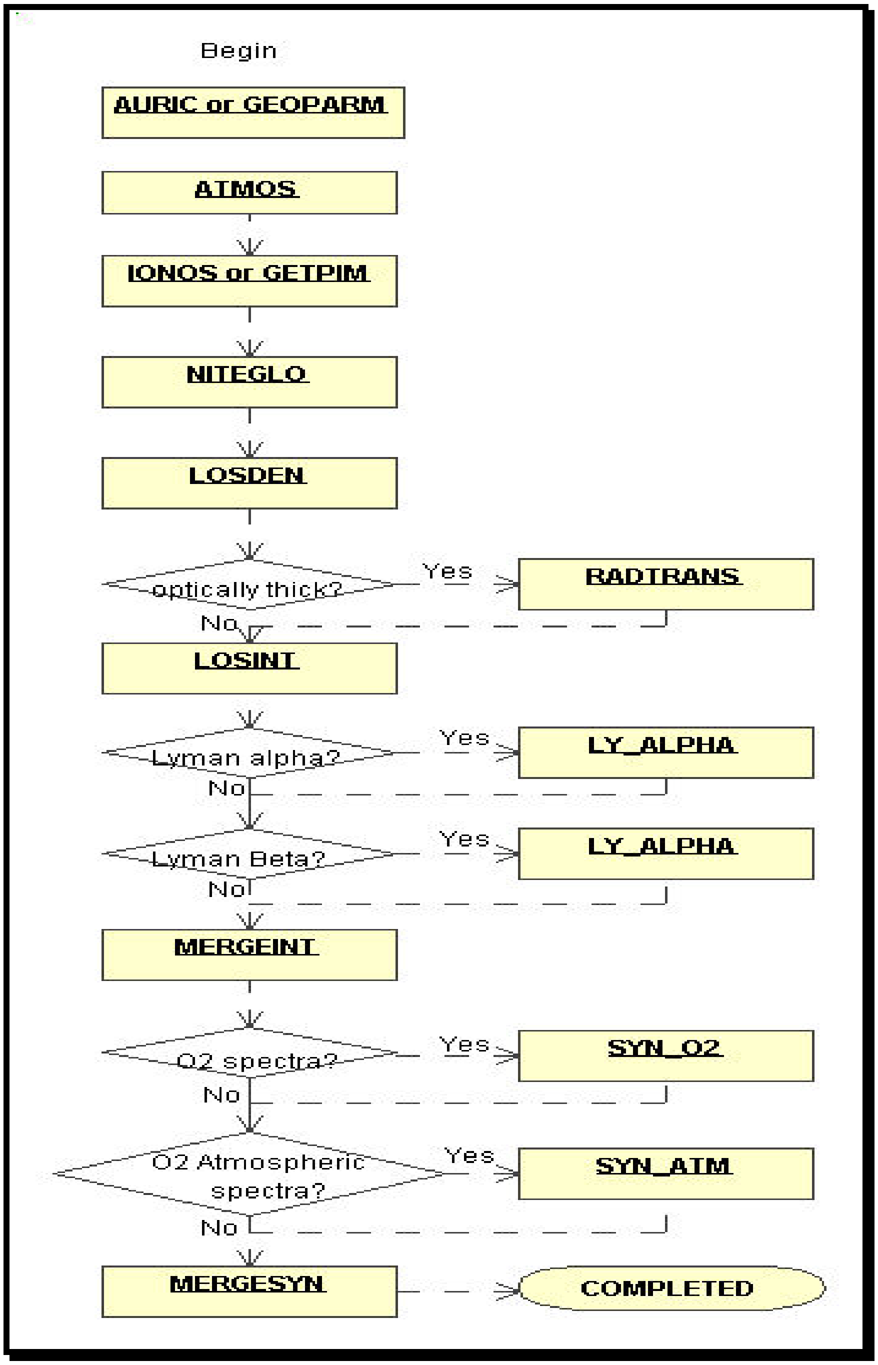

Figure 1.2 Nightglow execution flow chart

To initiate an AURIC run, the user must supply the following input files: `dbpath.inp`, `param.inp`, `view.inp`, `radtrans.opt`, `ly_alpha.opt`, `ly_beta.opt`, and `spect.inp`. A quick reference of their contents is given in Figure 1.3. Because these input files are essential for a successful AURIC run, Chapter 3 is dedicated to a detailed description of them.

The AURIC output files are discussed in Chapter 7, including their contents, file formats, physical units, and sample plots. Figure 1.4 gives a quick listing of their names and contents. The user need not consider all of the output files, only the ones that provide physically observable quantities.

file name	contents
dbpath.inp	absolute path to the AURIC database directory
param.inp	geophysical parameters
view.inp	viewing geometry parameters
ly_alpha.opt	acillary Lyman alpha evaluation parameters
ly_beta.opt	acillary Lyman beta evaluation parameters
spect.inp	spectral radiance parameters
radtrans.opt	switches to control radiative transport calculation

Figure 1.3 Input files and their contents

1.5 Execution

Executing AURIC will produce a set of output files. Their names are fixed from run to run, so it is advised that they be separated by directories. Otherwise existing files will be overwritten. A run is defined by its input parameters as stored in the input (*.inp and *.opt) files. If any one of the parameters is changed the result should be considered a new run.

Interactive vs. Batch

There are two execution modes in AURIC: interactive and batch. Recall that AURIC is a suite of stand-alone programs. The interactive mode requires the user to follow the execution flowcharts (Figures 1.1 and 1.2), type each program's name sequentially and wait for it to finish before activating the next one. The batch mode will alleviate the typing and waiting. At your request, the AURIC user interface will create a batch file which contains the necessary instructions for the operating system to complete an AURIC run. An additional advantage of the batch mode is that one can prepare a number of runs in advance without actually starting them and slowing down the system. Once the batch files are in place, you can queue them at a lower priority or save them for the computer's off-hours.

User Interface

To help the user in constructing the necessary input files, AURIC includes an user-interface program called **auric**. In general, AURIC program will not prompt the user for inputs. The exceptions are the programs **utils** and **getpim** which require user inputs in order to execute. Since the user interface program is recommended for executing AURIC quickly and reliably, Chapter 2 of this manual is dedicated to its description.

file name	Contents
atmos.dat	neutral atmosphere
attsolar.dat	attenuated solar flux
chemden.dat	chemical densities
chemin.vpr	electron impact volume production rates
chemout.ver	volume emission rates for the chemically active dayglow features
colden.dat	neutral column densities
dayglo.int	dayglow line-of-sight radiances
dayglo.ver	dayglow volume emission rates
dglthick.int	optically thick dayglow radiances
dglthin.int	optically thin dayglow radiances
e_impact.ver	volume emission rates by electron impact
eflux	Photoelectron fluxes including vertical transport
escape.dat	upward escape photoelectron fluxes
ionos.dat	Ionosphere
losden.dat	slant column densities
ly_alpha.int	lyman alpha radiances
ly_beta.int	lyman abeta radiances
lyman_db.alpha	lyman alpha source functions
lyman_db.beta	lyman beta source functions
merge.syn	comprehensive spectral radiance
n2_1pg.syn	N_2 1PG spectral radiances
n2_2pg.syn	N_2 2PG spectral radiances
n2_lbh.syn	N_2 LBH spectral radiances
n2_vk.syn	N_2 VK spectral radiances
n2p_1ng.syn	N_2^+ 1NG spectral radiances
n2p_mnl.syn	N_2^+ Meinel spectral radiances
nglthick.int	optically thick nightglow radiances
nglthin.int	optically thin nightglow radiances
niteglo.int	nightglow radiances
niteglo.ver	nightglow volume emission rates
no_bands.syn	NO bands spectral radiances
o2_nglow.syn	O_2 nightglow spectra
o2synden.dat	O_2 Herzberg and Chamberlain densities
pdis.vpr	photo-dissociation rates
peflux.dat	photoelectron flux

pesource.dat	photoelectron source function
photo.ver	photoionization or photodissociation produced volume emission rates
photodep.dat	solar EUV photoabsorption deposition rates
photoion.vpr	photoionization rates
solar.dat	incident solar EUV flux

Figure 1.4 Output files and contents

Platforms

AURIC is available under a variety of platforms, including UNIX, Linux, and Windows. A detailed listing of the supported environments can be found in Appendix B. AURIC can be ported to additional platforms provided they are equipped with a Fortran 77 compiler. Relative to the user, AURIC looks and functions almost identically on different platforms.

Viewing Output

When an AURIC run is completed, you will be able to immediately plot the results if you have access to IDL (Interactive Data Language). IDL is a programmable commercial graphics package. The IDL plotting routines for AURIC are stored in a directory at the same level as the AURIC database files and executables. If you do not have access to IDL, you will have to plot output using your own graphics package. Note that the output files are described in Chapter 7. If you are analyzing data, then you will have to write custom programs regardless of IDL's availability. It is for that reason that AURIC does not furnish a more comprehensive graphical capability.

1.6 Miscellaneous

A listing of miscellaneous items that should be noted.

Notations

This document employs the following notations:

bold	program names
`courier`	file names
<u>underline</u>	menu options or emphasized words
italics	miscellaneous uses

File extensions

All AURIC files are limited to eight characters long, plus a three-character extension. This limitation (due to Windows) was implemented to ensure cross-platform portability. Below is a listing of AURIC file extensions:

*.dat	various data files
*.doc	documentation files

*.f	Fortran source code files
*.h	Fortran include files
*.inp	input files
*.int	data files (radiances)
*.opt	ancillary or optional inputs
*.pro	IDL source code files
*.sig	database cross section files
*.syn	data files (synthetic spectra)
*.txt	ASCII text files
*.ver	data files (volume emission rates)
*.vpr	data files (volume production rates)

Some platform-dependent extensions:

UNIX	*.sh	shell script files
	no extension	executable files
Windows	*.bat	batch files
	*.exe	executable files

Case Sensitivity

Some operating systems are case sensitive with regard to commands and file names and they tend to favor lower case. For that reason, AURIC designates all of its file names (program or data files) to lower case internally. Therefore, when you are working in a case sensitive environment, it is recommended you always use lower case to avoid potential difficulties.

Diagnostic Messages

At times, AURIC displays precautionary diagnostic messages. These messages are used by the AURIC developers and maintenance team in case of run-time errors. Normally, the user should not be concerned with their presence.

Underflow Exceptions

On some platforms, AURIC will cause underflow exception warnings. While the AURIC software is capable of handling such exceptions, it is not possible to suppress system warnings as they occur, even when the exceptions are properly addressed. Therefore, the user should ignore such messages as they do not adversely affect the execution of AURIC.

1.7 Getting Started

If you are a first-time user and would like a step-by-step instruction, go to Chapter 2 where you will be shown exactly how to use the user interface and make an AURIC run.

Chapter 2 - User Interface

2.1 What Is It?

AURIC V1.2 includes a platform-independent, text-based user interface program. It is designed to interact with the user and provide helpful information on entering the proper input parameters, which is the most complex task in using AURIC. Modern implementations typically employ a graphical user interface (GUI) for this purpose. A GUI can be very user-friendly when it supports the use of mouse and cursor keys since the user can edit data more efficiently. However, hardware dependence can limit portability severely. A GUI normally requires hardware-dependent coding to support different platforms. To avoid an overwhelming ratio of development effort on the user interface alone, AURIC employs a design which simultaneously supports a large number of operating system and terminal configurations. Written in Fortran 77, it uses traditional text-based menus so the user can select data items for editing.

2.2 Start Up

To start the user interface, first go to an empty directory. It now becomes your current directory. If you are not sure how to do this, chapters 5, 6, and 7 give some system-specific instructions. Identify your operating system and locate the appropriate chapter to be consulted. All input and output files will be created and stored in the current directory. Now type *auric* at the system prompt (Cywgin users in Windows must type *auric.sh*). It is assumed here that all neccessary paths and environment variables have been set up by the user to point to the AURIC directory which contains the executables. Since most AURIC users are on UNIX, a typical UNIX prompt (%) is used here to represent the system prompt.

```
% auric
```

You should see a logo screen as shown in Figure 2.1. Follow the directions on the screen and press the <Enter> key. You will now see the main menu screen, as in Figure 2.2.

There are ten options on the main menu. They are all indexed with a number except the last option, which is indexed x. To select an option, just type its corresponding index and press <Enter>. You may be wondering why the exit option is not indexed by a number like the others. The reason is that there are several menu screens in this interface program, with each having an exit option which is consistently marked x. Therefore, you will always type x whenever you wish to exit from a menu.

```
***************************************************

                AURIC Version 1.2

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***************************************************


 Program INPHELP

 Press <Enter> to continue...
```

Figure 2.1 Logo screen.

```
     Main Menu

 1:  Introduction
 2:  Database address
 3:  Geophysical parameters
 4:  Viewing geometry parameters
 5:  Spectral parameters
 6:  Select spectral features
 7:  Create a batch file
 8:  Create radtrans option file
 9:  Create lyman alpha option file
10:  Create lyman beta option file
 x:  Exit

 Enter your choice:
```

Figure 2.2 Main menu screen.

2.3 Introduction Screen

A new user should start with option #1 Introduction. To select it, type 1 at the prompt, then press <Enter>.

```
Enter your choice: 1
```

As shown in Figure 2.3, you will be greeted with a welcome message, followed by the objective of this user interface. At the bottom of the screen, there is a message that says "Press <Enter> to continue...". After you have finished reading the display, press the <Enter> key to go to the next screen. It will show you how to make a menu selection.

The last screen says that after you have selected an option and have exited, there will be an asterisk (*) displayed next to it on the menu. Its purpose is to remind you that you have already selected that particular item on the menu. You are now finished with the Introduction option and will go back to the main menu.

```
Welcome to the AURIC user interface.

This program will help you choose the proper input
parameters.  These parameters are then stored to
appropriate files. You may also create a batch file
to execute AURIC. That will eliminate the need to
type individual program names.

Press <Enter> to continue...

This program is menu-driven. For example, you will
be shown menus like this:

1:  choice A
2:  choice B
3:  choice C
x:  exit

and be requested to enter a choice.

You simply type 2 if choice B is desired.

Press <Enter> to continue...

In the main menu, after you are finished with an
option, it will display a * next to it. Ex:

1: *choice A
2: *choice B
3:  choice C
x:  exit

It will serve a progress report.

Returning to the main menu.

Press <Enter> to continue...
```

Figure 2.3 Introduction screens.

2.4 Database Address

From the main menu, find option 2 Database address. It will let you create the database address input file, called `dbpath.inp`. This file contains the absolute path to the AURIC database files directory. If AURIC is properly installed on your system, you should never have to select this option. The AURIC interface program automatically creates the database address file with a default setting. If for some reason you need to change the default, selecting this option will activate the screen as shown in Figure 2.4. Note that you MUST use the proper path delimiter for the operating system you are using: use "/" for UNIX, Linux, and Cygwin and use "\" for DOS. After you have entered a new path, AURIC will validate it before returning you to the main menu.

```
AURIC needs to know where its database files are.
The database address is stored in a file called:
dbpath.inp  If you do not have this file and do not
know where the database files are, please see your
system manager.

The file "dbpath.inp" exists in your current
directory. It indicates that the AURIC database
files are located in directory:

    "/.../auric/database/"

Would you like to change it? (y/n) n

This path has been validated.
Writing to file: dbpath.inp
Returning to the main menu.

Press <Enter> to continue...
```

Figure 2.4 Database address screen.

2.5 Geophysical Inputs

You are now ready to select option 3 Geophysical parameters in the main menu. Its objective is to create the geophysical parameters input file, called `param.inp`. After you have selected this option, you will see the geophysical parameters menu as shown in Figure 2.5. It will display a set of default values.

> An experienced user may not wish to start a run with the default parameters every time. To override the default, you must have already created one or more AURIC input files from a previous run. Copy those files into the current directory and the interface program will read their values and display them for further editing.

```
Geophysical Parameters Menu

 1: upper bound of atmosphere (km) =    1000.0
 2: number of altitudes            =       100
 3: year/day (YYDDD)               =     92080
 4: universal time (sec)           =  45000.00
 5: latitude  (deg)                =     30.00
 6: longitude (deg)                =      0.00
 7: edit neutral density scale factors
 8: display derived parameters (F10.7, SZA, etc.)
 x: exit

Enter your choice:
```

Figure 2.5 Geophysical parameters screen.

Altitude Gridding

Option 1 is the upper bound of the model atmosphere (km). It is recommended that you set it at 1000 km. Option 2 is the number of altitude grid points. The altitude grid starts from the atmosphere upper bound and decrements down to the ground. AURIC employs a gridding algorithm which distributes points densely at the lower altitudes and sparsely higher up. A fixed number of points (52) is reserved for altitudes of 115 km and below, so a 100-point altitude grid will put 48 points above 115 km. A total of 100 points is the recommended value. Fewer points may be selected at the expence of lower accuracy.

Date and Time

To give the calendar day, use option 3 to enter the date in YYDDD format. YY is the year in the 20th century, and DDD is the day of the year. Therefore, the date January 10, 1994 will be represented as 94010. For your convenience, program **utils** will convert dates between the YYDDD and MM/DD/YY formats. Currently, AURIC does not accept dates after the 20th century, but it will as soon as the models MSIS and IGRF allow it. IGRF is used calculate the magnetic field parameters. It is limited to the dates on or before Dec. 31, 1994. Therefore, you may not run AURIC for any dates after, until the model is updated. Option 4 is used to enter the time of day in universal time in seconds.

Geoposition

The geoposition is given by option 5 and option 6. To enter a latitude in the southern hemisphere, use a negative value. A latitude of 60° S should be entered as -60.0. Likewise, a negative longitude is taken to represent west longitude. Be sure to enter the latitude and longitude in decimal degrees. For example, a latitude of 23° 30' should be entered as 23.50, not 23.30.

Neutral Density Scaling You have the option to scale the neutral densities. Through option 7, which activates a menu dedicated for density scale factors, you can scale each density species individually.

Derived Parameters At this point, you will have provided all necessary parameters to specify the geophysical environment. Please review them to make sure they are all correct. They may now be applied to obtain the derived parameters, which include F10.7, Ap, solar zenith angle (SZA), and solar local time. To obtain the F10.7 and Ap indices, AURIC utilizes a database supplied by NOAA (National Oceanic and Atmospheric Adminstration). If it successfully locates measured values for the date given, the values be updated automatically. Otherwise, it will give a message indicating a retrieval failure and display a menu for editing/entering the data. In that case, you should look up the measured values from appropriate sources (such as Journal of Geophysical Research) and manually enter their values. The solar zenith angle and solar local time are calculated next.

Exit Geophysical Menu You may now exit this menu. AURIC will display the derived parameters for your inspection. If any of your inputs are invalid, it will show an error message and ask you to reedit accordingly.

```
Density Scale Factors Menu

1: N2 scale factor =  1.00
2: O2 scale factor =  1.00
3: O  scale factor =  1.00
4: O3 scale factor =  1.00
5: NO scale factor =  1.00
6: N  scale factor =  1.00
7: He scale factor =  1.00
8: H  scale factor =  1.00
9: Ar scale factor =  1.00
x: exit

Enter your choice:
```

Figure 2.7 Density scale factors screen

2.6 Viewing Geometry

From the main menu, select option 3 Viewing geometry parameters. Its goal is to create the viewing geometry file, called `view.inp`. After AURIC informs you that a set of default values will be provided, you will see the viewing geometry parameters menu as in Figure 2.9.

Edit a Look Angle

Notice the line that says *Display Mode = Look angles (deg)*. In this case, the numbers on the screen are look (i.e., zenith) angles in degrees (decimal degrees) instead of tangent altitudes. To edit a look angle, select its corresponding index and enter the new value. The look angle is defined as the angle formed by the observer's line-of-sight and the vertical. Therefore a 0° look angle is looking straight up (zenith viewing), and a 180° look angle is looking directly down (nadir viewing).

```
 Viewing Geometry Parameters Menu

 Display Mode = Look angles (deg)
   1: 107.4049    2: 108.0006    3: 108.5778    4:..
   6: 110.2140    7: 110.7319    8: 111.2377    9:..
  11: 112.6905   12: 113.1555   13: 113.6119   14:..
  16: 114.9337   17: 115.3600   18: 115.7796   19:..
  21: 180.0000
   c: change display mode to tangent altitudes
   i: insert a look angle
   d: delete a look angle
   m: input in min/max/delta
   z: observer altitude (km) =   850.00
   x: exit

Enter your choice:
```

Figure 2.9 Viewing geometry screen.

Insert or Delete

To insert a look angle into the existing grid, select option i (i for insert). Upon completion, your new look angle will be displayed in its appropriate position, such that the look angle grid remains in a ascending order. To delete a look angle, select option d (d for delete). It will prompt you for the index of the look angle to be deleted.

Uniform Gridding

If you wish to define a look angle grid with uniform spacings, select option m and AURIC will prompt you to enter the minimum and maximum look angles, then the step size. This feature is more useful when you are in the tangent altitude mode.

Observer's Altitude

Option z enables you to change the observer's altitude in km. AURIC requires the observer to be located between 100 and 10,000 km.

Tangent Altitude

Sometimes you may wish to specify the lines-of-sight in tangent altitudes instead of look angles. You should first select option c (c for change mode), which will change the menu to the tangent altitude mode. Then you can edit/insert/delete the tangent altitudes the same way as you would with the look angles. Due to the nature of tangent altitudes, if one of your look angles is less than 90°, AURIC will not switch to the tangent altitude mode. So you have to work in the look angle mode when looking above 90° ($0 <$ look angle $< 90°$). Finally, you do not have to switch back to the look angle mode in order to exit from this menu.

2.7 Spectral Parameters

From the main menu, you are now ready to select option 5 Spectral parameters. It will create the spectral parameters file, called `spect.inp`. After AURIC informs you that a set of default values will be used, you will see the spectral parameters menu as in Figure 2.10.

Wavelength Region

In this menu, option 1 and option 2 specify the oberver's optical wavelength region in Angstroms. AURIC covers the region from 800 to 10000 Å, of which your region can be a subinterval if desired. AURIC generates synthetic spectra at one Å resolution, but any data you may wish to compare with will likely have a lower resolution. Option 3 lets you specify your instrument resolution in Å. AURIC will smooth the final spectra accordingly.

Temperatures

Option 4 and option 5 are reserved for specifying the rotational and vibrational temperatures (in Kelvin), respectively. The acceptable values are from 200 to 1000 K, and their default values are both 400 K.

2.8 Spectral Features

Although you have specified an optical region of interest and AURIC is able to automatically select the spectral features over this region, you may wish to manually select a portion of them (atomic features whose photons undergo multiple scattering and molecular band systems; note that radiances for optically thin atomic features are always calculated). Some spectral features (e.g. OI 1304 Å, OI1356 Å, and Lyman α) are computationally intensive to produce and may not be of interest to your specific task. To select the spectral features, activate option 6 in the main menu. It is illustrated in Figure 2.11 for dayglow mode.

```
Spectral Parameters Menu

1: starting wavelength (A)      =    800.0
2: stopping wavelength (A)      = 10000.0
3: instrument resolution (A)    =      1.0
4: rotational temperature (K)   =    400.0
5: vibrational temperature (K)  =    400.0
x: exit

Enter your choice:
```

Figure 2.10 Spectral parameters screen.

On top of this menu, your specified wavelength region is displayed. The body of the menu is a listing of pertinent features. These features either reside in the specified wavelength region or overlap it. You are now asked to select the features which AURIC will model. To select a feature, type its corresponding index and an asterisk (*) will appear in front of it. To unselect a feature, again type its index and the asterisk will be removed. If you desire to select all or most of the features, use option a (a for all) which will mark all features selected. Then you just unselect the unwanted features. Similarly, option u (u for unselect) will mark all features unselected.

Note that if you are calculating dayglow or nightglow and your wavelength region includes any or all of the following: OI 1304 Å, OI 1356 Å, OI 1040 Å, OI 1026 Å, OI 989 Å, ArI 1048 Å, ArI 1066 Å, NI 1135 Å, NI 1199 Å, OII 832(3)(4) Å, Lyman α H 1216 Å, or Lyman β H 1026 Å, you have the option to include these emission features. Since calculation of radiances for these emission features requires computationally intensive radiative transport, it is recommended that you only select them if necessary.

```
Available features for wavelength region
[800,10000] Angstrom.

A selected feature has a * designation in front of
it. Choosing a feature for the first time will mark
it selected. Choosing it again will unselect it.

 1:  O+e 1304 A + O2+e 1304 A
 2:  O+e 1356 A + O2+e 1356 A
 3:  1040 A
 4:  1026 A
 5:  989 A
 6:  1048 A
 7:  1066 A
 8:  1135 A
 9:  1199 A
10:  O+hv 832 A + O+e 832 A
11:  O+hv 833 A + O+e 833 A
12:  O+hv 834 A + O+e 834 A
13:  Lyman Alpha H 1216 A
14:  Lyman Beta H 1025 A
15:  N2 Lyman-Birge-Hopfield (LBH)
16:  N2 Vegard Kaplan (VK)
17:  N2 First Positive (1PG)
18:  N2 2nd Positive (2PG)
19:  N2+ 1st Negative (1NG)
20:  N2+ Meinel
21:  NO Bands (Gamma, Delta, Epsilon)
 a:  Select all features
 u:  Unselect all features
 x:  Exit

Enter your choice:
```

Figure 2.11 Dayglow spectral features screen.

2.9 Create Batch File

By now you should have specified all the inputs necessary to make an AURIC run, interactively or in batch. From the main menu, selecting option 7 will create a batch file. A new user should opt for the batch run as there is less chance for error. After the batch file is created, AURIC will display instructions on how to execute the batch file. Figure 2.12 show an example in UNIX.

```
You have just created the batch file: onerun.sh
Now you are ready to execute it.
After you exit this user interface program, type
the following:

  % source onerun.sh

where % is taken to be a typical UNIX prompt.

The instruction you are reading is stored in a
file: runbatch.txt

Returning to the main menu.

Press <Enter> to continue...
```

Figure 2.12 Batch run instruction screen.

```
    Main Menu

 1: *Introduction
 2: *Database address
 3: *Geophysical parameters
 4: *Viewing geometry parameters
 5: *Spectral parameters
 6: *Select spectral features
 7: *Create a batch file
 8: *Create radtrans option file
 9: *Create lyman alpha option file
10: *Create lyman beta option file
 x:  Exit

 Enter your choice: x

 Normal exit from program INPHELP


 Would you like to start the AURIC batch execution
 now? (y/n)
n
```

Figure 2.13 Exit the main menu screen.

2.10 Options File

Option 8 is intended to give experienced users more control of the radiative transport portion of the AURIC package. The options file contains many switches which govern the radiative transport calculations of optically thick emission features. Since radiative transport is computationally intensive, the user may wish to forego calculations of these emission features if not absolutely required.

Using the options file, only the desired radiative transport features are considered. The user is advised to read screen output of program **radtrans** since it reports if calculations have been turned off by the options file

2.11 Lyman Parameter Files

Options 9 and 10 are intended to give experienced users more control of the Lyman α 1216 Å and Lyman β 1026 Å portions of the AURIC package, repsectively.

2.12 Exit Interface

You are now ready to exit the user interface program. Select option x exit and AURIC will prompt you whether you would like to start the batch file (Figure 2.13). If you answer yes, the batch run will begin foreground execution immediately. If you answer no, it is then up to you to activate the batch file at your convenience (recall the instructions are stored in the file: `runbatch.txt`).

Chapter 3 - Input Files

3.1 Overview

AURIC is designed to be completely driven by input files. This minimizes interactions with the user during the execution stage. There are several AURIC input files and their accuracy and integrity are essential. Most of the work in using AURIC lies in creating these input files properly. The easiest way to produce them is to invoke the user interface program, as described in chapter 2. It will ensure that all inputs are within allowable limits and consistent. While the user interface is perfectly suitable to handle a few AURIC runs in short time, if you wish to make many runs, from hundreds to even thousands, it will take too long to rely on the user interface program. You should consider creating the input files externally. It is simple to write a small program in any language to automatically generate all of the needed input files. For that purpose, this chapter describes each of the AURIC input files in detail, with special attention on the file structures and formats.

> All AURIC input files are written in ASCII so that they can be modified with any text editor.

3.2 Database Address File

Name `dbpath.inp`

This input file contains the absolute path to the directory where the AURIC database files reside. The database files are a set of data files whose contents are completely invariant of the user's input parameters. The user is strongly urged not to modify any of the AURIC database files.

When editing the database address file, be sure there are no leading blanks. In addition, the path must end with a proper delimiter for your operating system. Figure 3.1 gives some examples.

3.3 Geophysical Parameters File

Name `param.inp`

This file contains the geophysical parameters used in AURIC. Together, these parameters specify the model's physical environment such as the atmosphere composition. Figure 3.2 shows a sample file.

```
/home/smith/auric/database/
```

```
c:\auric\database\
```

Figure 3.1 Sample database address file for UNIX/Linux and Windows, respectively. Note they are all exactly one line long.

When modifying this file, it is essential that the given parameter identifiers be left unaltered. Each parameter is uniquely specified by its identifier which appears after its value. Each row should contain exactly one numerical value followed by the identifier followed by an optional one-line description.

Some parameters in this file are derived from others. The solar zenith angle (`SZA`), solar local time (`SLT`), and geomagnetic parameters (`GMLAT, GMLON, DPANG`) can all be derived from the geoposition (`GLAT, GLON`) and time (`YYDDD, UTSEC`). Additionally, the solar activity and magnetic activity indices (F10.7's and Ap's) can be retrieved from a database of measurements using the date and time. Such derived parameters are generated by either program **geoparm** or **auric** (user interface). However, sometimes the AURIC database cannot provide the F10.7 and Ap measurements for the date specified. Then it becomes the user's responsibility to supply the needed values. The user can, of course, modify the derived parameters but is discouraged from doing so.

AURIC utilizes a database file provided by NOAA (National Oceanic and Atmospheric Administration). It contains the daily measurements of F10.7's and Ap's from 1947 through 1999.

> Important! Although the user does not have to specify values for all parameters in this file, a temporary value should be entered rather than leaving a parameter blank.

```
Mandatory parameters:
       100   NALT        : number of altitude points
    1000.0   ZUB         : upper bound of atmosphere
     87120   YYDDD       : year & day (YYDDD format)
       0.0   UTSEC       : universal time (sec)
     30.00   GLAT        : latitude (deg)
      0.00   GLON        : longitude (deg)
      1.00   SCALE(N2)   : N2 density scale factor
      1.00   SCALE(O2)   : O2 density scale factor
      1.00   SCALE(O)    : O  density scale factor
      1.00   SCALE(O3)   : O3 density scale factor
      1.00   SCALE(NO)   : NO density scale factor
      1.00   SCALE(N)    : N  density scale factor
      1.00   SCALE(He)   : He density scale factor
      1.00   SCALE(H)    : H  density scale factor
      1.00   SCALE(Ar)   : Ar density scale factor
Derived parameters:
     33.33   GMLAT       : geomagnetic latitude (deg)
     75.76   GMLON       : geomagnetic longitude (deg)
     40.75   DPANG       : magnetic dip angle (deg)
     29.52   SZA         : solar zenith angle (deg)
     12.38   SLT         : solar local time (hours)
    167.20   F10DAY      : F10.7 (current day)
    166.10   F10PRE      : F10.7 (previous day)
    179.00   F10AVE      : F10.7 (81-day average)
      4.12   AP(1)       : daily Ap
      3.00   AP(2)       : 3-hour Ap
      3.00   AP(3)       : 3-hour Ap
      6.00   AP(4)       : 3-hour Ap
      3.00   AP(5)       : 3-hour Ap
      3.62   AP(6)       : average 3-hour Ap
     13.25   AP(7)       : average 3-hour Ap
```

Figure 3.2 Sample geophysical parameters file.

Altitude Grid

AURIC has a customized algorithm that generates the altitude grid so there are more grid points where the peak of emission is occuring. `NALT` is the number of altitude points specified by the user. `ZUB` represents the atmosphere upper bound (in km). Setting `ZUB` to 1000 km is sufficient for most applications.

Date and Time

The `YYDDD` parameter contains the calendar date in the YYDDD format. YY represent the year in the 20th century while DDD is the day of the year. For instance, January 2, 1993 will be denoted as 93002. Program **utils** will help you to convert date between YYDDD and MM/DD/YY formats. `UTSEC` is the universal time in seconds. Note that AURIC only supports YYDDD values between 47001 and 99365. YYDDD values outside of this range will produce a warning message and request the user to input geophysical parameters that cannot be extracted from data files.

Geoposition

The geoposition is specified by GLAT and GLON. GLAT is the geodetic latitude. A positive value denotes the northern hemisphere while a negative value denotes the southern hemisphere. GLON is the geodetic longitude. A positive value denotes east while a negative value denotes west.

Scale Neutral Densities

The density scale factors enable you to scale each neutral density profile individually.

Derived Parameters

The following parameters are all “derived parameters” which are provided by the program **geoparm** or **auric**. GMLAT and GMLON are the geomagnetic latitude and longitude. DPANG is the magnetic dip angle. SZA is the solar zenith angle and SLT is the solar local time.

F10DAY, F10PRE, and F10AVE are the 10.7 cm flux inputs to the MSIS and solar EUV models. F10DAY is the 10.7 cm flux for the day specified by YYDDD. F10PRE is the 10.7 cm flux for the previous day. F10AVE is an 81-day running average centered on the day specified by YYDDD.

The seven AP indices are inputs to the MSIS model and may be entered as a daily index or a series of 3-hour values. Both the 10.7 cm flux and the AP indices are retrieved from the NOAA database.

If only the daily Ap is desired, its value should be entered into AP(1), and -1 should be assigned to AP(2) (AP(3)...AP(7) are ignored). To use the 3-hour ap indices, enter values for AP(1)...AP(7) in the following manner:

AP(1) = daily Ap.
AP(2) = 3-hour ap index for current time.
AP(3) = 3-hour ap index for 3 hours before current time.
AP(4) = 3-hour ap index for 6 hours before current time.
AP(5) = 3-hour ap index for 9 hours before current time.
AP(6) = average of 8 3-hour ap indices from 12 to 33 hours prior to current time.
AP(7) = average of 8 3-hour ap indices from 36 to 57 hours prior to current time.

PARAMETER	LOWER	UPPER	UNITS

NALT	70	100	N/A
ZUB	500	1500	km
YYDDD	47001	99365	N/A
UTSEC	0	86399	seconds
GLAT	-90	90	degrees (decimal)
GLON	-360	360	degrees (decimal)
SCALE(N2)	0.5	2.0	dimensionless
SCALE(O2)	0.5	2.0	dimensionless
SCALE(O)	0.1	10.0	dimensionless
SCALE(O3)	0.1	10.0	dimensionless
SCALE(NO)	0.01	100.0	dimensionless
SCALE(N)	0.1	10.0	dimensionless
SCALE(He)	0.1	10.0	dimensionless
SCALE(H)	0.1	10.0	dimensionless
SCALE(Ar)	0.1	10.0	dimensionless
GMLAT	-90	90	degrees (decimal)
GMLON	-360	360	degrees (decimal)
DPANG	0	90	degrees (decimal)
SZA	0	90	degrees (decimal)
SLT	0	24	hours (decimal)
F10DAY	67	350	dimensionless
F10PRE	67	350	dimensionless
F10AVE	67	350	dimensionless
AP(1)	0	250	dimensionless
AP(2)	0†	250	dimensionless
AP(3)	0†	250	dimensionless
AP(4)	0†	250	dimensionless
AP(5)	0†	250	dimensionless
AP(6)	0†	250	dimensionless
AP(7)	0†	250	dimensionless

† Entering -1 in AP(2) - AP(7) causes AURIC to use the daily Ap value given in AP(1).

Table 3.1 Ranges and physical units for geophysical parameters.

3.4 Viewing Geometry File

Name `view.inp`

This file contains the observer's viewing geometry specifications, including the observing altitude and look angles. Figure 3.3 shows a sample file.

```
   500.0000   observer altitude (km)
    90.00000
    93.09067
    94.37138
    95.35452
    96.18361
    96.91432
    97.57517
    98.18314
    98.74920
    99.28106
    99.78428
   100.26308
   100.72076
   101.15988
   101.58257
   101.99055
   102.38532
   102.76806
   103.13982
   103.50154
   103.85397
   104.19785
   104.53374
   104.86221
   105.18372
   105.49873
   105.80761
   106.11071
   106.40836
   106.70085
   106.98846
   107.27141
   107.54993
   107.82423
   108.09452
   108.36095
   108.62370
   108.88292
   109.13876
   109.39137
   109.64083
   109.88728
   110.13084
   110.37162
   110.60969
   110.84516
```

Figure 3.3 Sample viewing geometry file

As with the geophysical parameters file, the file format is important. The first record must contain the observer's altitude in kilometers. It must be between 100 and 10,000 km. As shown in Figure 3.3, the look angles follow the observer's altitude. There must be at least one and at most 100 look angle values in the file.

Each look angle must be placed on its own row, free-formatted. Look angles must be between 0° (zenith viewing) and 180° (nadir viewing).

The order of the look angles is not significant nor are their step increments. However, for plotting purposes, it is suggested that the look angle values increase monotonically.

3.5 Spectral Parameter File

Name `spect.inp`

This file contains the input parameters for the synthetic spectra modules. Parameters include the user's selected wavelength interval (Å), instrument resolution (Å), rotational temperature (K), and vibrational temperature (K). Figure 3.4 shows a sample file. The starting and stopping wavelengths of the wavelength interval must be on the first and second row, respectively. The wavelength interval must lie entirely within the interval from 800 to 10000 Å. The instrument resolution must be an integer greater than or equal to one and less than or equal to 51. The instrument resolution must be odd. If an even number is entered, the smoothing function will increment it by one Å. The last two rows of the file contain the rotational and vibrational temperatures in degrees Kelvin (use of default values is strongly recommended).

```
   800.0  starting wavelength     (A)
 10000.0  stopping wavelength     (A)
     1.0  wavelength grid spacing (A)
     1.0  instrument resolution   (A)
   400.0  rotational temperature  (K)
   400.0  vibrational temperature (K)
```

Figure 3.4 Sample spectral parameter file

3.6 RADTRANS Options

Name `radtrans.opt`

This file contains options which enable the user to toggle (ON/OFF) radiative transport calculations for individual atomic lines. It is created by the user interface program. A sample file is shown in Figure 3.5. It can be modified with a text editor.

```
Options for code RADTRANS:
------------------------------------------------------
Radiative Transport (ON/OFF)
         832  = ON
         833  = ON
         834  = ON
         1304 = ON
         1356 = ON
         1040 = ON
         1026 = ON
         989  = ON
         1048 = ON
         1066 = ON
         1135 = ON
         1199 = ON
------------------------------------------------------
```

Figure 3.5 Sample RADTRANS options file

3.7 Lyman Parameters

Name `ly_alpha.opt` and `ly_beta.opt`

These files contain ancillary parameters which provide interested users with more control of the Lyman alpha and Lyman beta codes. They are created by the user interface program. A sample `ly_alpha.opt` file is shown in Figure 3.6. It can be modified with a text editor.

```
Ancillary Lyman alpha evaluation parameters:
1000.0   SATT  : definition depends on IGEO value
  -1.0   SATD  : definition depends on IGEO value
  90.0   ZAZI  : LOS azimuth with respect to
                 solar direction (deg)
  -1.0 LYALCF  : solar lyman alpha line center
                 flux (if > 0)
  -1.0  D_EXO  : exobase [H] density (if > 0)
  -1.0   FLUX  : [H] vertical diffusive flux (if > 0)
  -1.0  D_MAX  : mesospheric peak [H] (if > 0)
```

Figure 3.6 Sample `ly_alpha.opt` parameter file

IGEO — Flag for selecting the manner in which the MSIS-90 thermospheric profile for atomic hydrogen densities is extended to higher altitudes.

SATT — IGEO=1: SATT is the effective satellite component exobase temperature (K).
IGEO=0: SATT is the satellite critical radius in planetary radii.

SATD — IGEO=1: SATD is the effective satellite component exobase density (cm^{-3}). The default value for SATD is -1.0, in which case SATD is set equal to the MSIS-90 H- atom density at the exobase (464 km) and SATT is set equal to the MSIS-90 exobase temperature. If SATD > 0.0, then that value of SATD and the values of SATT are used.

IGEO=0: SATD is ignored.

ZAZI — Line-of-sight azimuth with respect to the solar direction. For ZOBS < 1000 km, the default value (ZAZI = 90.0) is sufficient..

LYALCF — Solar Lyman alpha line center flux. If LYALCF < 0.0, then the value is obtained from the scaled Hinterreger reference flux. If LYALCF > 0.0, then the entered value is used.

Chapter 4 - Programs

4.1 Introduction

For each AURIC stand-alone program, this chapter shows its name, purpose, and corresponding input/output files.

4.2 Program Descriptions

User Interface	name	**auric** or **auric.sh**
	purpose	Interacts with the user to get input parameters and creates the appropriate AURIC input files.
	input file(s)	`dbpath.inp, param.inp, view.inp, spect.inp`
	output file(s)	`dbpath.inp, param.inp, view.inp, spect.inp, option.inp, lyman.inp, runbatch.txt, onerun.bat`
	comment	This module is a combination of a shell script file (**auric.sh**) and a Fortran executable file (**inphelp)**.
Geophys. Parameters	name	**geoparm**
	purpose	Calculates geophysical parameters (geomagnetic coordinates, magnetic dip angle, solar zenith angle and solar local time). Upon the user's approval, **geoparm** retrieves the solar and magnetic activity indices from a database.
	input file(s)	`dbpath.inp, param.inp`
	output file(s)	`param.inp`
Neutral Atmosphere	name	**atmos**
	purpose	Produces a model atmosphere (neutral density and temperature) using the Naval Research Laboratory NRLMSISE-00 and the SHARC model.
	input file(s)	`dbpath.inp, param.inp`
	output file(s)	`atmos.dat`
Ionosphere	name	**ionos**
	purpose:	Produces an electron density profile using the FAIM (Fully Analytical Ionospheric Model) model.
	input file(s)	`param.inp, atmos.dat`
	output file(s)	`ionos.dat`
	name	**getpim**
	purpose	Converts a PIM (Parameterized Ionospheric Model) electron density profile to AURIC format.
	input file(s)	PIM output EDP file, `param.inp, atmos.dat`

	output file(s)	`ionos.dat`
	comment	Programs **ionos** and **getpim** should not be used together in a single run.
Solar EUV Irradiance	name	**solar**
	purpose	Produces a solar EUV irradiance spectrum for the Hinteregger wavelengths.
	input file(s)	`dbpath.inp, param.inp`
	output file(s)	`solar.dat`
Slant Column Densities	name	**colden**
	purpose	Calculates slant column densities for solar zenith angle in param.inp.
	input file(s)	`param.inp, atmos.dat`
	output file(s)	`colden.dat`
Photoelectron Source Function	name	**pesource**
	purpose	Calculates the photoelectron source function, photoionization rates, photo-dissociation rates, and associated volume emission rates.
	input file(s)	`dbpath.inp, atmos.dat, colden.dat, solar.dat`
	output file(s)	`attsolar.dat, pesource.dat, photoion.vpr, pdis.vpr, photo.ver, photode.dat`
Photoelectron Flux	name	**peflux**
	purpose	Calculates the photoelectron flux.
	input file(s)	`dbpath.inp, param.inp, atmos.dat, ionos.dat, pesource.dat`
	output file(s)	`peflux.dat`
Photoelectron Flux	name	**eflux**
	purpose	Calculates the photoelectron flux including vertical transport. Code **eflux** should be run instead of code **peflux** if the solar zenith angle exceeds 60 degrees. Note that the output file must be manually renamed to `peflux.dat` in order to use the calculated fluxes in subsequent calculations.
	input file(s)	`dbpath.inp, param.inp, atmos.dat, ionos.dat, pesource.dat`
	output file(s)	`eflux.dat, escape.dat`
Photoelectron Impact	name	**e_impact**

Excitation	purpose	Integrates cross sections times photoelectron flux to obtain volume emission rates and volume production rates.
	input file(s)	`dbpath.inp, atmos.dat, param.inp, peflux.dat`
	output file(s)	`e_impact.ver, chemin.vpr`
Daytime Chemistry	name	**daychem**
	purpose	Calculates time-dependent chemical densities and, where appropriate, corresponding volume emission rates.
	input file(s)	`dbpath.inp, param.inp, atmos.dat, photoion.dat, pdis.vpr, chemin.vpr`
	output file(s)	`chemout.ver, chemden.dat`
Merge All Volume Emission Rates	name	**mergever**
	purpose	Places all volume emission rates (from multiple sources) into a single file.
	input file(s)	`e_impact.ver, chemout.ver, photo.ver`
	output file(s)	`dayglo.ver`
Line-of-Sight Column Density	name	**losden**
	purpose	Calculates line-of-sight column densities of N_2^+ and NO if daytime or Herzberg I, Herzberg II, and Chamberlain if nighttime.
	input file(s)	`param.inp, view.inp, atmos.dat, colden.dat, chemden.dat, o2synden.dat`
	output file(s)	`losden.dat`
Radiative Transport	name	**radtrans**
	purpose	Calculates column emission rates for optically thick emission features (day or night).
	input file(s)	`dbpath.inp, param.inp, view.inp, atmos.dat, ionos.dat, dayglo.ver, niteglo.ver, radtrans.opt`
	output file(s)	`dayglo.ver, niteglo.ver, dglthick.int, nglthick.int`
Line-of-sight Integrator	name	**losint**
	purpose	Calculates column emission rates for optically thin emission features (day or night).
	input file(s)	`dbpath.inp, param.inp, view.inp, atmos.dat, dayglo.ver, niteglo.ver`
	output file(s)	`dglthin.int, nglthin.int`

Lyman Alpha	name	**ly_alpha**
	purpose	Calculates H Lyman Alpha 1216 Å column emission rates.
	input file(s)	`dbpath.inp, param.inp, view.inp, ly_alpha.opt`
	output file(s)	`ly_alpha.int, lyman_db.alpha`
Lyman Beta	name	**ly_beta**
	purpose	Calculates H Lyman Beta 1026 Å column emission rates.
	input file(s)	`dbpath.inp, param.inp, view.inp, ly_beta.opt`
	output file(s)	`ly_beta.int, lyman_db.beta`
Merge All Column Emission Rates	name	**mergeint**
	purpose	Places all column emission rates (from multiple sources) into a single file.
	input file(s)	`dglthin.int, dglthick.int, nglthin.int, nglthick.int, ly_alpha.int, ly_beta.int`
	output file(s)	`dayglo.int, niteglo.int`
N_2 LBH	name	**syn_lbh**
	purpose	Produces N_2 Lyman-Birge-Hopfield spectra in Rayleigh $Å^{-1}$.
	input file(s)	`dbpath.inp, spect.inp, dayglo.int`
	output file(s)	`n2_lbh.syn`
N_2 VK	name	**syn_vk**
	purpose	Produces N_2 Vegard-Kaplan spectra in Rayleigh $Å^{-1}$.
	input file(s)	`dbpath.inp, spect.inp, dayglo.int`
	output file(s)	`n2_vk.syn`
N_2 1PG	name	**syn_1pg**
	purpose	Produces N_2 First Positive spectra in Rayleigh $Å^{-1}$.
	input file(s)	`spect.inp, dayglo.int`
	output file(s)	`n2_1pg.syn`
N_2 2PG	name	**syn_2pg**
	purpose	Produces N_2 Second Positive spectra in Rayleigh $Å^{-1}$.
	input file(s)	`dbpath.inp, spect.inp, dayglo.int`
	output file(s)	`n2_2pg.syn`

N_2^+ 1NG	name	**syn_1ng**
	purpose	Produces N_2^+ First Negative spectra in Rayleigh Å^{-1}.
	input file(s)	`dbpath.inp, spect.inp, losden.dat`
	output file(s)	`n2p_1ng.syn`
N_2^+ MNL	name	**syn_mnl**
	purpose	Produces N_2^+ Meinel spectra in Rayleigh Å^{-1}.
	input file(s)	`dbpath.inp, spect.inp, losden.dat`
	output file(s)	`n2p_mnl.syn`
NO Bands	name	**syn_no**
	purpose	Produces NO band (δ, γ, ε) spectra in Rayleigh Å^{-1}.
	input file(s)	`dbpath.inp, spect.inp, losden.dat`
	output file(s)	`no_bands.syn`
O_2 Atmospheric	name	**syn_atm**
	purpose	Produces O_2 Atmospheric (0-0) band spectra in Rayleigh Å^{-1}.
	input file(s)	`dbpath.inp, spect.inp, niteglo.ver`
	output file(s)	`o2_atm.syn`
O_2 Nightglow	name	**syn_o2**
	purpose	Produces O_2 Herzberg and Chamberlain nightglow spectra in Rayleigh Å^{-1}.
	input file(s)	`dbpath.inp, spect.inp, losden.dat`
	output file(s)	`o2_nglow.syn`
Merge synthetic spectra	name	**mergesyn**
	purpose	Places all spectra (from multiple sources) into a single file.
	input file(s)	`param.inp, view.inp, spect.inp, n2_lbh.syn, n2_vk.syn, n2p_1pg.syn, n2_2pg.syn, n2_1ng.syn, n2_mnl.syn, no_bands.syn, o2_atm.syn, o2_nglow.syn, dayglo.int, niteglo.int`
	output file(s)	`merge.syn`
Nightglow Volume Emission Rates	name	**niteglo**
	purpose	Calculates nightglow volume emission rates.
	input file(s)	`dbpath.inp, atmos.dat, ionos.dat`
	output file(s)	`niteglo.ver`

4.3 Utility Program — This program provides miscellaneous utilities for AURIC users.

name	**utils**
purpose	Performs a miscellaneous set of functions useful to AURIC users. They include: (1) Display current AURIC version and date released. (2) Display the boundary dates in the geophysical measurements database. (3) Calculate Q_{EUV} for a given band in the incident solar flux. (4) Scale a given wavelength region in the incident solar flux spectrum to a new Q_{EUV} value or scale entire region. (5) Convert a calendar date from MM/DD/YY to YYDDD format. (6) Convert a calendar date from YYDDD to MM/DD/YY format. (7) Convert look angles to tangent altitudes. (8) Calculate integrated radiance over specified wavelength region. (9) Convert spectra from Rayleigh $Å^{-1}$ to Watt cm^{-2} $ster^{-1}$ $(cm^{-1})^{-1}$
input file(s)	dependent on application.
output file(s)	dependent on application.

Chapter 5 - AURIC in UNIX/Linux

5.1 Overview

This chapter gives a tutorial on how to make an AURIC run in an UNIX or Linux environment. Although there exist many varieties of UNIX implementations, such as Sun, SGI, IBM, their differences should be transparent to an user running AURIC. Therefore, this section should serve well for most UNIX users, regardless of their specific environment. AURIC has been tested on a number of UNIX platforms; see Appendix B for a complete listing. In this chapter, instruction begins in Sections 5.2, 5.3, and 5.4 with an introduction to the UNIX operating system which emphasizes the commands necessary for running AURIC**.** Directions for setting up a run follow in Section 5.5. Finally, Section 5.6 lists a complete sample session.

This tutorial assumes that the user has a basic understanding of computer systems. The user need not have experience with UNIX, but is expected to be familiar with the concepts of file and directory creation and management in general. Specific UNIX commands for these operations are discussed. It is expected that AURIC has been properly installed on the user's system.

5.2 Introduction to UNIX

The following sections introduce the user to the basic UNIX commands necessary for the successful execution of AURIC codes. In places where a command is entered at the prompt, the percent sign (%) is used as a symbol for a typical UNIX prompt. Commands are shown in lower case and in `Courier Font`. The mandatory user inputs are in *italics*. Brackets, "`[`" and "`]`", are used to denote any optional inputs, as in:

% `command` [*option*] *argument*

where *option* is optional, but *argument* is not.

This guide should only be used as a summary of UNIX commands used most frequently while running AURIC. For further information, the UNIX operating system offers an on-line help manual that may be invoked by the following command at the prompt:

% `man` *commandname*

where *commandname* is the actual name of the command for which help is desired.

5.3 Directory and File Management

Most operating systems have a set of commands for the creation and management of directories and files. For AURIC execution, the user should first know how to create, delete, and navigate between directories.

Changing Directories

Changing directories in UNIX is accomplished with the `cd` command. Windows users will find the UNIX `cd` command similar to its Windows counterpart. The syntax for the command is:

% `cd` [*directory*]

where *directory* represents an absolute or relative path name to the target directory. Note that the *directory* argument is optional. Entering `cd` without an argument returns the user to his home directory.

Directories may contain subdirectories. The syntax of the directory path is important in reaching the desired destination. For example, to get to the `database` subdirectory in the `auric` subdirectory, use the command:

% `cd auric/database`

where the `auric` directory is below the current directory. Note that directories descend from left to right in the path name and that directory names are separated by a foreslash. In general, to move down to the nth directory, enter the command:

% `cd` *directory1/directory2/directory3/.../directoryn*

To move to the parent directory, enter the command:

% `cd` ..

where ".." denotes the parent directory. For further information on the `cd` command, use the `man` command to access the on-line help manuals.

Creating and Deleting Directories

Directories may be created and removed by the commands `mkdir` (for make directory) and `rmdir` (for remove directory), respectively. The syntax for these commands is as follows:

% `mkdir` *dirname*

% `rmdir` *dirname*

where *dirname* is the name of the directory to be created or deleted. In the above example, subdirectory *dirname* is created in the current directory. To create a new directory elsewhere, use the `cd` command to move to the location first, then create the directory with `mkdir`. Command `rmdir` will not remove a directory if it is not empty. For further information on these commands use the `man` command to read the on-line help manuals.

Copying File

To copy a file in UNIX, use the `cp` command. Its syntax is demonstrated below:

% `cp` *filename dirname*

where *filename* is the name of the file to be copied, and *dirname* is its destination directory. This form of the `cp` command preserves the file name, meaning that the new file will retain the name of the original file.

Removing File

UNIX offers the `rm` command for removing unwanted files. The `rm` command is used as follows:

% `rm` *filename*

where *filename* is the name of the file, including any directory path information as well as any of the shorthand symbols mentioned. For example,

% `rm test.dat`

removes the file `test.dat` from the current directory.

5.4 Wildcards

UNIX has several shorthand symbols for uses in changing directories and managing files. The tilde symbol (~) represents the directory path to the user's home directory. When used with the `cd`, (~) moves the user from any location to his home directory. The command `cd` when entered without input performs the same function. However, in other UNIX commands, the (~) symbol is useful for accessing directories below the home directory. The period or dot (`.`) represents the directory path to the current directory. Likewise, the double-dot (..) represents the path to the current directory's parent. When used with `cd`, it moves the user up to the parent directory. These symbols may be used in conjunction with directory names. For example,

```
% cd ~/auric/database
```

moves the user directly to the `database` directory, where `auric` is a subdirectory under the user's home directory.

An additional symbol useful for file and directory manipulation is the (*) or wildcard symbol. When used with a `cp` or `rm` command, the (*) symbol can be substituted for characters in the filename. The wildcard (*) matches any string. For example, the `cp` command most often employed by AURIC users is as follows:

```
% cp ~/auric/*.inp .
```

which copies any file located in the sample run directory and with extension `.inp` to the current directory. The destination (`.`), however, signifies the current directory. The (*) symbol may be used with the `rm` command as well, but the user is advised to use extreme caution. It is quite easy to delete files unknowingly when the (*) symbol is used indiscriminately.

WARNING! Windows users should note that the wildcard symbol behaves differently in UNIX. A command such as:

% cp ~/main/* *

which uses the wildcard as a target destination filename will rename all files to a single target filename, destroying all preceding files.

Any of the special shorthand characters may be used with the `cp` command. For example,

```
% cp ~/auric/view.inp ~/test
```

copies `view.inp` to the `test` directory without changing the file name `view.inp`. Observe that the file name may include directory path information as well as the name of the file to be copied.

5.5 Preparation

To prepare an AURIC run, the user should first create a new directory to save the results. This directory will hold the input and output files used by AURIC. The user must then provide the necessary input files, preferably with the AURIC user interface program.

Editing Input Files

There are several text editors available to the UNIX user for modifying the AURIC input files. The `vi` editor is the standard for the UNIX operating system. For instructions on using the `vi` editor, check the on-line help with the `man` command or ask the system manager for available literature. Other editors may also be available.

Interactive Execution After the work directory and the input files are prepared, the user is ready to execute the AURIC programs. If AURIC has been properly installed, executing the programs should be as easy as entering each program's name. Refer to the software flowcharts in Chapter 1 for the proper execution sequence.

Batch Execution

The batch method for AURIC is particularly useful when the user is making many runs. Rather than entering the AURIC program names at the prompt, one can create a batch file which contains the same commands. The batch file is then executed to make a complete AURIC run. Recall from Chapter 2 that the AURIC user interface should be used to create such a batch file.

Viewing the Output

All AURIC input and output files are written in ASCII format. As a result, all files may be edited using a standard text editor or viewed with a file browser command such as `more`. The output files can also be imported into a graphics package in order to be viewed in plots.

5.6 A Sample Run

This section gives a complete AURIC dayglow run. Recall that AURIC can be executed in both interactive or batch mode. Although the batch mode is recommended for a new user for there is less chance for error, the interactive mode is chosen here for it is better suited for demonstration. The input values used were taken directly from the sample files shown in Chapter 3. The windows to follow display the steps taken, show what is entered at the prompt, and display the output that would appear on the screen.

The following window displays the initial steps prior to execution of the first module. They are:

- Login into an account
- Create a new directory and move there

- Execute program **auric** to set up the input files. This step has been thoroughly described in Chapter 2, so it is not repeated here.

```
login: ******
password: ******

% mkdir test
% cd test
% auric
```

Next, we set up the atmospheric, ionospheric, and solar environment:

- Execute program **atmos** to produce the neutral atmosphere.
- Execute program **ionos** to produce the model ionosphere.
- Execute program **solar** to produce the solar EUV irradiances.
- Execute program **colden** to calculate the slant column densities.

```
% atmos
******************************************************

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******************************************************

 Program ATMOS

 Writing to file: atmos.dat

 Normal exit from program ATMOS

FORTRAN STOP

% ionos
******************************************************

                    AURIC Version 1.2

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******************************************************
```

```
 Program IONOS

 Writing to file: ionos.dat

 Normal exit from program IONOS
```

```
FORTRAN STOP
% solar
*****************************************************
                    AURIC Version 1.2
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*****************************************************
 Program SOLAR
 Using the Hinteregger model.

 Writing to file: solar.dat
 Normal exit from program SOLAR
FORTRAN STOP
% colden
*****************************************************
                    AURIC Version 1.2
Copyright (C) 1997-2002 by Computational Physics Inc.

*****************************************************
 Program COLDEN
 Writing to file: colden.dat
 Normal exit from program COLDEN
FORTRAN STOP
```

We now calculate the photoelectron source function and flux:

- Execute program **pesource** to calculate the photoelectron source function. This program also produces photoionization rates, photo-dissociation rates, and where appropriate, associated volume emission rates.
- Execute program **peflux** to calculate the photoelectron flux.

```
% pesource
*****************************************************
                    AURIC Version 1.2
```

```
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******************************************************

 Program PESOURCE
   100 wavelengths completed
   200 wavelengths completed
   300 wavelengths completed
   400 wavelengths completed
   500 wavelengths completed
   600 wavelengths completed
   700 wavelengths completed
   800 wavelengths completed

 Writing to file: pesource.dat

 Writing to file: photoion.vpr

 Writing to file: pdis.vpr

 Writing to file: photo.ver

 Writing to file: attsolar.dat

 Writing to file: photodep.dat

 Normal exit from program PESOURCE

FORTRAN STOP

% peflux
******************************************************

                    AURIC Version 1.2

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******************************************************

 Program PEFLUX

 Writing to file: peflux.dat

 Normal exit from program PEFLUX

FORTRAN STOP
```

If the solar zenith angle for dayglow conditions exceeds about 60 degrees it is advisable to execute program **eflux** rather than **peflux** to calculate photoelectron flux that include vertical transport. The output file `eflux.dat` from program **eflux** must be renamed to `peflux.dat` if you wish to use the transported photoelectron fluxes as input to program **e_impact**. Note that program **eflux** requires a certain amount of static memory so the following command should be executed before executing **eflux:**

```
% limit stacksize 128M
```

```
Running program Electron_Flux

General message
From : Electron_Flux
Error accessing incident flux file.
Assuming no incident flux.
  Source_Function.Number_Altitudes =   100
  Source_Function.Number_Energies =   205

  Constructing Elastic_Cross_Sections object
  Constructing Inelastic_Cross_Sections object
  Constructing Ionosphere object
  Constructing Atmosphere object

  Performing multi-stream calculations

  Working on energy  7.05000000000000E+02
  Working on energy  6.05000000000000E+02
  Working on energy  5.05000000000000E+02
  Working on energy  4.05000000000000E+02
  Working on energy  3.05000000000000E+02
  Working on energy  2.05000000000000E+02
  Working on energy  1.05000000000000E+02
  Working on energy  4.70000000000000E+01
  Working on energy  2.70000000000000E+01
  Working on energy  7.00000000000000E+00

  writing file eflux.dat...

  writing file escape.dat...

Normal exit from program Electron_Flux
```

We next execute program **e_impact** to calculate production rates by electron impact. One set of rates is used in the chemistry modeling. A second set is used directly for calculating radiances.

```
% e_impact

******************************************************

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******************************************************

 Program E_IMPACT
 Feature = N2+e LBH
 Feature = N2+e 1PG
 Feature = N2+e 2PG
 Feature = N2+e 1493 A
 Feature = N2+e 1743 A
 Feature = O+e 832 A (initial)
 Feature = O+e 833 A (initial)
```

```
 Feature = O+e 834 A (initial)
 Feature = O+e 1304 A (initial)
 Feature = O+e 1356 A (initial)
 Feature = O+e 7774 A
 Feature = O+e 8446 A
 Feature = N+e 1493 A
 Feature = N+e 1743 A
 Feature = O2+e 8446 A
 Feature = O2+e 7774 A
 Feature = O2+e 1304 A (initial)
 Feature = O2+e 1356 A (initial)
 Feature = N2+e 1085 A
 Feature = Ar+e 1048 A (initial)
 Feature = Ar+e 1066 A (initial)
 Feature = N2+e BH1
 Feature = O+e 1026 A triplet (initial)
 Feature = O+e 1026 A doublet (initial)
 Feature = O+e 1026 A singlet (initial)
 Feature = O2+e 1026 A triplet (initial)
 Feature = O2+e 1026 A doublet (initial)
 Feature = O2+e 1026 A singlet (initial)
 Feature = O+e 989 A triplet (initial)
 Feature = O+e 989 A doublet (initial)
 Feature = O+e 989 A singlet (initial)
 Feature = O2+e 989 A triplet (initial)
 Feature = O2+e 989 A doublet (initial)
 Feature = O2+e 989 A singlet (initial)
 Feature = O+e 1040 A (initial)
 Feature = O2+e 1040 A (initial)
 Feature = O+e 1152 A
 Feature = N2+e 1243 A
 Feature = N2+e 1200 A
 Feature = N2+e 1134 A
 Feature = N+e 1199 A (initial)
 Feature = N+e 1135 A (initial)

 Writing to file: e_impact.ver
 Feature = N2+
 Feature = N2 (N+ + N*)
 Feature = O2+
 Feature = O2 -> O+
 Feature = O+(4So)
 Feature = O+(2Do)
 Feature = O+(2Po)
 Feature = N2(A)
 Feature = O(1D) (e + O)
 Feature = O(1S)
 Feature = N2 (N* + N(4So))

 Writing to file: chemin.vpr

 Normal exit from program E_IMPACT

FORTRAN STOP
```

Program **daychem** is now executed to model the time-dependent daytime chemistry.

```
% daychem
```

```
******************************************************

                    AURIC Version 1.2

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******************************************************

 Program DAYCHEM

 Starting the chemical reactions.

 Elapsed model time =   0.25 minutes.
 Elapsed model time =   0.50 minutes.
 Elapsed model time =   1.00 minutes.
 Elapsed model time =   5.00 minutes.
 Elapsed model time =  10.00 minutes.
 Elapsed model time =  20.00 minutes.

 Writing to file: chemden.dat

 Writing to file: chemout.ver

 Normal exit from program DAYCHEM

FORTRAN STOP
```

The next two steps are to place all volume emission rates in the same file and calculate line-of-sight column densities for N_2^+ and NO.

- Execute program **mergever** to incorporate the volume emission rates from different sources into a single file.
- Execute program **losden** to calculate N_2^+ and NO line-of-sight column densities.

```
% mergever

******************************************************

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******************************************************

 Program MERGEVER

 Writing to file: dayglo.ver

 Normal exit from program MERGEVER

FORTRAN STOP

% losden
```

```
*****************************************************

                    AURIC Version 1.2

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*****************************************************

 Program LOSDEN

 Writing to file: losden.dat

 Normal exit from program LOSDEN

FORTRAN STOP
```

Next, execute program **radtrans** to calculate optically thick volume emission rates and column emission rates.

```
% radtrans
*****************************************************

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*****************************************************

 Program RADTRANS

 Working on emission feature 1356 A

 Working on emission feature 1304 A

 Working on emission feature 1040 A

 Working on emission feature 1026 A triplet

 Working on emission feature 1026 A doublet

 Working on emission feature 1026 A singlet

 Working on emission feature 989 A triplet

 Working on emission feature 989 A doublet

 Working on emission feature 989 A singlet

 Working on emission feature 1048 A

 Working on emission feature 1066 A

 Working on emission feature 1135 A

 Working on emission feature 1199 A
```

```
 Working on emission feature 832 A
 Working on emission feature 833 A
 Working on emission feature 834 A
 Writing to file: dayglo.ver
 Writing to file: dglthick.int
 Normal exit from program RADTRANS
```

We now execute program **losint** to calculate optically thin column emission rates.

```
% losint
*******************************************************
                    AURIC Version 1.2
Copyright (C) 1997-2002 by Computational Physics Inc.

*******************************************************
 Program LOSINT
 Writing to file: dglthin.int
 Normal exit from program LOSINT
FORTRAN STOP
```

Program **ly_alpha** is executed to generate Lyman Alpha column emission rates. Recall that this program is computationally intensive and should be activated only if Lyman Alpha is specifically desired.

```
% ly_alpha
******************************************************
                    AURIC Version 1.2
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******************************************************
 Program LY_ALPHA
 Writing to file: ly_alpha.int
 Normal exit from program LY_ALPHA
```

```
FORTRAN STOP
```

Program **ly_beta** is executed to generate Lyman Beta column emission rates. Recall that this program is computationally intensive and should be activated only if Lyman Beta is specifically desired.

```
% ly_beta
*****************************************************
                    AURIC Version 1.2
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*****************************************************
 Program LY_BETA
 Writing to file: ly_beta.int
 Normal exit from program LY_BETA
FORTRAN STOP
```

The next step is to execute program **mergeint** to combine the various column emission rates into a single file.

```
% mergeint
*****************************************************
                    AURIC Version 1.2
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*****************************************************
 Program MERGEINT
 Writing to file: dayglo.int
 Normal exit from program MERGEINT
FORTRAN STOP
```

Total system radiances for N_2 LBH, N_2 VK, N_2 1PG, N_2 2PG, plus slant column densities of N_2^+ and NO have already been calculated in this sample run. The next step is to construct the corresponding synthetic spectra.

- Execute program **syn_lbh** to generate N_2 LBH spectral radiances.
- Execute program **syn_vk** to generate N_2 VK spectral radiances.
- Execute program **syn_1pg** to generate N_2 1PG spectral radiances.
- Execute program **syn_2pg** to generate N_2 2PG spectral radiances.
- Execute program **syn_1ng** to generate N_2^+ 1NG spectral radiances.
- Execute program **syn_mnl** to generate N_2^+ Meinel spectral radiances.
- Execute program **syn_no** to generate NO bands (γ, δ, ε) spectral radiances.

```
% syn_lbh
******************************************************
                    AURIC Version 1.2
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******************************************************
 Program SYN_LBH
 Writing to file: n2_lbh.syn
 Normal exit from program SYN_LBH
FORTRAN STOP
% syn_vk
******************************************************
                    AURIC Version 1.2
Copyright (C) 1997-2002 by Computational Physics Inc.

******************************************************
Program SYN_VK
 Writing to file: n2_vk.syn
 Normal exit from program SYN_VK
FORTRAN STOP
% syn_1pg
******************************************************
```

```
                    AURIC Version 1.2
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*******************************************************

 Program SYN_1PG

 Writing to file: n2_1pg.syn

 Normal exit from program SYN_1PG

FORTRAN STOP

% syn_2pg

*******************************************************

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*******************************************************

Program SYN_2PG

 Writing to file: n2_2pg.syn

 Normal exit from program SYN_2PG

FORTRAN STOP

% syn_1ng

*******************************************************

                    AURIC Version 1.2

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*******************************************************

 Program SYN_1NG

 Writing to file: n2p_1ng.syn

 Normal exit from program SYN_1NG

FORTRAN STOP

% syn_mnl

*******************************************************

                    AURIC Version 1.2

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*******************************************************
```

```
 Program SYN_MNL
 Writing to file: n2p_mnl.syn
 Normal exit from program SYN_MNL
FORTRAN STOP
% syn_no
*****************************************************
                    AURIC Version 1.2
Copyright (C) 1997-2002 by Computational Physics Inc.

*****************************************************
 Program SYN_NO
 Writing to file: no_bands.syn
 Normal exit from program SYN_NO
FORTRAN STOP
```

The final step is to execute program **mergesyn** to combine the various spectral systems into total spectra. It also smoothes the final spectra to the specified instrument resolution.

```
% mergesyn
*****************************************************
                    AURIC Version 1.2
Copyright (C) 1997-2002 by Computational Physics Inc.

*****************************************************
 Program MERGESYN

  Adding spectra from file n2_lbh.syn
  Adding spectra from file n2_vk.syn
  Adding spectra from file n2_1pg.syn
  Adding spectra from file n2_2pg.syn
  Adding spectra from file n2p_1ng.syn
  Adding spectra from file n2p_mnl.syn
  Adding spectra from file no_bands.syn
  Adding 1356 A
  Adding 1304 A
  Adding 1040 A
  Adding 1026 A triplet
  Adding 1026 A doublet
  Adding 1026 A singlet
  Adding 989 A triplet
  Adding 989 A doublet
  Adding 989 A singlet
```

```
Adding 1048 A
Adding 1066 A
Adding 1135 A
Adding 1199 A
Adding 832 A
Adding 833 A
Adding 834 A
Adding N2+e 1493 A
Adding N2+e 1743 A
Adding O+e 7774 A
Adding O+e 8446 A
Adding N+e 1493 A
Adding N+e 1743 A
Adding O2+e 8446 A
Adding O2+e 7774 A
Adding N2+e 1085 A
Adding O+e 1152 A
Adding N2+e 1243 A
Adding N2+e 1200 A
Adding N2+e 1134 A
Adding O+(2Do) hv 3727 A
Adding O+(2Po) hv 2470 A
Adding O+(2Po) hv 7320 A
Adding O+(2Po) hv 7330 A
Adding N(2Do) hv 5200 A
Adding N(2Po) hv 3466 A
Adding O(1D) hv 6300 A
Adding O(1D) hv 6364 A
Adding O(1S) hv 2972 A
Adding O(1S) hv 5577 A
Adding N2+(HP+H)+hv 1743 A
Adding N2+(HP+H)+hv 1493 A
Adding N2+(HP+H)+hv 1412 A
Adding N2+(HP+H)+hv 1327 A
Adding N2+(HP+H)+hv 1319 A
Adding N2+(HP+H)+hv 1310 A
Adding N2+(HP+H)+hv 1243 A
Adding N2+(HP+H)+hv 1200 A
Adding N2+(HP+H)+hv 1177 A
Adding N2+(HP+H)+hv 1168 A
Adding N2+(HP+H)+hv 1134 A
Adding N2+(HP+H)+hv 1100 A
Adding N2+(HP+H)+hv 1098 A
Adding N2+(HP+H)+hv 1068 A
Adding N2+(HP+H)+hv 1054 A
Adding N2+(HP+H)+hv 1043 A
Adding N2+(HP+H)+hv  964 A
Adding N2+(HP+H)+hv  953 A
Adding N2+(HP+H)+hv  910 A
Adding N2+(HP+H)+hv  906 A
Adding N2+(HP+H)+hv  887 A
Adding N2+(HP+H)+hv  876 A
Adding N2+(HP+H)+hv  870 A
Adding N2+(HP+H)+hv  862 A
Adding N2+(HP+H)+hv 2143 A
Adding N2+(HP+H)+hv 2139 A
Adding N2+(HP+H)+hv 1085 A
Adding N2+(HP+H)+hv  916 A
Adding 1641 A
Adding 1172 A triplet
Adding 1172 A doublet
Adding 1172 A singlet
Adding HI 1215 A Lyman alpha
Adding HI 1025 A Lyman beta
```

```
 Smoothing the spectra to a resolution of 1.0 Angstroms...
 Writing to file: merge.syn
 Normal exit from program MERGESYN
FORTRAN STOP
AURIC batch run is completed.
```

Chapter 6 - AURIC in Windows

6.1 Overview

This chapter gives a tutorial on how to make an AURIC run in a Windows environment. Instruction begins in Sections 6.2 through 6.4 with an introduction to the DOS operating system which emphasizes the commands necessary for running AURIC. Directions for setting up an AURIC run follow in Section 6.5.

This tutorial assumes that the user has a basic understanding of computer systems. The user need not have experience with Windows, but is expected to be familiar with the concepts of file and directory creation and management in general. Specific Windows commands for these operations are discussed. It is assumed that AURIC has been properly installed.

It is strongly suggested that the user run AURIC in the Cygwin environment rather than in a DOS window (see http://sources.redhat.com/cygwin/). The Cygwin project provides a bash shell environment that can be used instead of a DOS environment. The Cygwin bash shell provides most UNIX commands so users familiar with UNIX can run AURIC in a familiar environment within Microsoft Windows. Users that wish to run AURIC in DOS should continue reading the following sections. Note that since AURIC is compiled in the Cygwin environment the compiled executables do NOT have a .exe extension and will not execute in DOS. All binary files in the bin directory should be modified to have a .exe extension if the user wishes to run AURIC in DOS.

6.2 Introduction to DOS

The following sections introduce the user to the basic Windows commands necessary for the successful execution of the AURIC codes. In places where a command is entered at a prompt, the "C:\>" character sequence is used as a symbol of a typical Windows prompt. Commands are shown in `lower case` with user-specified inputs in *italics*. Brackets, "[" and "]", are used to show optional command input, as in:

C:\> `command` [*option*] *argument*

where *option* is optional, but *argument* is not.

This guide should only be used as a summary of Windows commands used most frequently while running AURIC. For further information, consult the Windows user's guide.

6.3 Directory and File Management

Most operating systems have a set of commands for the creation and management of directories and files. For AURIC execution, the user should first know how to create, delete, and navigate between directories.

Changing Directories

Changing directories in Windows is accomplished with the `cd` command. UNIX users will find the Windows `cd` command similar to its UNIX counterpart. The syntax for the command is:

C:\> `cd` [*directory*]

where *directory* represents an absolute or relative path name to the target directory. Note that the *directory* argument is optional. Entering `cd` without an argument displays the user's current directory position.

Directories may contain subdirectories. The syntax of the directory path is important in reaching the desired destination. For example, to get to the `data` subdirectory in the `auric` directory, use the command:

C:\> `cd auric\data`

where the `auric` directory is below the current directory. Note that directories descend from left to right in the path name and that directory names are separated by a backslash. In general, to move down to the nth directory, type:

C:\> `cd` *directory1\directory2\directory3\...\directoryn*

To move to the parent directory, enter the command:

C:\> `cd` ..

where ".." denotes the parent directory.

Creating and Deleting Directories

Directories may be created and removed by the commands `md` and `rd`, respectively. The syntax for these commands is as follows:

C:\> `md` *dirname*

C:\> `rd` *dirname*

where *dirname* is the name of the directory to be created or deleted. In the above example, *dirname* is created below the current directory. To create a new directory elsewhere, use the `cd` command to move to the location first, then create the directory with `md`. Note that `rd` will not remove a directory if it is not empty.

Copying and Deleting Files

The Windows commands for file manipulation that the AURIC user may require are `copy` and `del` which copy and delete files respectively. The `copy` command syntax follows:

C:\> `copy` *filename dirname*

where *filename* is the name of the file to be copied and *dirname* is its destination. This form of the `copy` command preserves the filename, meaning that the new copies will retain the name of the original file.

Windows offers the `del` command for deleting unwanted files. The `del` command is used as follows:

C:\> `del` *filename*

where *filename* is the name of the file, including any directory path information as well as any of the shorthand symbols mentioned. For example,

C:\> `del test.dat`

deletes the file `test.dat` from the current directory. Note that the current directory is implied as the location for `test.dat`.

6.4 Wildcards

Windows offers several shorthand symbols for use in changing directories and managing files. The period "." represents the directory path to the current directory. Likewise, a ".." represents the path to the current directory's parent. When used with `cd`, it moves the user up to the parent directory.

An additional symbol useful for file and directory manipulation is the "*" or wildcard symbol. Used with a `copy` or `del` command, the "*" symbol can be substituted for characters in the filename.

The wildcard "*" matches any string. For example, the `copy` command most often employed by AURIC users is as follows:

```
C:\> copy \auric\input\*.inp  .
```

copies any file located in the input directory ending with extensions `.inp` to the current directory. The "*" symbol may be used with the `del` command as well, but the user is advised to use extreme caution. It is quite easy to delete files unknowingly when the "*" symbol is used indiscriminately.

6.5 Running AURIC

To begin an AURIC run, the user should first create a new directory to save the results. This directory will hold the input and output files used by AURIC. Then, the user must provide the input files, preferably with the user interface program.

Editing Input Files

There are many text editors available to the Windows user for modifying the AURIC input files. Any text editor that can read and write ASCII files may be used to modify the AURIC files. The Windows editors, `edlin` or `edit`, should be adequate for most purposes. For help concerning Windows editors, ask the system managers for information or literature.

Interactive Execution

After the work directory and the input files are prepared, the user is ready to execute the AURIC programs. If AURIC has been properly installed, executing the programs should be as easy as entering each program's name. AURIC can be run interactively or in batch mode. Refer to the software flowcharts in Chapter 1 for the execution sequence.

Batch Execution

The batch method for running AURIC is particular useful when the user is making many AURIC runs. Rather than entering the AURIC commands at the "C:\>" prompt, the user may create a batch file which contains the same commands. Recall from Chapter 2 that the AURIC user interface should be used to construct a batch file.

Viewing the Output

All AURIC input and output files are written ASCII format. As a result, all files may be edited using a standard text editor or viewed with a file browser command such as `type`.

6.6 A Sample Run

The reader is referred to section 5.6 for a sample run since the output from AURIC when run in Windows looks very similar to the output obtained when run in UNIX or Linux.

Chapter 7 - Output Files and Plots

Introduction

This chapter gives a complete description of the more pertinent AURIC output files. Also included are examples of output files generated with the sample inputs given in Chapter 3. Each section below provides the name, origin, and contents of an output file. These files are grouped by their order of creation. A generic text format is used by AURIC to output all files. The first line of each file contains the number of independent variable values (e.g. number of altitudes) followed by the number of dependent variable values (e.g. number of neutral constituents) followed by the number of information lines included (if any). The information lines provide additional information which is only relevant to the given file. Following the last information line (if any) is a label for the independent variable (e.g. "Altitudes (km)") then the values for the independent variable. Next is a single line description of the dependent variable (e.g. "Neutral Atmosphere"). If the dependent variable is one-dimensional, the description is followed by a label for the dependent variable and then the corresponding values. If the dependent variable is two-dimensional, the description is followed by groups consisting of a label and then values of the dependent variable which correspond to the label.

The outputs presented in this chapter are the same that appeared in the previous version of the manual. We note this in case the user wishes to make comparisons with these results. While differences may occur, the outputs to follow should not deviate significantly from V1.2 outputs and thus should serve as a useful guide for determining whether the user has properly set the conditions for comparative runs.

7.1 Neutral Atmosphere

file name `atmos.dat`
created by **atmos**
modified by none

The neutral atmosphere file contains an altitude grid (km), neutral temperature (K), and densities (cm^{-3}) of N_2, O_2, O, O_3, NO, N, He, H, and Ar. This file is normally generated by program **atmos**, but it can also be supplied by the user. A sample file is shown in Figure 7.1 and its corresponding plots in Figure 7.2.

Replace Model Atmosphere

It is easy to replace the AURIC model atmosphere. Since the atmosphere is specified by a single file, the user merely has to replace it with another file. You first execute program **atmos** and generate the file `atmos.dat`. Obtain the altitude grid from the file and put the desired atmosphere on this grid. Some interpolation may be required. Be sure your file meets all of the file format specifications as described in the above paragraph. Rename the original file to something else for later use and name the new file `atmos.dat`. Continue the execution of AURIC but be do not run program **atmos** again.

> Very important! The altitude grid in this file must be arranged in descending order, starting with the highest altitude.

```
  100    10
Altitudes (km)
    1000.00      955.94      913.82      873.56      835.07      798.28
     763.11      729.49      697.35      666.62      637.25      609.18
     582.34      556.68      532.15      508.71      486.29      464.87
     444.39      424.81      406.09      388.20      371.10      354.75
     339.12      324.18      309.89      296.24      283.19      270.71
     258.78      247.38      236.48      226.06      216.10      206.58
     197.48      188.78      180.46      172.51      164.91      157.64
     150.70      144.06      137.71      131.64      125.84      120.30
     115.00      114.00      113.00      112.00      111.00      110.00
     109.00      108.00      107.00      106.00      105.00      104.00
     103.00      102.00      101.00      100.00       99.00       98.00
   .
   .
   .
   Neutral Atmosphere
Tn  (K)
  1.215E+03  1.215E+03  1.215E+03  1.215E+03  1.215E+03  1.215E+03
  1.215E+03  1.215E+03  1.215E+03  1.215E+03  1.215E+03  1.215E+03
  1.215E+03  1.215E+03  1.214E+03  1.214E+03  1.214E+03  1.214E+03
  1.213E+03  1.213E+03  1.212E+03  1.211E+03  1.210E+03  1.208E+03
  1.205E+03  1.202E+03  1.198E+03  1.193E+03  1.186E+03  1.178E+03
  1.168E+03  1.156E+03  1.141E+03  1.124E+03  1.103E+03  1.079E+03
  1.051E+03  1.018E+03  9.813E+02  9.392E+02  8.918E+02  8.387E+02
  7.797E+02  7.145E+02  6.430E+02  5.648E+02  4.800E+02  3.839E+02
  2.869E+02  2.724E+02  2.592E+02  2.474E+02  2.368E+02  2.275E+02
  2.194E+02  2.123E+02  2.061E+02  2.008E+02  1.962E+02  1.923E+02
  1.891E+02  1.866E+02  1.846E+02  1.833E+02  1.826E+02  1.824E+02
  .
  .
  .
[N2]
  3.779E+01  9.278E+01  2.212E+02  5.123E+02  1.154E+03  2.527E+03
  5.389E+03  1.119E+04  2.266E+04  4.473E+04  8.619E+04  1.622E+05
  2.982E+05  5.362E+05  9.435E+05  1.626E+06  2.744E+06  4.542E+06
  7.377E+06  1.176E+07  1.843E+07  2.840E+07  4.305E+07  6.427E+07
  9.455E+07  1.372E+08  1.966E+08  2.782E+08  3.895E+08  5.399E+08
  7.416E+08  1.011E+09  1.369E+09  1.844E+09  2.474E+09  3.312E+09
  4.431E+09  5.936E+09  7.981E+09  1.080E+10  1.474E+10  2.041E+10
  2.875E+10  4.151E+10  6.198E+10  9.697E+10  1.623E+11  3.051E+11
  6.807E+11  8.039E+11  9.528E+11  1.133E+12  1.351E+12  1.614E+12
  1.933E+12  2.319E+12  2.786E+12  3.351E+12  4.035E+12  4.862E+12
  5.860E+12  7.060E+12  8.499E+12  1.022E+13  1.226E+13  1.468E+13
  .
```

```
:
:
```

Figure 7.1 Sample neutral atmosphere file.

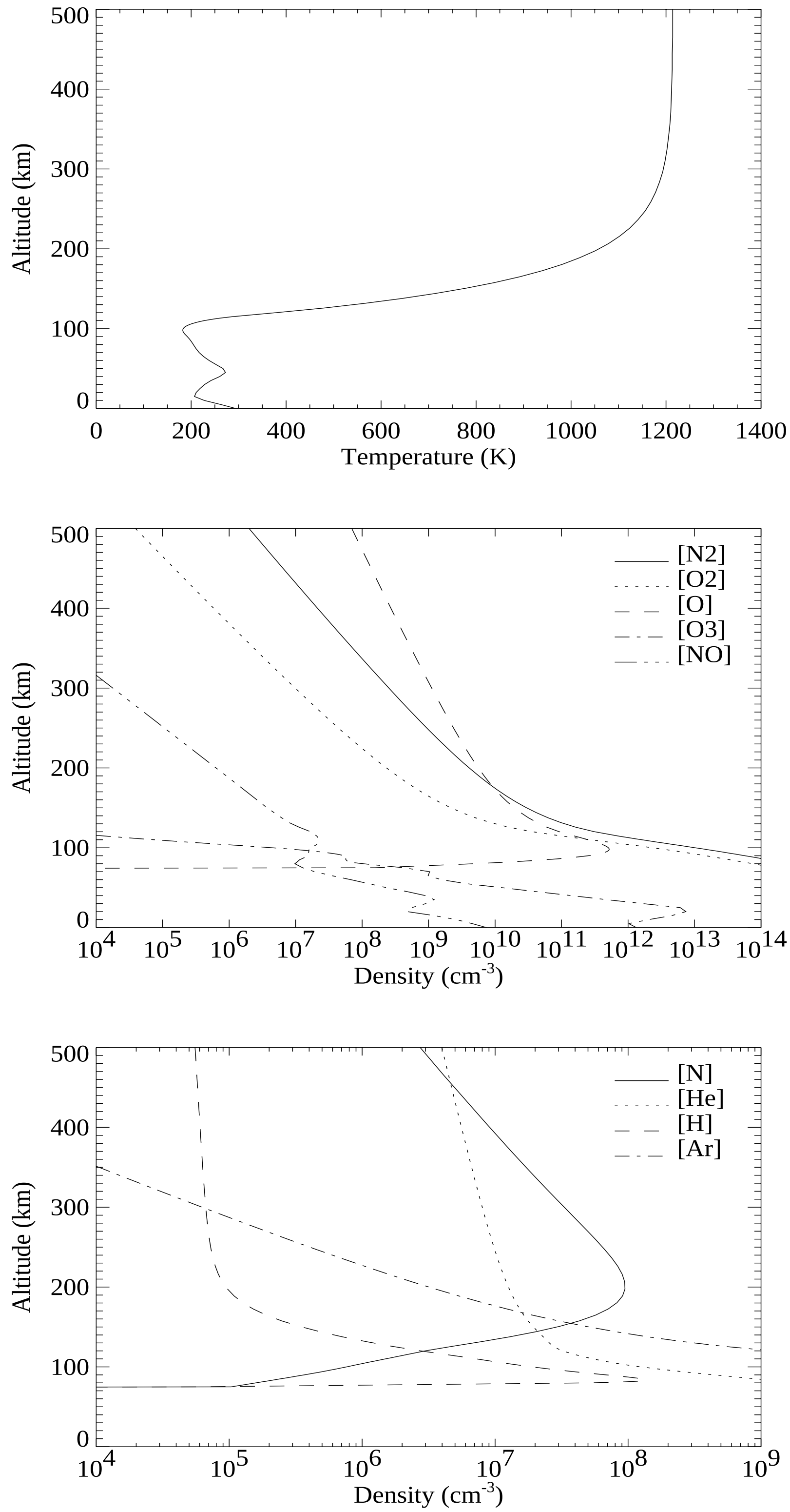


Figure 7.2 Neutral densities and temperature versus altitude.

7.2 Ionosphere

file name `ionos.dat`

created by **ionos** or **getpim**
modified by none

The ionosphere file contains an altitude grid (km) and electron densities (cm^{-3}). It can be generated by program **ionos** (FAIM model), program **getpim** (PIM model), or supplied by the user. A sample file is shown in Figure 7.3 and a plot in Figure 7.4.

The altitude grid in this file must be identical to that of the neutral atmosphere file.

```
  100    1
Altitudes (km)
    1000.00      955.94      913.82      873.56      835.07      798.28
     763.11      729.49      697.35      666.62      637.25      609.18
     582.34      556.68      532.15      508.71      486.29      464.87
     444.39      424.81      406.09      388.20      371.10      354.75
     339.12      324.18      309.89      296.24      283.19      270.71
     258.78      247.38      236.48      226.06      216.10      206.58
     197.48      188.78      180.46      172.51      164.91      157.64
     150.70      144.06      137.71      131.64      125.84      120.30
     115.00      114.00      113.00      112.00      111.00      110.00
     109.00      108.00      107.00      106.00      105.00      104.00
     103.00      102.00      101.00      100.00       99.00       98.00
      97.00       96.00       95.00       94.00       93.00       92.00
      91.00       90.00       89.00       88.00       87.00       86.00
      85.00       84.00       83.00       82.00       81.00       80.00
      75.00       70.00       65.00       60.00       55.00       50.00
      45.00       40.00       35.00       30.00       25.00       20.00
      15.00       10.00        5.00        0.00
Electron Density (cm^-3)
[e-]
  1.764E+04  2.567E+04  3.673E+04  5.168E+04  7.155E+04  9.753E+04
  1.309E+05  1.731E+05  2.255E+05  2.894E+05  3.661E+05  4.563E+05
  5.605E+05  6.785E+05  8.090E+05  9.503E+05  1.099E+06  1.252E+06
  1.404E+06  1.550E+06  1.685E+06  1.802E+06  1.898E+06  1.967E+06
  2.007E+06  2.016E+06  1.981E+06  1.905E+06  1.795E+06  1.659E+06
  1.507E+06  1.348E+06  1.193E+06  1.049E+06  9.198E+05  8.081E+05
  7.137E+05  6.345E+05  5.673E+05  5.089E+05  4.562E+05  4.074E+05
  3.622E+05  3.215E+05  2.873E+05  2.616E+05  2.455E+05  2.376E+05
  2.328E+05  2.315E+05  2.299E+05  2.279E+05  2.254E+05  2.222E+05
  2.184E+05  2.138E+05  2.083E+05  2.018E+05  1.943E+05  1.858E+05
  1.762E+05  1.656E+05  1.541E+05  1.417E+05  1.287E+05  1.152E+05
  1.016E+05  8.798E+04  7.477E+04  6.221E+04  5.056E+04  4.006E+04
  3.088E+04  2.309E+04  1.672E+04  1.170E+04  7.910E+03  5.169E+03
  3.276E+03  2.032E+03  1.251E+03  7.814E+02  5.072E+02  3.480E+02
  9.490E+01  3.269E+01  1.262E+01  5.310E+00  2.269E+00  9.412E-01
  3.730E-01  1.405E-01  5.009E-02  1.687E-02  5.347E-03  1.591E-03
  4.428E-04  1.149E-04  2.766E-05  0.000E+00
```

Figure 7.3 Sample ionosphere file.

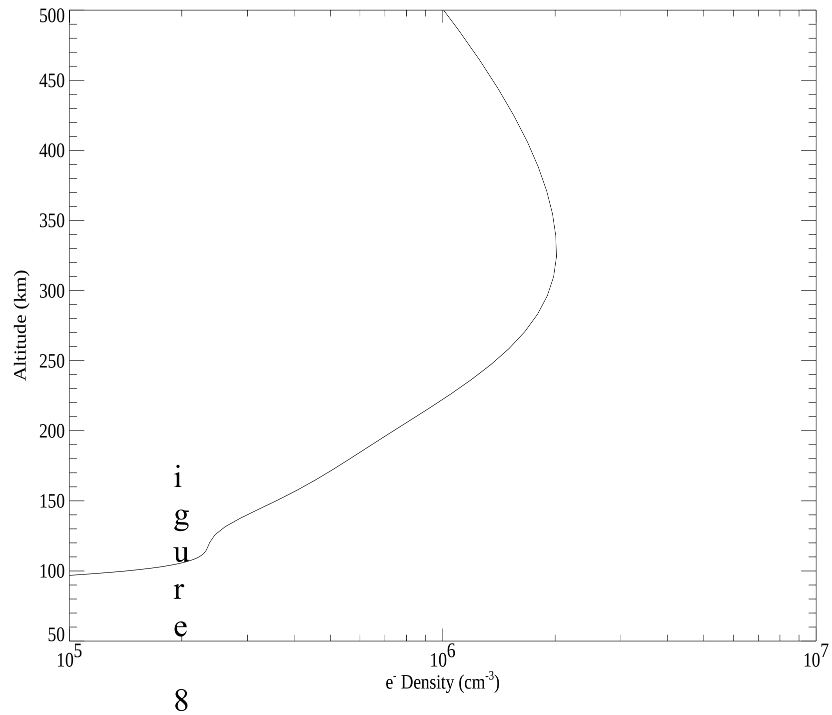


Figure 7.4 Electron density versus altitude.

7.3 Solar Irradiance

file name `solar.dat`
created by **solar**
modified by none

This file contains the solar EUV flux (cm^{-2} s^{-1}) and the corresponding wavelength grid (Å). It can be generated by program **solar** or supplied by the user. A sample file is shown in Figure 7.5 and its plot in Figure 7.6.

Important! The wavelength grid of this file should not be altered.

814 1
Wavelengths (A)

11.00	13.00	15.00	17.00	18.62	18.97
21.60	21.80	22.10	28.47	28.79	29.52
30.02	30.43	33.74	40.95	43.76	44.02
44.16	45.66	46.40	46.67	47.87	49.22
50.52	50.69	52.30	52.91	54.15	54.42
55.06	55.34	56.08	56.92	57.36	57.56
57.88	58.96	59.62	60.30	60.85	61.07
61.63	61.90	62.30	62.35	62.77	63.16
63.30	63.65	64.11	64.60	65.21	65.71
65.85	66.26	66.30	66.37	67.14	67.35

.
.
.

Solar EUV Flux (photons cm^-2 s^-1)
Hinteregger Flux

2.381E+06	3.259E+06	7.896E+06	5.389E+06	1.253E+06	4.137E+06
3.760E+06	1.253E+06	3.760E+06	5.690E+06	1.692E+07	1.489E+07
1.991E+06	8.212E+06	1.252E+07	5.790E+06	1.058E+07	7.720E+06
8.685E+06	4.825E+06	1.360E+07	8.850E+06	9.956E+06	2.166E+07
1.690E+07	1.690E+07	1.763E+07	2.453E+06	1.814E+07	7.965E+06
6.547E+06	2.527E+07	5.168E+06	1.637E+07	1.372E+07	1.106E+07
1.125E+07	6.756E+06	6.756E+06	5.531E+06	7.965E+06	1.108E+07
5.539E+06	1.106E+07	2.269E+05	4.298E+06	5.565E+06	8.630E+06
1.412E+07	9.071E+06	6.689E+06	5.531E+06	6.638E+06	9.071E+06
7.846E+06	1.760E+07	1.485E+07	2.347E+07	4.910E+06	7.814E+06

.
.
.

Figure 7.5 Sample solar EUV flux file.

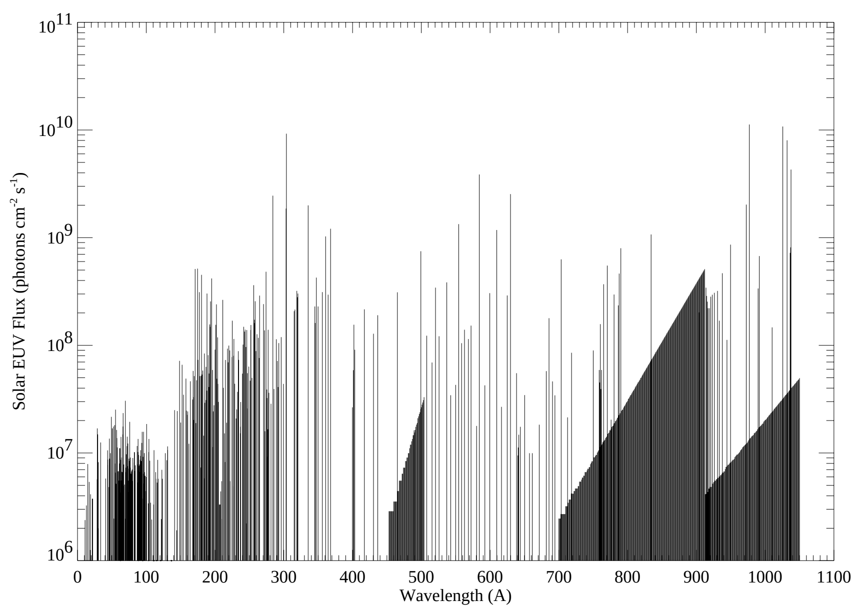


Figure 7.6 Solar EUV flux versus wavelength.

7.4 Neutral Column file name `colden.dat`

Densities created by **colden**
modified by none

This file contains slant column densities of N_2, O_2, O, O_3, NO, N, He, H, and Ar (cm^{-2}) at a particular solar zenith angle for calculating solar EUV attenuation. A sample file is shown in Figure 7.7 and its plot in Figure 7.8.

The altitude grid in this file must be identical to that of the neutral atmosphere file.

```
100    9    1
SZA = 30.420
Altitudes (km)
   1000.00     955.94     913.82     873.56     835.07     798.28
    763.11     729.49     697.35     666.62     637.25     609.18
    582.34     556.68     532.15     508.71     486.29     464.87
    444.39     424.81     406.09     388.20     371.10     354.75
    339.12     324.18     309.89     296.24     283.19     270.71
    258.78     247.38     236.48     226.06     216.10     206.58
    197.48     188.78     180.46     172.51     164.91     157.64
    150.70     144.06     137.71     131.64     125.84     120.30
    115.00     114.00     113.00     112.00     111.00     110.00
    109.00     108.00     107.00     106.00     105.00     104.00
  .
  .
Slant column densities (cm^-2)
[N2]
  1.613E+08  4.949E+08  1.262E+09  2.974E+09  6.693E+09  1.454E+10
  3.069E+10  6.301E+10  1.261E+11  2.462E+11  4.691E+11  8.734E+11
  1.590E+12  2.831E+12  4.936E+12  8.428E+12  1.411E+13  2.316E+13
  3.731E+13  5.904E+13  9.181E+13  1.404E+14  2.112E+14  3.130E+14
  4.569E+14  6.577E+14  9.342E+14  1.310E+15  1.815E+15  2.488E+15
  3.374E+15  4.533E+15  6.037E+15  7.978E+15  1.047E+16  1.367E+16
  1.775E+16  2.298E+16  2.969E+16  3.835E+16  4.961E+16  6.442E+16
  8.420E+16  1.113E+17  1.494E+17  2.053E+17  2.925E+17  4.426E+17
  7.456E+17  8.317E+17  9.335E+17  1.054E+18  1.198E+18  1.370E+18
  1.576E+18  1.823E+18  2.119E+18  2.474E+18  2.903E+18  3.419E+18
  .
  .
 [O2]
  5.842E+05  2.099E+06  6.042E+06  1.598E+07  4.021E+07  9.749E+07
  2.288E+08  5.208E+08  1.151E+09  2.475E+09  5.175E+09  1.054E+10
  2.091E+10  4.047E+10  7.643E+10  1.410E+11  2.542E+11  4.481E+11
  7.734E+11  1.308E+12  2.167E+12  3.523E+12  5.623E+12  8.818E+12
  1.359E+13  2.062E+13  3.082E+13  4.537E+13  6.590E+13  9.452E+13
  1.340E+14  1.878E+14  2.607E+14  3.586E+14  4.896E+14  6.639E+14
  8.956E+14  1.203E+15  1.613E+15  2.162E+15  2.902E+15  3.914E+15
  5.320E+15  7.335E+15  1.034E+16  1.508E+16  2.331E+16  3.971E+16
  7.962E+16  9.187E+16  1.069E+17  1.255E+17  1.485E+17  1.771E+17
  2.126E+17  2.567E+17  3.116E+17  3.799E+17  4.647E+17  5.701E+17
   .
   .
```

Figure 7.7 Sample slant column densities file.

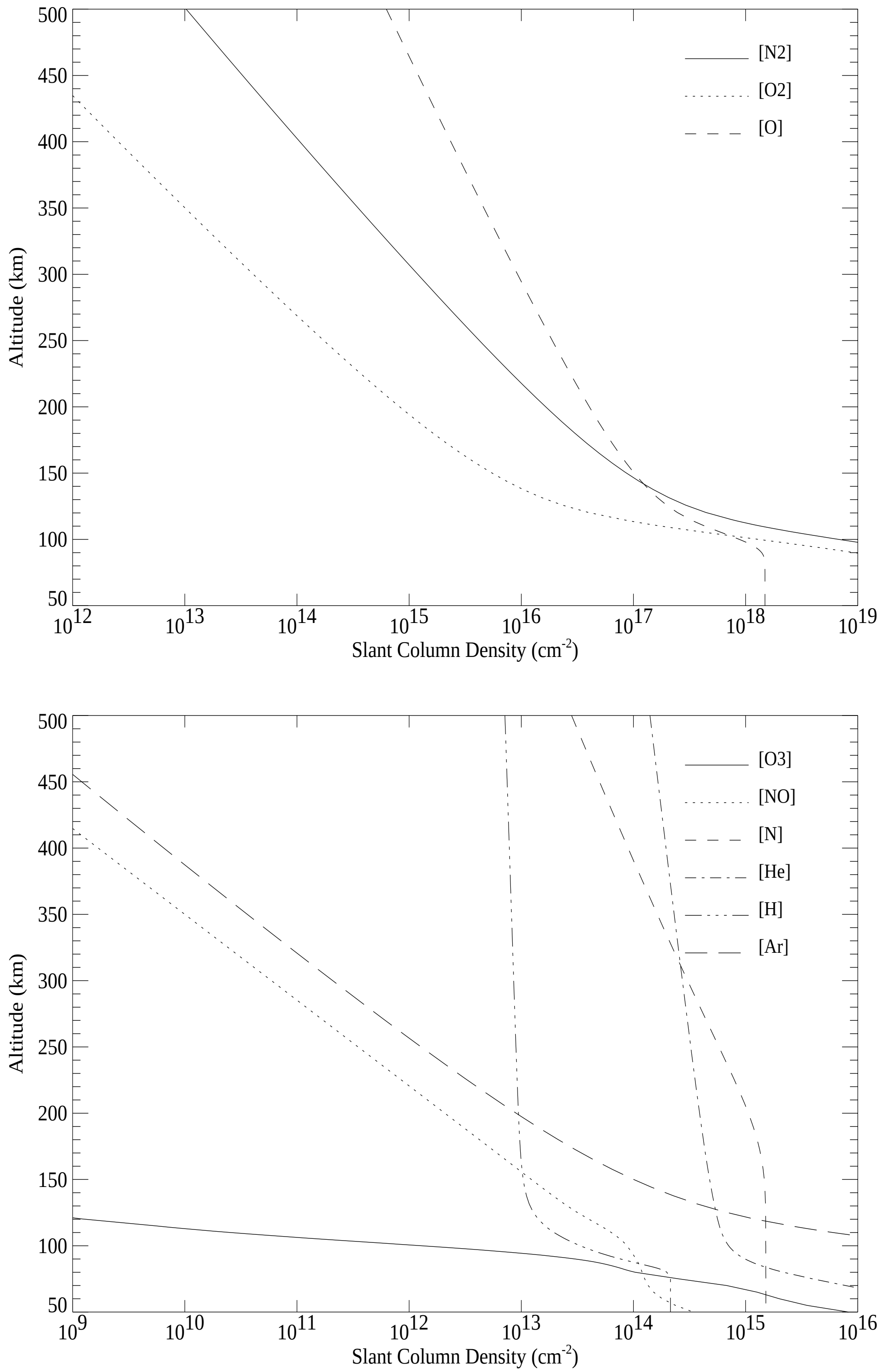


Figure 7.8 Slant column densities versus altitude for the SZA given in Figure 7.7.

7.5 Photoelectron Source Function

file name `pesource.dat`
created by **pesource**
modified by none

This file contains the photoelectron source function ($cm^{-3}\ s^{-1}\ eV^{-1}$) as a function of energy and altitude. A sample file is shown in Figure 7.9 and a plot in Figure 7.13.

```
  205   100
Energies (eV)
       800.00       795.00        790.00        785.00       780.00        775.00
       770.00       765.00        760.00        755.00       750.00        745.00
       740.00       735.00        730.00        725.00       720.00        715.00
       710.00       705.00        700.00        695.00       690.00        685.00
       680.00       675.00        670.00        665.00       660.00        655.00
       650.00       645.00        640.00        635.00       630.00        625.00
       620.00       615.00        610.00        605.00       600.00        595.00
       590.00       585.00        580.00        575.00       570.00        565.00
       560.00       555.00        550.00        545.00       540.00        535.00
       530.00       525.00        520.00        515.00       510.00        505.00
  .
  .
  .

Photoelectron source function (electrons cm^-3 s^-1 eV^-1)
Altitude = 1000.000
  0.000E+00   5.564E-09    4.177E-13    8.851E-10    0.000E+00   0.000E+00
  0.000E+00   0.000E+00   0.000E+00   0.000E+00    0.000E+00   0.000E+00
  0.000E+00   0.000E+00   0.000E+00   0.000E+00   0.000E+00   1.544E-10
  4.531E-10   2.023E-15    1.359E-09    2.861E-13    6.040E-10   8.146E-14
  0.000E+00   0.000E+00   0.000E+00   0.000E+00   0.000E+00   0.000E+00
  1.054E-10   3.513E-11    1.161E-10    6.640E-10   6.797E-14   1.184E-09
  6.331E-14   4.639E-10    6.253E-14    0.000E+00   0.000E+00   0.000E+00
  0.000E+00   8.873E-09   0.000E+00   0.000E+00   0.000E+00   0.000E+00
  2.109E-10   5.974E-10    1.757E-10    1.902E-09   6.673E-10   2.107E-09
  2.110E-10   2.842E-13    6.322E-10    0.000E+00   0.000E+00   0.000E+00
  .
  .
  .
Altitude = 955.940
  0.000E+00   9.295E-09    1.026E-12   1.478E-09   0.000E+00   0.000E+00
  0.000E+00   0.000E+00   0.000E+00   0.000E+00   0.000E+00   0.000E+00
  0.000E+00   0.000E+00   0.000E+00   0.000E+00   0.000E+00    2.606E-10
  7.568E-10   5.647E-15    2.270E-09   7.028E-13   1.009E-09    2.000E-13
  0.000E+00   0.000E+00   0.000E+00   0.000E+00   0.000E+00   0.000E+00
  1.762E-10   5.869E-11    1.940E-10   1.109E-09   1.675E-13    1.977E-09
  1.557E-13   7.750E-10    1.535E-13   0.000E+00   0.000E+00   0.000E+00
  0.000E+00   1.482E-08   0.000E+00   0.000E+00   0.000E+00   0.000E+00
  3.524E-10   9.981E-10    2.936E-10   3.182E-09   1.115E-09    3.520E-09
  3.526E-10   6.977E-13    1.056E-09  0.000E+00   0.000E+00   0.000E+00
  .
  .
  .
```

Figure 7.9 Sample photoelectron source function file.

7.6 Photoionization Production Rates

file name	`photoion.vpr`
created by	**pesource**
modified by	none

This file contains photoionization rates (cm^{-3} s^{-1}) as functions of altitude and feature. A sample file is shown in Figure 7.10 and its plot in Figure 7.13.

```
   100    25
Altitudes (km)
      1000.00      955.94      913.82     873.56       835.07      798.28
      763.11      729.49      697.35     666.62       637.25      609.18
      582.34      556.68      532.15     508.71       486.29      464.87
      444.39      424.81      406.09     388.20       371.10      354.75
      339.12      324.18      309.89     296.24       283.19      270.71
      258.78      247.38      236.48     226.06       216.10      206.58
      197.48      188.78      180.46     172.51       164.91      157.64
      150.70      144.06      137.71     131.64       125.84      120.30
      115.00      114.00      113.00     112.00       111.00      110.00
      109.00      108.00      107.00     106.00       105.00      104.00
   .
   .
   .
Photoionization Rates (cm^-3 s^-1)
N2+(X)
   1.055E-05   2.589E-05   6.173E-05   1.430E-04   3.220E-04   7.051E-04
   1.504E-03   3.122E-03   6.321E-03   1.247E-02   2.403E-02   4.520E-02
   8.305E-02   1.492E-01   2.623E-01   4.513E-01   7.602E-01   1.255E+00
   2.032E+00   3.227E+00   5.031E+00   7.703E+00   1.158E+01   1.711E+01
   2.485E+01   3.549E+01   4.986E+01   6.885E+01   9.354E+01   1.250E+02
   1.641E+02   2.118E+02   2.684E+02   3.339E+02   4.071E+02   4.860E+02
   5.672E+02   6.457E+02   7.148E+02   7.661E+02   7.891E+02   7.755E+02
   7.172E+02   6.145E+02   4.803E+02   3.352E+02   2.050E+02   1.132E+02
   7.018E+01   6.759E+01   6.601E+01   6.520E+01   6.472E+01   6.407E+01
   6.282E+01   6.054E+01   5.706E+01   5.239E+01   4.667E+01   4.028E+01
   .
   .
   .
N2+(A)
   1.285E-05   3.155E-05   7.522E-05   1.742E-04   3.924E-04   8.593E-04
   1.832E-03   3.804E-03   7.702E-03   1.520E-02   2.928E-02   5.508E-02
   1.012E-01   1.818E-01   3.195E-01   5.499E-01   9.261E-01   1.529E+00
   2.475E+00   3.930E+00   6.126E+00   9.377E+00   1.410E+01   2.083E+01
   3.025E+01   4.321E+01   6.073E+01   8.393E+01   1.142E+02   1.529E+02
   2.013E+02   2.608E+02   3.320E+02   4.153E+02   5.098E+02   6.129E+02
   7.205E+02   8.255E+02   9.184E+02   9.872E+02   1.017E+03   9.980E+02
   9.199E+02   7.847E+02   6.096E+02   4.223E+02   2.580E+02   1.471E+02
   9.567E+01   9.242E+01   9.039E+01   8.934E+01   8.870E+01   8.781E+01
   8.610E+01   8.298E+01   7.821E+01   7.181E+01   6.397E+01   5.520E+01
   .
   .
   .
```

Figure 7.10 Sample photoionization rates file.

7.7 Primary Dissociation Rates

file name	`pdis.vpr`
created by	**pesource**

modified by none

This file contains photo-dissociation rates (cm^{-3} s^{-1}) as functions of altitude and feature. A sample file is shown in Figure 7.11 and its plot in Figure 7.13.

```
  100    2
Altitudes (km)
    1000.00      955.94      913.82      873.56      835.07      798.28
    763.11       729.49      697.35      666.62      637.25      609.18
    582.34       556.68      532.15      508.71      486.29      464.87
    444.39       424.81      406.09      388.20      371.10      354.75
    339.12       324.18      309.89      296.24      283.19      270.71
    258.78       247.38      236.48      226.06      216.10      206.58
    197.48       188.78      180.46      172.51      164.91      157.64
    150.70       144.06      137.71      131.64      125.84      120.30
    115.00       114.00      113.00      112.00      111.00      110.00
    109.00       108.00      107.00      106.00      105.00      104.00
  .
  .
  .
Photodissociation Rates (cm^-3 s^-1)
O(1D)
  5.039E-07   1.407E-06   3.796E-06   9.917E-06   2.507E-05   6.144E-05
  1.460E-04   3.367E-04   7.536E-04   1.639E-03   3.470E-03   7.143E-03
  1.433E-02   2.802E-02   5.345E-02   9.953E-02   1.811E-01   3.221E-01
  5.606E-01   9.556E-01   1.596E+00   2.616E+00   4.208E+00   6.650E+00
  1.033E+01   1.581E+01   2.382E+01   3.540E+01   5.198E+01   7.537E+01
  1.082E+02   1.538E+02   2.170E+02   3.040E+02   4.240E+02   5.890E+02
  8.164E+02   1.132E+03   1.574E+03   2.200E+03   3.100E+03   4.421E+03
  6.423E+03   9.578E+03   1.487E+04   2.430E+04   4.289E+04   8.364E+04
  1.733E+05   1.978E+05   2.237E+05   2.500E+05   2.764E+05   3.013E+05
  3.267E+05   3.487E+05   3.653E+05   3.907E+05   4.104E+05   4.332E+05
  .
  .
  .
N(*)
  5.556E-05   1.364E-04   3.252E-04   7.532E-04   1.697E-03   3.715E-03
  7.923E-03   1.645E-02   3.331E-02   6.575E-02   1.267E-01   2.384E-01
  4.382E-01   7.876E-01   1.385E+00   2.386E+00   4.023E+00   6.651E+00
  1.078E+01   1.715E+01   2.679E+01   4.108E+01   6.188E+01   9.157E+01
  1.331E+02   1.901E+02   2.666E+02   3.668E+02   4.951E+02   6.547E+02
  8.470E+02   1.071E+03   1.323E+03   1.594E+03   1.876E+03   2.162E+03
  2.450E+03   2.747E+03   3.067E+03   3.424E+03   3.815E+03   4.225E+03
  4.608E+03   4.921E+03   5.131E+03   5.213E+03   5.090E+03   4.464E+03
  2.508E+03   2.043E+03   1.579E+03   1.153E+03   7.987E+02   5.329E+02
  3.539E+02   2.428E+02   1.763E+02   1.357E+02   1.089E+02   8.909E+01
```

Figure 7.11 Sample photo-dissociation rates file.

7.8 Photodissociation/ Photoionization Emission Rates

file name `photo.ver`
created by **pesource**
modified by none

This file contains photodissociation/photoionization produced volume emission rates (cm^{-3} s^{-1}) as functions of altitude and feature. A sample file is shown in Figure 7.12 and its plot in Figure 7.13.

```
   100     4
Altitudes (km)
   1000.00      955.94      913.82      873.56     835.07      798.28
    763.11      729.49      697.35      666.62     637.25      609.18
    582.34      556.68      532.15      508.71     486.29      464.87
    444.39      424.81      406.09      388.20     371.10      354.75
    339.12      324.18      309.89      296.24     283.19      270.71
    258.78      247.38      236.48      226.06     216.10      206.58
    197.48      188.78      180.46      172.51     164.91      157.64
    150.70      144.06      137.71      131.64     125.84      120.30
    115.00      114.00      113.00      112.00     111.00      110.00
    109.00      108.00      107.00      106.00     105.00      104.00
  .
  .
  .
Photoionization/Photodissociation Produced Volume Emission Rates (cm^-3 s^-1)
O+hv 834 A (initial)
  2.582E-03   4.312E-03   7.083E-03   1.145E-02   1.820E-02   2.848E-02
  4.392E-02   6.667E-02   9.976E-02   1.471E-01   2.139E-01   3.070E-01
  4.345E-01   6.073E-01   8.380E-01   1.142E+00   1.539E+00   2.048E+00
  2.696E+00   3.510E+00   4.520E+00   5.753E+00   7.253E+00   9.050E+00
  1.118E+01   1.368E+01   1.657E+01   1.991E+01   2.366E+01   2.786E+01
  3.249E+01   3.752E+01   4.289E+01   4.852E+01   5.427E+01   6.000E+01
  6.547E+01   7.037E+01   7.434E+01   7.691E+01   7.760E+01   7.585E+01
  7.119E+01   6.337E+01   5.277E+01   4.058E+01   2.885E+01   1.995E+01
  1.490E+01   1.433E+01   1.377E+01   1.319E+01   1.250E+01   1.169E+01
  1.071E+01   9.591E+00   8.349E+00   7.045E+00   5.739E+00   4.501E+00
  3.387E+00   2.436E+00   1.667E+00   1.080E+00   6.601E-01   3.794E-01
  2.047E-01   1.037E-01   4.943E-02   2.223E-02   9.416E-03   3.729E-03
  1.351E-03   4.331E-04   0.000E+00   0.000E+00   0.000E+00   0.000E+00
  .
  .
  .
 N2+hv 1085 A
  1.599E-07   3.925E-07   9.357E-07   2.167E-06   4.881E-06   1.069E-05
  2.279E-05   4.733E-05   9.583E-05   1.891E-04   3.644E-04   6.855E-04
  1.260E-03   2.264E-03   3.980E-03   6.853E-03   1.155E-02   1.909E-02
  3.093E-02   4.918E-02   7.681E-02   1.179E-01   1.777E-01   2.635E-01
  3.846E-01   5.526E-01   7.823E-01   1.091E+00   1.501E+00   2.036E+00
  2.726E+00   3.605E+00   4.705E+00   6.064E+00   7.718E+00   9.699E+00
  1.203E+01   1.470E+01   1.767E+01   2.087E+01   2.409E+01   2.709E+01
  2.936E+01   3.032E+01   2.935E+01   2.597E+01   2.045E+01   1.441E+01
  .
  .
  .
```

Figure 7.12 Sample photodissociation/photoionization produced volume emission rates file.

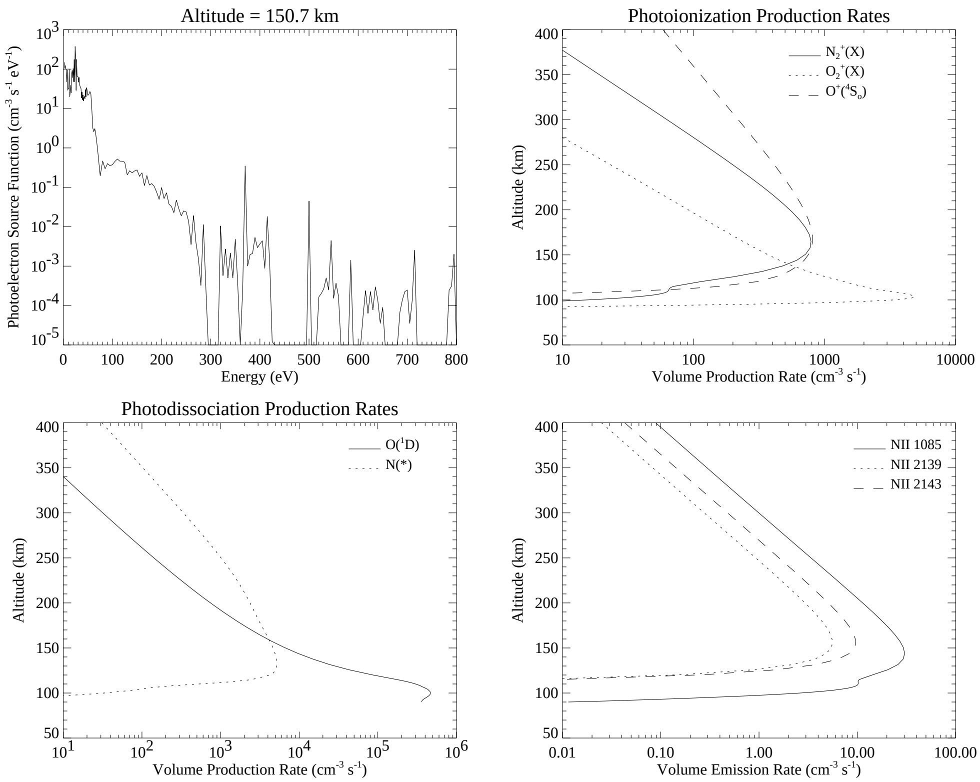


Figure 7.13 Top left: Photoelectron source function (cm^{-3} s^{-1} eV^{-1}). Top right: Photoionization production rates (cm^{-3} s^{-1}). Bottom left: Photodissociation production rates (cm^{-3} s^{-1}). Bottom right: Photodissociation/ photoionization produced volume emission rates (cm^{-3} s^{-1}) versus altitude.

7.9 Photoelectron Flux

file name: `peflux.dat`
created by: **peflux**
modified by: none

This file contains the photoelectron flux (electrons cm^{-2} s^{-1} eV^{-1}) as a function of energy and altitude (same as the photoelectron source function). A sample file is shown in Figure 7.14 and a plot in Figure 7.15.

```
  205   100
Energies (eV)
   800.00     795.00     790.00     785.00     780.00     775.00
   770.00     765.00     760.00     755.00     750.00     745.00
   740.00     735.00     730.00     725.00     720.00     715.00
   710.00     705.00     700.00     695.00     690.00     685.00
   680.00     675.00     670.00     665.00     660.00     655.00
   650.00     645.00     640.00     635.00     630.00     625.00
   620.00     615.00     610.00     605.00     600.00     595.00
   590.00     585.00     580.00     575.00     570.00     565.00
   560.00     555.00     550.00     545.00     540.00     535.00
   530.00     525.00     520.00     515.00     510.00     505.00
      .
      .
      .

Photoelectron flux (electrons cm^-2 s^-1 eV^-1)
Altitude = 1000.000
 0.000E+00  2.249E+02  1.381E+02  1.231E+02  1.019E+02  1.000E+02
 1.001E+02  9.834E+01  9.602E+01  9.418E+01  9.281E+01  9.161E+01
 9.051E+01  8.949E+01  8.856E+01  8.771E+01  8.692E+01  9.186E+01
 1.056E+02  9.741E+01  1.422E+02  1.226E+02  1.334E+02  1.232E+02
 1.189E+02  1.177E+02  1.170E+02  1.159E+02  1.148E+02  1.137E+02
 1.164E+02  1.154E+02  1.173E+02  1.368E+02  1.271E+02  1.604E+02
 1.447E+02  1.512E+02  1.437E+02  1.404E+02  1.392E+02  1.383E+02
 1.372E+02  4.116E+02  3.095E+02  2.495E+02  2.399E+02  2.448E+02
 2.509E+02  2.624E+02  2.561E+02  3.032E+02  2.988E+02  3.387E+02
 3.150E+02  2.983E+02  3.113E+02  3.034E+02  2.973E+02  2.938E+02
      .
      .
      .

Altitude = 955.940
 0.000E+00  2.453E+02  1.422E+02  1.245E+02  1.033E+02  1.031E+02
 1.035E+02  1.014E+02  9.877E+01  9.689E+01  9.554E+01  9.432E+01
 9.317E+01  9.212E+01  9.116E+01  9.028E+01  8.947E+01  9.498E+01
 1.098E+02  1.002E+02  1.491E+02  1.263E+02  1.380E+02  1.267E+02
 1.223E+02  1.213E+02  1.207E+02  1.196E+02  1.184E+02  1.172E+02
 1.202E+02  1.191E+02  1.212E+02  1.425E+02  1.311E+02  1.675E+02
  1.492E+02  1.563E+02  1.482E+02  1.448E+02  1.437E+02  1.429E+02
 1.417E+02  4.419E+02  3.202E+02  2.527E+02  2.460E+02  2.540E+02
 2.607E+02  2.724E+02  2.648E+02  3.166E+02  3.102E+02  3.532E+02
 3.258E+02  3.077E+02  3.230E+02  3.143E+02  3.077E+02  3.041E+02
      .
      .
      .
```

Figure 7.14 Sample photoelectron flux file.

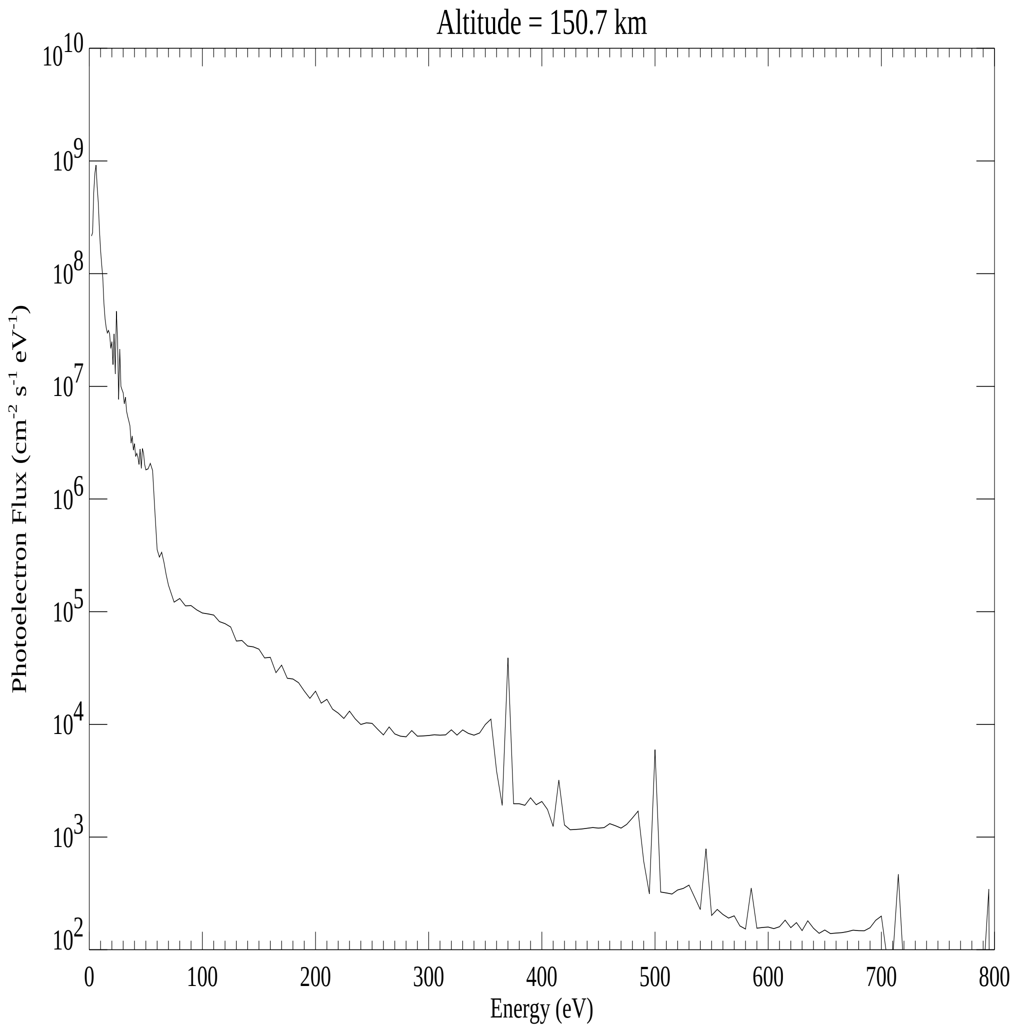


Figure 7.15 Photoelectron flux versus energy.

7.10 Electron Impact Production Rates

file name `chemin.vpr`
created by **e_impact**
modified by none

This file contains electron impact production rates (cm^{-3} s^{-1}) for chemistry modeling. A sample file is shown in Figure 7.16 and its plot in Figure 7.18.

```
100    11
Altitudes (km)
. 1000.00     955.94     913.82     873.56     835.07     798.28
   763.11     729.49     697.35     666.62     637.25     609.18
   582.34     556.68     532.15     508.71     486.29     464.87
   444.39     424.81     406.09     388.20     371.10     354.75
   339.12     324.18     309.89     296.24     283.19     270.71
   258.78     247.38     236.48     226.06     216.10     206.58
   197.48     188.78     180.46     172.51     164.91     157.64
   150.70     144.06     137.71     131.64     125.84     120.30
   115.00     114.00     113.00     112.00     111.00     110.00
   109.00     108.00     107.00     106.00     105.00     104.00
   103.00     102.00     101.00     100.00      99.00      98.00
  .
  .
  .
Electron Impact Production Rates (cm^-3 s^-1)
O+(4So)
  8.402E-04  1.591E-03  2.957E-03  5.395E-03  9.663E-03  1.698E-02
  2.934E-02  4.972E-02  8.286E-02  1.357E-01  2.186E-01  3.467E-01
  5.409E-01  8.311E-01  1.258E+00  1.877E+00  2.759E+00  3.997E+00
  5.708E+00  8.027E+00  1.111E+01  1.512E+01  2.025E+01  2.667E+01
  3.452E+01  4.392E+01  5.499E+01  6.792E+01  8.239E+01  9.855E+01
  1.162E+02  1.350E+02  1.547E+02  1.750E+02  1.954E+02  2.154E+02
  2.342E+02  2.510E+02  2.646E+02  2.736E+02  2.766E+02  2.718E+02
  2.578E+02  2.339E+02  2.012E+02  1.636E+02  1.279E+02  1.028E+02
  9.239E+01  9.141E+01  9.000E+01  8.801E+01  8.494E+01  8.071E+01
  7.508E+01  6.821E+01  6.027E+01  5.166E+01  4.279E+01  3.418E+01
  2.625E+01  1.930E+01  1.353E+01  8.981E+00  5.629E+00  3.312E+00
  .
  .
  .
```

Figure 7.16 Sample electron impact production rates file.

7.11 Electron Impact Emission Rates

file name `e_impact.ver`
created by **e_impact**
modified by none

This file contains electron impact emission rates (cm^{-3} s^{-1}). A sample file is shown in Figure 7.17 and its plot in Figure 7.18.

```
  100    18
Altitudes (km)
  1000.00     955.94     913.82     873.56     835.07     798.28
   763.11     729.49     697.35     666.62     637.25     609.18
   582.34     556.68     532.15     508.71     486.29     464.87
   444.39     424.81     406.09     388.20     371.10     354.75
   339.12     324.18     309.89     296.24     283.19     270.71
   258.78     247.38     236.48     226.06     216.10     206.58
   197.48     188.78     180.46     172.51     164.91     157.64
   150.70     144.06     137.71     131.64     125.84     120.30
   115.00     114.00     113.00     112.00     111.00     110.00
   109.00     108.00     107.00     106.00     105.00     104.00
   103.00     102.00     101.00     100.00      99.00      98.00
    97.00      96.00      95.00      94.00      93.00      92.00
    91.00      90.00      89.00      88.00      87.00      86.00
    85.00      84.00      83.00      82.00      81.00      80.00
```

```
    75.00       70.00       65.00       60.00       55.00       50.00
    45.00       40.00       35.00       30.00       25.00       20.00
    15.00       10.00        5.00        0.00
Volume Emission Rates (cm^-3 s^-1)
N2+e LBH
  1.415E-07   3.973E-07   1.082E-06   2.856E-06   7.319E-06   1.819E-05
  4.396E-05   1.031E-04   2.354E-04   5.227E-04   1.130E-03   2.382E-03
  4.892E-03   9.805E-03   1.919E-02   3.668E-02   6.848E-02   1.250E-01
  2.228E-01   3.882E-01   6.608E-01   1.099E+00   1.784E+00   2.830E+00
  4.388E+00   6.653E+00   9.891E+00   1.442E+01   2.061E+01   2.889E+01
  3.971E+01   5.350E+01   7.063E+01   9.139E+01   1.159E+02   1.443E+02
  1.761E+02   2.108E+02   2.470E+02   2.827E+02   3.144E+02   3.386E+02
  3.494E+02   3.418E+02   3.133E+02   2.669E+02   2.151E+02   1.807E+02
  1.869E+02   1.942E+02   2.025E+02   2.110E+02   2.188E+02   2.244E+02
  2.269E+02   2.251E+02   2.183E+02   2.065E+02   1.897E+02   1.692E+02
  1.461E+02   1.217E+02   9.745E+01   7.474E+01   5.473E+01   3.814E+01
  2.527E+01   1.593E+01   9.612E+00   5.566E+00   3.099E+00   1.649E+00
  8.250E-01   3.759E-01   0.000E+00   0.000E+00   0.000E+00   0.000E+00
  0.000E+00   0.000E+00   0.000E+00   0.000E+00   0.000E+00   0.000E+00
  0.000E+00   0.000E+00   0.000E+00   0.000E+00   0.000E+00   0.000E+00
  0.000E+00   0.000E+00   0.000E+00   0.000E+00   0.000E+00   0.000E+00
  0.000E+00   0.000E+00   0.000E+00   0.000E+00
N2+e 1PG
  4.345E-07   1.223E-06   3.340E-06   8.849E-06   2.276E-05   5.680E-05
  1.378E-04   3.247E-04   7.448E-04   1.662E-03   3.613E-03   7.656E-03
  1.581E-02   3.188E-02   6.278E-02   1.208E-01   2.270E-01   4.173E-01
  7.500E-01   1.318E+00   2.264E+00   3.805E+00   6.255E+00   1.007E+01
  1.587E+01   2.453E+01   3.731E+01   5.582E+01   8.205E+01   1.184E+02
  1.675E+02   2.320E+02   3.141E+02   4.154E+02   5.367E+02   6.776E+02
  8.361E+02   1.008E+03   1.187E+03   1.361E+03   1.513E+03   1.626E+03
  1.671E+03   1.625E+03   1.478E+03   1.250E+03   1.001E+03   8.439E+02
  8.878E+02   9.256E+02   9.679E+02   1.012E+03   1.051E+03   1.081E+03
  1.096E+03   1.089E+03   1.059E+03   1.003E+03   9.240E+02   8.258E+02
  7.146E+02   5.965E+02   4.789E+02   3.682E+02   2.702E+02   1.887E+02
  1.253E+02   7.918E+01   4.787E+01   2.777E+01   1.548E+01   8.250E+00
  4.131E+00   1.883E+00   0.000E+00   0.000E+00   0.000E+00   0.000E+00
  0.000E+00   0.000E+00   0.000E+00   0.000E+00   0.000E+00   0.000E+00
  0.000E+00   0.000E+00   0.000E+00   0.000E+00   0.000E+00   0.000E+00
  0.000E+00   0.000E+00   0.000E+00   0.000E+00   0.000E+00   0.000E+00
  0.000E+00   0.000E+00   0.000E+00   0.000E+00
        .
        .
```

Figure 7.17 Sample electron impact emission rates file.

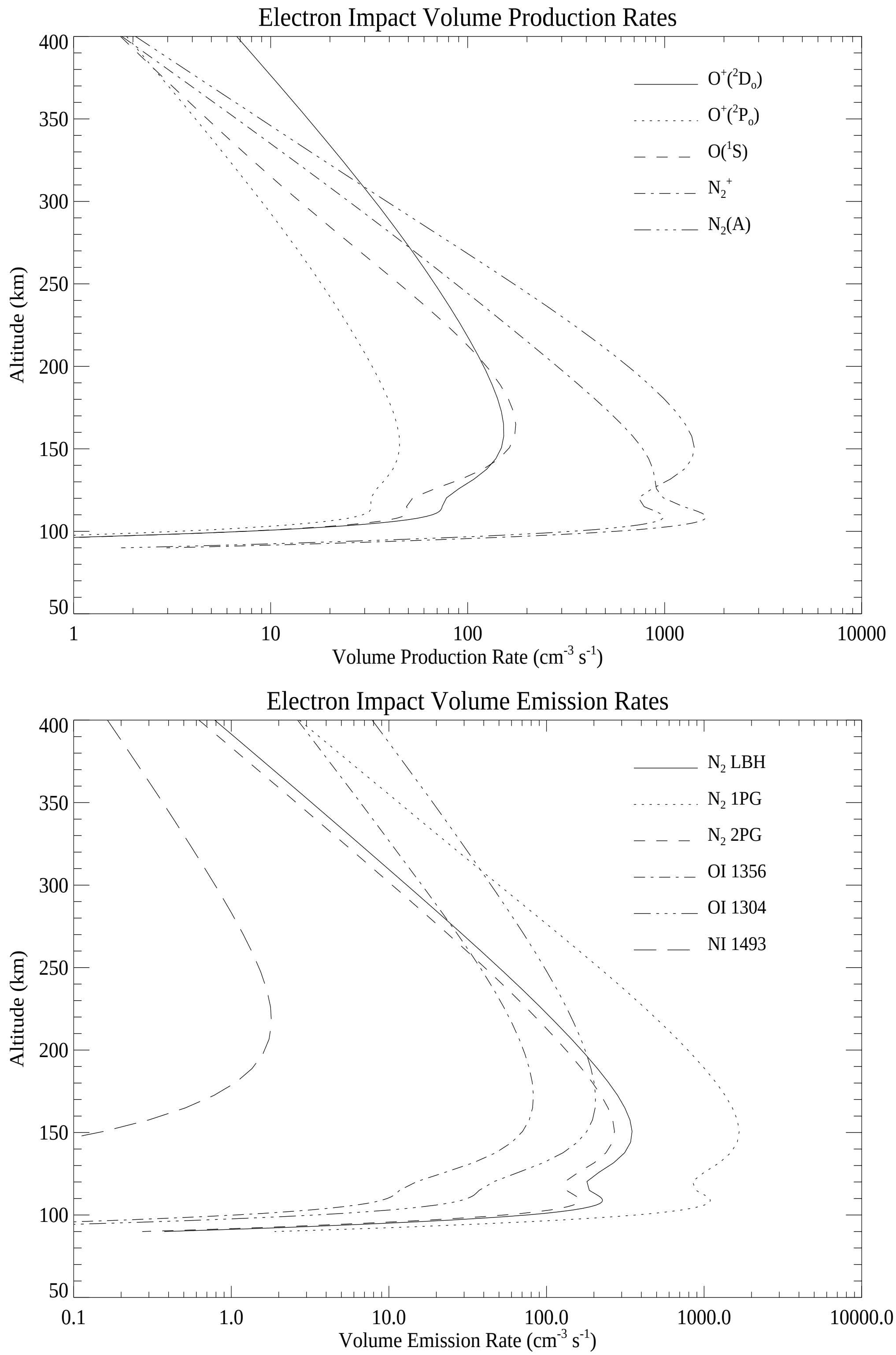


Figure 7.18 Top: Selected electron impact production rates (cm^{-3} s^{-1}). Bottom: Selected electron impact emission rates (cm^{-3} s^{-1}).

7.12 Chemical Densities

file name `chemden.dat`
created by **daychem**
modified by none

This file contains the densities (cm^{-3}) of various chemical species. A sample file is shown in Figure 7.19 and its plots in Figure 7.21.

```
  100    13
Altitudes (km)
   1000.00     955.94     913.82     873.56     835.07     798.28
    763.11     729.49     697.35     666.62     637.25     609.18
    582.34     556.68     532.15     508.71     486.29     464.87
    444.39     424.81     406.09     388.20     371.10     354.75
    339.12     324.18     309.89     296.24     283.19     270.71
    258.78     247.38     236.48     226.06     216.10     206.58
    197.48     188.78     180.46     172.51     164.91     157.64
    150.70     144.06     137.71     131.64     125.84     120.30
    115.00     114.00     113.00     112.00     111.00     110.00
    109.00     108.00     107.00     106.00     105.00     104.00
    103.00     102.00     101.00     100.00      99.00      98.00
  .
  .
  .
Chemical Densities (cm^-3)
[NO+]
  9.380E-01  9.163E-01  9.112E-01  9.769E-01  1.263E+00  2.142E+00
  4.485E+00  1.010E+01  2.253E+01  4.721E+01  9.150E+01  1.633E+02
  2.694E+02  4.075E+02  5.818E+02  7.927E+02  1.019E+03  1.271E+03
  1.537E+03  1.857E+03  2.216E+03  2.534E+03  2.919E+03  3.353E+03
  3.855E+03  4.467E+03  5.190E+03  6.082E+03  7.217E+03  8.682E+03
  1.048E+04  1.288E+04  1.642E+04  2.111E+04  2.746E+04  3.571E+04
  4.612E+04  5.810E+04  7.061E+04  8.150E+04  9.055E+04  9.518E+04
  9.510E+04  9.014E+04  8.084E+04  6.877E+04  5.703E+04  4.846E+04
  4.187E+04  4.127E+04  4.040E+04  3.919E+04  3.780E+04  3.651E+04
  3.436E+04  3.255E+04  3.047E+04  2.811E+04  2.582E+04  2.337E+04
  2.105E+04  1.897E+04  1.654E+04  1.457E+04  1.343E+04  1.247E+04
  .
  .
  .
[O2+]
  9.647E-01  9.460E-01  9.209E-01  8.903E-01  8.585E-01  8.381E-01
  8.625E-01  1.008E+00  1.437E+00  2.465E+00  4.658E+00  8.892E+00
  1.637E+01  2.865E+01  4.723E+01  7.400E+01  1.097E+02  1.573E+02
  2.162E+02  2.874E+02  3.811E+02  4.970E+02  6.451E+02  8.336E+02
  1.075E+03  1.383E+03  1.790E+03  2.314E+03  3.009E+03  3.925E+03
  5.083E+03  6.519E+03  8.837E+03  1.172E+04  1.555E+04  2.052E+04
  2.683E+04  3.412E+04  4.252E+04  5.104E+04  5.923E+04  6.647E+04
  7.221E+04  7.607E+04  7.827E+04  7.960E+04  8.015E+04  8.075E+04
  8.507E+04  8.771E+04  9.105E+04  9.383E+04  9.755E+04  1.026E+05
  1.070E+05  1.130E+05  1.192E+05  1.233E+05  1.268E+05  1.269E+05
  1.257E+05  1.226E+05  1.144E+05  1.045E+05  8.813E+04  7.103E+04
  .
  .
  .
```

Figure 7.19 Sample chemical densities file.

7.13 Chemical Volume

file name `chemout.ver`

Emission Rates   created by **daychem**
modified by none

This file contains the chemically produced volume emission rates (cm^{-3} s^{-1}). A sample file is shown in Figure 7.20 and its plots in Figure 7.21.

```
  100   11
Altitudes (km)
  1000.00    955.94    913.82    873.56    835.07    798.28
   763.11    729.49    697.35    666.62    637.25    609.18
   582.34    556.68    532.15    508.71    486.29    464.87
   444.39    424.81    406.09    388.20    371.10    354.75
   339.12    324.18    309.89    296.24    283.19    270.71
   258.78    247.38    236.48    226.06    216.10    206.58
   197.48    188.78    180.46    172.51    164.91    157.64
   150.70    144.06    137.71    131.64    125.84    120.30
   115.00    114.00    113.00    112.00    111.00    110.00
   109.00    108.00    107.00    106.00    105.00    104.00
   103.00    102.00    101.00    100.00     99.00     98.00
  .
  .
  .
Volume Emission Rates (cm^-3 s^-1)
O+(2Do) hv 3727 A
  3.112E-02  4.801E-02  7.106E-02  1.009E-01  1.378E-01  1.806E-01
  2.290E-01  2.808E-01  3.338E-01  3.841E-01  4.284E-01  4.638E-01
  4.876E-01  4.998E-01  4.969E-01  4.815E-01  4.563E-01  4.218E-01
  3.824E-01  3.414E-01  3.008E-01  2.625E-01  2.276E-01  1.961E-01
  1.681E-01  1.434E-01  1.217E-01  1.031E-01  8.671E-02  7.266E-02
  6.055E-02  5.016E-02  4.127E-02  3.368E-02  2.720E-02  2.170E-02
  1.704E-02  1.311E-02  9.838E-03  7.145E-03  4.990E-03  3.308E-03
  2.058E-03  1.178E-03  6.086E-04  2.774E-04  1.103E-04  3.932E-05
  1.351E-05  1.109E-05  9.055E-06  7.338E-06  5.868E-06  4.618E-06
  3.554E-06  2.667E-06  1.945E-06  1.374E-06  9.374E-07  6.161E-07
  3.895E-07  2.357E-07  1.362E-07  7.465E-08  3.872E-08  1.891E-08
  .
  .
  .
O+(2Po) hv 2470 A
  2.756E-03  4.611E-03  7.585E-03  1.228E-02  1.956E-02  3.067E-02
  4.736E-02  7.200E-02  1.079E-01  1.593E-01  2.319E-01  3.327E-01
  4.706E-01  6.563E-01  9.028E-01  1.224E+00  1.635E+00  2.151E+00
  2.786E+00  3.546E+00  4.427E+00  5.413E+00  6.476E+00  7.565E+00
  8.613E+00  9.544E+00  1.028E+01  1.079E+01  1.100E+01  1.091E+01
  1.055E+01  9.956E+00  9.166E+00  8.237E+00  7.226E+00  6.178E+00
  5.142E+00  4.155E+00  3.248E+00  2.443E+00  1.758E+00  1.196E+00
  7.605E-01  4.434E-01  2.322E-01  1.066E-01  4.242E-02  1.508E-02
  5.193E-03  4.267E-03  3.488E-03  2.832E-03  2.268E-03  1.788E-03
  1.378E-03  1.036E-03  7.569E-04  5.357E-04  3.658E-04  2.407E-04
  1.523E-04  9.228E-05  5 335E-05  2.926E-05  1.518E-05  7.420E-06
  .
  .
  .
```

Figure 7.20 Sample chemical emission rate file.

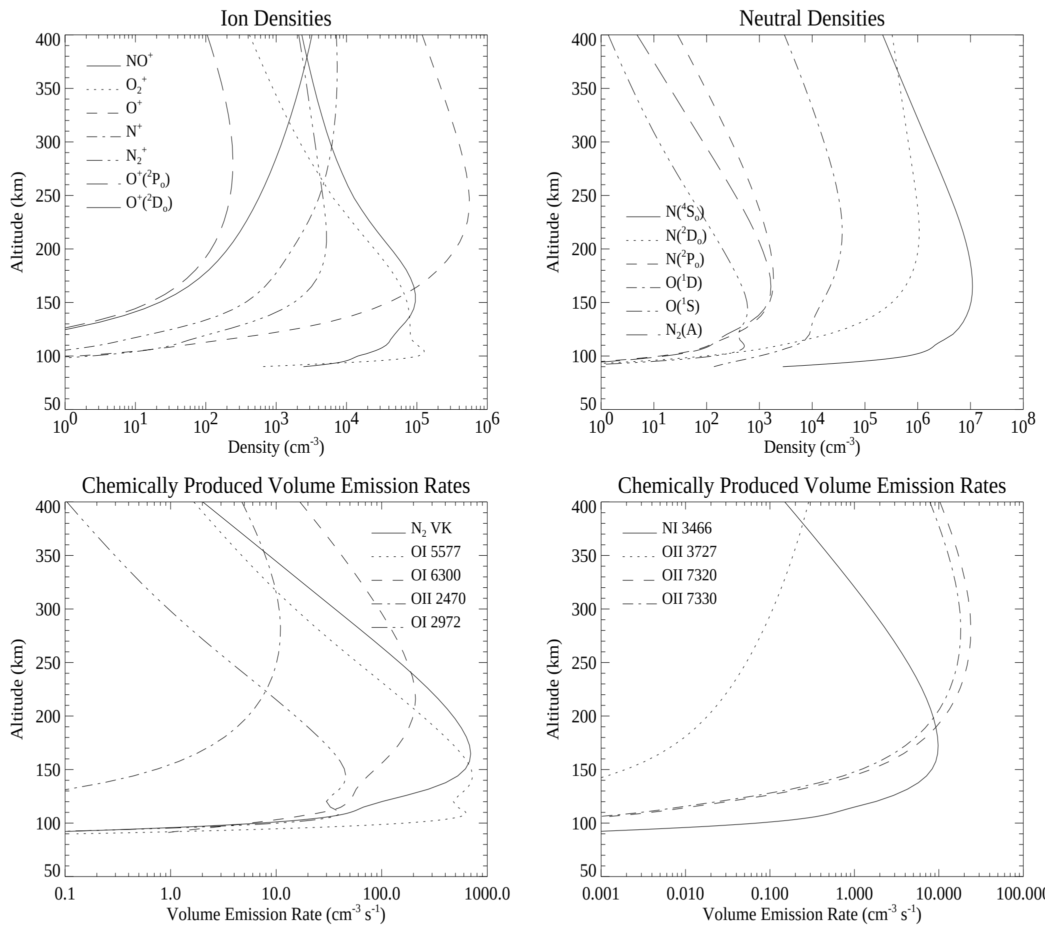


Figure 7.21 Top left: Selected ion densities versus altitude (cm^{-3}). Top right: Selected neutral chemical densities versus altitude (cm^{-3}). Bottom left and right: Selected chemically produced emission rates (cm^{-3} s^{-1}).

7.14 Line-of-Sight Column Densities

file name `losden.dat`
created by **losden**
modified by none

This file contains the line-of-sight column densities (cm^{-2}) of N_2^+ and NO as a function of look angle. They are used to calculate the radiances of the N_2^+ 1NG and NO γ, δ, εband systems. A sample file is shown in Figure 7.22 and its plot in Figure 7.23.

```
    46    10     1
ZOBS = 500.000
Zenith Angles (deg)
     90.00          93.09          94.37          95.35          96.18          96.91
     97.58          98.18          98.75          99.28          99.78         100.26
    100.72         101.16         101.58         101.99         102.39         102.77
    103.14         103.50         103.85         104.20         104.53         104.86
    105.18         105.50         105.81         106.11         106.41         106.70
    106.99         107.27         107.55         107.82         108.09         108.36
    108.62         108.88         109.14         109.39         109.64         109.89
    110.13         110.37         110.61         110.85
  .
  .
  .
Slant column densities (cm^-2)
[N2+]
  9.230E+10    1.402E+11    1.724E+11    2.007E+11    2.323E+11    2.619E+11
  2.950E+11    3.266E+11    3.620E+11    3.957E+11    4.334E+11    4.692E+11
  5.096E+11    5.497E+11    5.909E+11    6.349E+11    6.777E+11    7.256E+11
  7.748E+11    8.233E+11    8.773E+11    9.334E+11    9.920E+11    1.053E+12
  1.115E+12    1.183E+12    1.252E+12    1.323E+12    1.392E+12    1.456E+12
  1.511E+12    1.548E+12    1.560E+12    1.545E+12    1.501E+12    1.427E+12
  1.338E+12    1.245E+12    1.168E+12    1.106E+12    1.057E+12    1.016E+12
  9.815E+11    9.510E+11    9.238E+11    8.993E+11
  .
  .
  .
[NO] gamma v=0
  7.644E+08    1.691E+09    2.754E+09    3.997E+09    6.099E+09    8.595E+09
  1.281E+10    1.788E+10    2.641E+10    3.669E+10    5.395E+10    7.475E+10
  1.096E+11    1.574E+11    2.215E+11    3.223E+11    4.465E+11    6.494E+11
  9.399E+11    1.304E+12    1.885E+12    2.723E+12    3.915E+12    5.565E+12
  7.816E+12    1.123E+13    1.611E+13    2.307E+13    3.298E+13    4.708E+13
  6.712E+13    9.555E+13    1.378E+14    1.968E+14    2.784E+14    3.977E+14
  5.743E+14    8.590E+14    1.440E+15    2.240E+15    2.577E+15    2.681E+15
  2.540E+15    2.615E+15    3.777E+15    4.831E+15
  .
  .
  .
```

Figure 7.22 Sample line-of-sight column densities file.

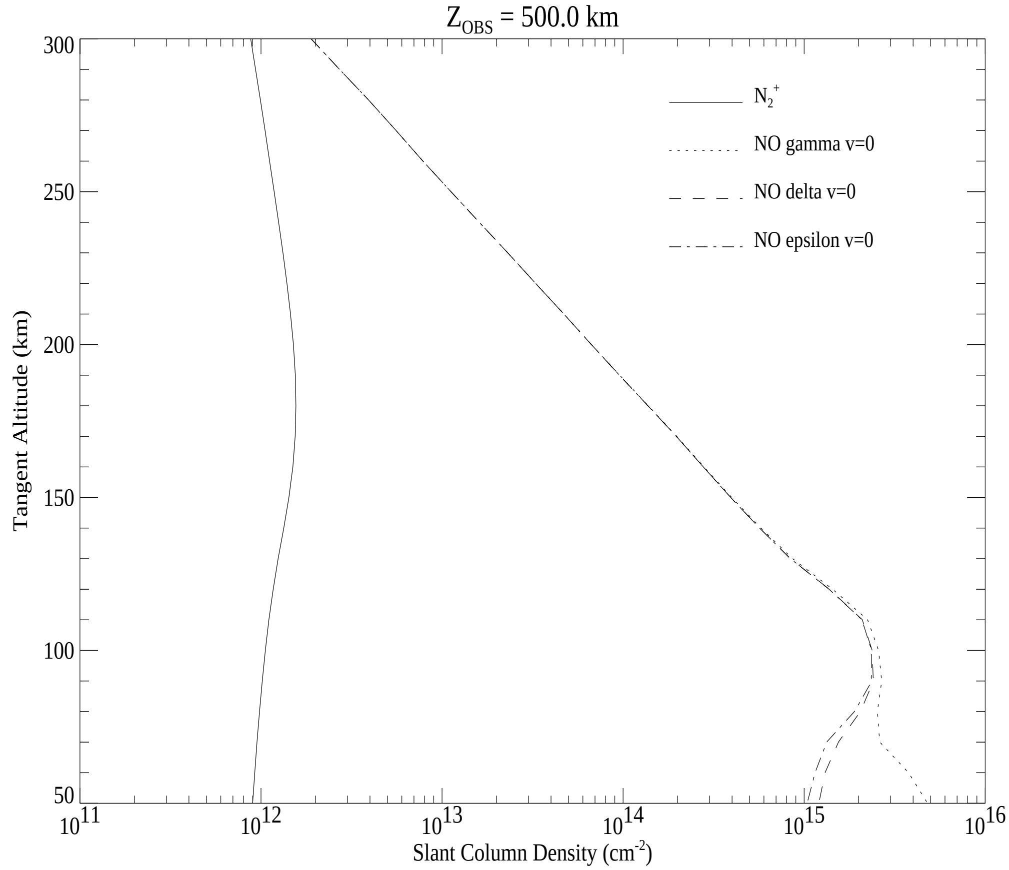


Figure 7.23 Line-of-sight column densities versus tangent altitude.

7.15 Line-of-Sight Column Emission Rates

file name `dayglo.int`
created by **mergeint**
modified by none

This file contains the line-of-sight column emission rates (in Rayleighs) as a function of look angle. A sample file is shown in Figure 7.24 and its plot in Figure 7.25.

```
   46   52    1
ZOBS = 500.000
Zenith Angles (deg)
     90.00          93.09         94.37       95.35          96.18          96.91
     97.58          98.18         98.75       99.28          99.78         100.26
    100.72         101.16        101.58      101.99         102.39         102.77
    103.14         103.50        103.85      104.20         104.53         104.86
    105.18         105.50        105.81      106.11         106.41         106.70
    106.99         107.27        107.55      107.82         108.09         108.36
    108.62         108.88        109.14      109.39         109.64         109.89
    110.13         110.37        110.61      110.85
Column Emission Rates (R)
1304 A
  7.737E+03   7.964E+03   7.918E+03   8.140E+03   8.456E+03   8.734E+03
  9.104E+03   9.429E+03   9.743E+03   1.017E+04   1.053E+04   1.090E+04
  1.141E+04   1.184E+04   1.237E+04   1.290E+04   1.341E+04   1.408E+04
  1.467E+04   1.537E+04   1.607E+04   1.674E+04   1.761E+04   1.836E+04
  1.929E+04   2.011E+04   2.109E+04   2.197E+04   2.298E+04   2.390E+04
  2.494E+04   2.586E+04   2.692E+04   2.784E+04   2.889E+04   2.988E+04
  3.076E+04   3.161E+04   3.191E+04   3.043E+04   2.980E+04   2.937E+04
  2.904E+04   2.876E+04   2.851E+04   2.828E+04
1356 A
  4.028E+01   6.765E+01   8.692E+01   1.125E+02   1.377E+02   1.656E+02
  2.070E+02   2.478E+02   2.939E+02   3.634E+02   4.309E+02   5.079E+02
  6.245E+02   7.356E+02   8.897E+02   1.057E+03   1.238E+03   1.503E+03
  1.760E+03   2.102E+03   2.476E+03   2.877E+03   3.443E+03   3.976E+03
  4.691E+03   5.362E+03   6.195E+03   6.953E+03   7.797E+03   8.498E+03
  9.130E+03   9.521E+03   9.597E+03   9.388E+03   8.630E+03   7.640E+03
  6.708E+03   5.994E+03   5.607E+03   5.342E+03   5.125E+03   4.939E+03
  4.777E+03   4.633E+03   4.504E+03   4.388E+03
        .
        .
```

Figure 7.24 Sample line-of-sight column emission rates (R).

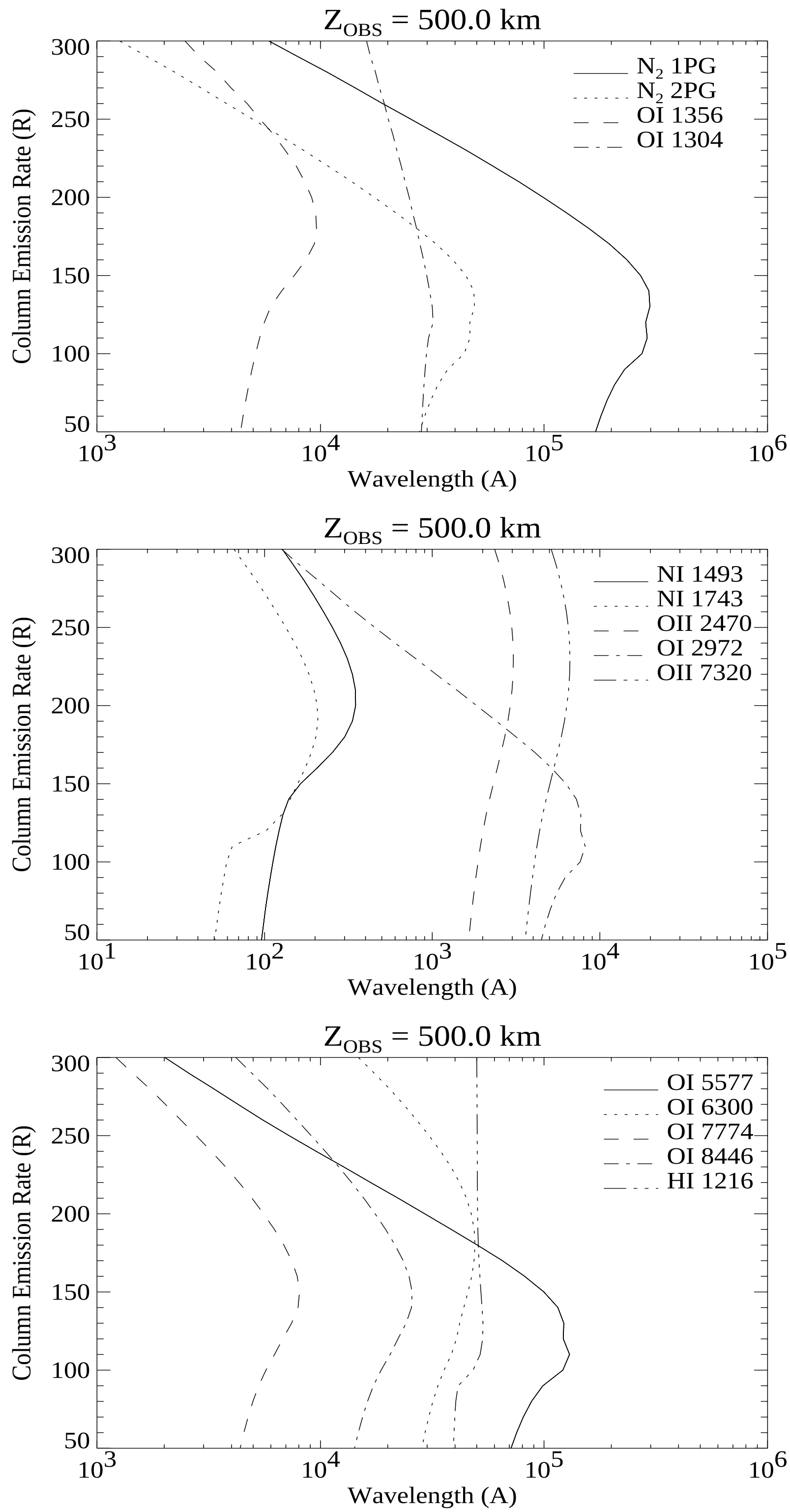


Figure 7.25 Selected line-of-sight column emission rates versus tangent altitude.

7.16 Synthetic Spectra

The files listed below contain synthetic spectra (R/Å) for the systems identified in the file names.

file name `n2_lbh.syn`
created by **syn_lbh**
modified by none
content N_2 Lyman-Birge-Hopfield synthetic spectra (R/Å). A sample file is shown in Figure 7.26 and its plot in Figure 7.27.

file name `n2_vk.syn`
created by **syn_vk**
modified by none
content N_2 Vegard Kaplan synthetic spectra (R/Å). A sample plot is shown in Figure 7.27.

file name `n2_1pg.syn`
created by **syn_1pg**
modified by none
content N_2 First Positive synthetic spectra (R/Å). A sample plot is shown in Figure 7.27.

file name `n2_2pg.syn`
created by **syn_2pg**
modified by none
content N_2 Second Positive synthetic spectra (R/Å). A sample plot is shown in Figure 7.27.

file name `n2p_1ng.syn`
created by **syn_1ng**
modified by none
content N_2^+ First Negative synthetic spectra (R/Å). A sample plot is shown in Figure 7.28.

file name `n2p_mnl.syn`
created by **syn_mnl**
modified by none

content N_2^+ Meinel synthetic spectra (R/Å). A sample plot is shown in Figure 7.28.

file name `no_bands.syn`
created by **syn_no**
modified by none
content NO (δ, γ, ε) bands system spectra (R/Å). A sample plot is shown in Figure 7.28.

file name `merge.syn`
created by **mergesyn**
modified by none
content composite synthetic spectra (R/Å) for all user-specified features. A sample plot is shown in Figure 7.28.

```
1601    46    2
ZOBS = 500.000
RES  = 1.000
Wavelengths (A)
    1260.00    1261.00    1262.00    1263.00    1264.00    1265.00
    1266.00    1267.00    1268.00    1269.00    1270.00    1271.00
    1272.00    1273.00    1274.00    1275.00    1276.00    1277.00
    1278.00    1279.00    1280.00    1281.00    1282.00    1283.00
    1284.00    1285.00    1286.00    1287.00    1288.00    1289.00
    1290.00    1291.00    1292.00    1293.00    1294.00    1295.00
    1296.00    1297.00    1298.00    1299.00    1300.00    1301.00
    1302.00    1303.00    1304.00    1305.00    1306.00    1307.00
    1308.00    1309.00    1310.00    1311.00    1312.00    1313.00
    1314.00    1315.00    1316.00    1317.00    1318.00    1319.00
          .
          .
Synthetic spectra (R/A)
Zenith Angle = 90.000
0.000E+00   0.000E+00   0.000E+00   0.000E+00   0.000E+00   0.000E+00
  0.000E+00   0.000E+00   0.000E+00   0.000E+00   0.000E+00   0.000E+00
  0.000E+00   0.000E+00   0.000E+00   0.000E+00   0.000E+00   0.000E+00
  0.000E+00   0.000E+00   0.000E+00   0.000E+00   0.000E+00   0.000E+00
  0.000E+00   0.000E+00   0.000E+00   0.000E+00   0.000E+00   0.000E+00
  0.000E+00   0.000E+00   0.000E+00   0.000E+00   0.000E+00   0.000E+00
  0.000E+00   0.000E+00   1.363E-02   3.940E-02   2.096E-02   1.223E-02
  6.120E-03   2.730E-03   2.288E-03   8.822E-04   5.084E-04   2.813E-04
  1.445E-04   6.006E-05   5.902E-05   2.043E-05   6.373E-03   1.837E-02
  9.779E-03   5.703E-03   2.854E-03   1.274E-03   1.067E-03   4.114E-04
          .
          .
Zenith Angle = 93.090
  0.000E+00     0.000E+00   0.000E+00   0.000E+00   0.000E+00   0.000E+00
  0.000E+00   0.000E+00   0.000E+00   0.000E+00   0.000E+00   0.000E+00
  0.000E+00   0.000E+00   0.000E+00   0.000E+00   0.000E+00   0.000E+00
  0.000E+00   0.000E+00   0.000E+00   0.000E+00   0.000E+00   0.000E+00
  0.000E+00   0.000E+00   0.000E+00   0.000E+00   0.000E+00   0.000E+00
  0.000E+00   0.000E+00   0.000E+00   0.000E+00   0.000E+00   0.000E+00
  0.000E+00   0.000E+00   0.000E+00   0.000E+00   0.000E+00   0.000E+00
  0.000E+00   0.000E+00   0.000E+00   0.000E+00   0.000E+00   0.000E+00
  0.000E+00   0.000E+00   2.699E-02   7.802E-02   4.151E-02   2.422E-02
  1.212E-02   5.406E-03   4.532E-03   1.747E-03   1.007E-03   5.570E-04
  2.861E-04   1.189E-04   1.169E-04   4.046E-05   1.262E-02   3.638E-02
  1.937E-02   1.129E-02   5.651E-03   2.522E-03   2.113E-03   8.147E-04
          .
```

Figure 7.26 Sample file containing N_2 LBH synthetic spectra.

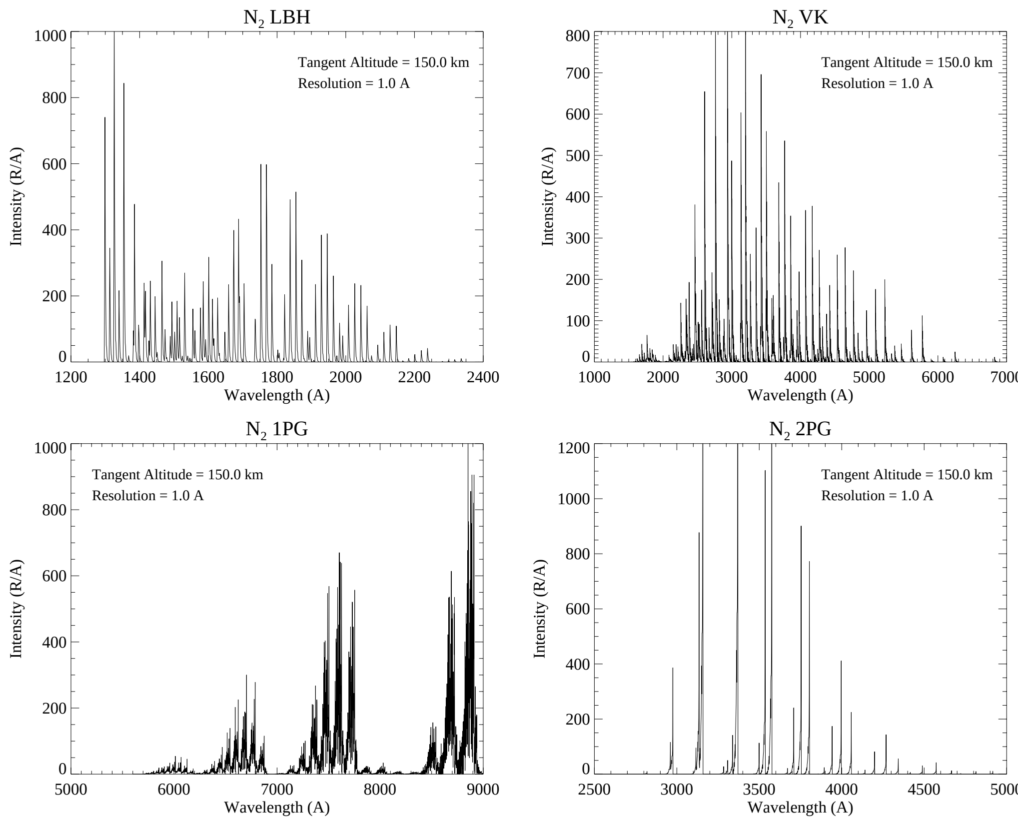


Figure 7.27 Top left: An example of an N_2 LBH spectrum versus wavelength. Top right: An example of an N_2 VK spectrum versus wavelength. Bottom left: An example of an N_2 1PG spectrum versus wavelength. Bottom right: An example of an N_2 2PG spectrum versus wavelength.

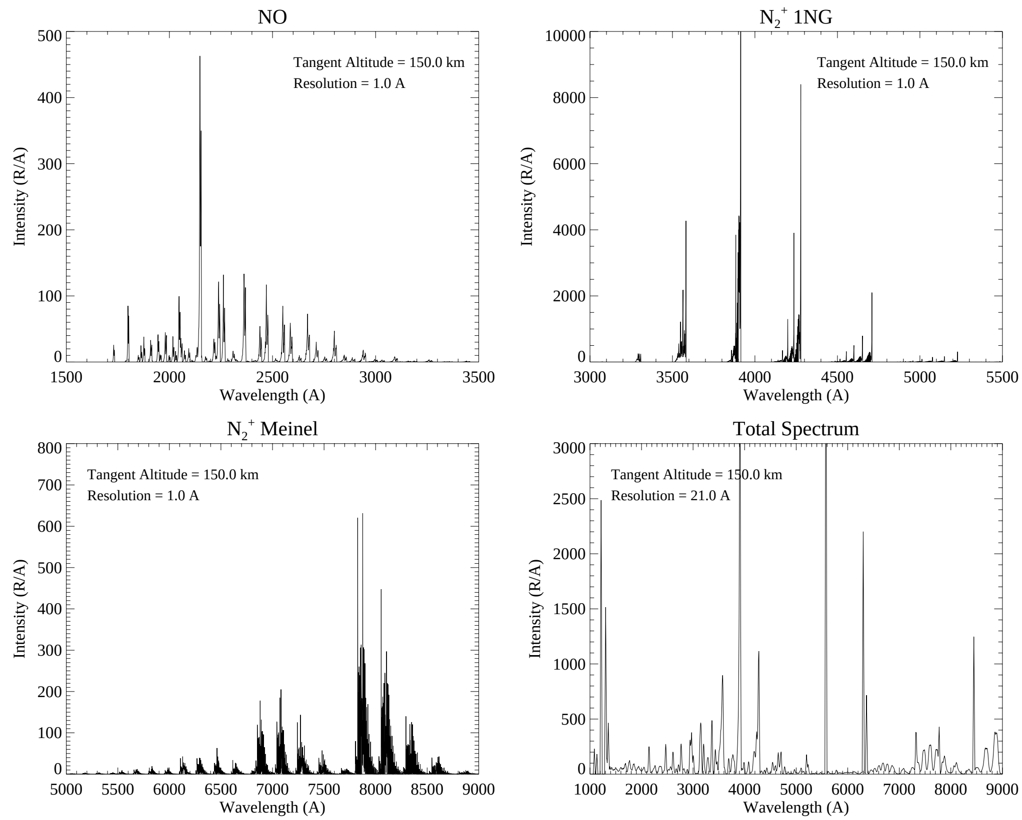


Figure 7.28 Top left: An example of an NO spectrum versus wavelength. Top right: An example of an N_2^+ 1NG spectrum versus wavelength. Bottom left: An example of an N_2^+ Meinel spectrum versus wavelength. Bottom right: An example of the total spectrum versus wavelength.

7.17 Nightglow Files

For a nightglow run, some files and plots will look different from their dayglow counterparts. To illustrate, this section displays the nighttime ionosphere, volume emission rates, radiances, and synthetic spectra.

The geophysical parameters file used is shown in Fig 7.29. The `view.inp` file is shown in Fig 7.30. The remaining input files were left unchanged from the dayglow case considered in Chapter 2.

```
Mandatory parameters:
     100   NALT        : number of altitude points
   1000.0   ZUB        : upper bound of atmosphere (km)
    92080   YYDDD      : year & day (YYDDD format)
  45000.0   UTSEC      : universal time (sec)
    50.00   GLAT       : latitude (deg)
   180.00   GLON       : longitude (deg)
     1.00   SCALE(N2)  : N2 density scale factor
     1.00   SCALE(O2)  : O2 density scale factor
     1.00   SCALE(O)   : O  density scale factor
     1.00   SCALE(O3)  : O3 density scale factor
     1.00   SCALE(NO)  : NO density scale factor
     1.00   SCALE(N)   : N  density scale factor
     1.00   SCALE(He)  : He density scale factor
     1.00   SCALE(H)   : H  density scale factor
     1.00   SCALE(Ar)  : Ar density scale factor
Derived parameters:
    44.63   GMLAT      : geomagnetic latitude (deg)
   237.83   GMLON      : geomagnetic longitude (deg)
    61.63   DPANG      : magnetic dip angle (deg)
   129.71   SZA        : solar zenith angle (deg)
  0.37625   SLT        : solar local time (hours)
   167.20   F10DAY     : F10.7 (current day)
   166.10   F10PRE     : F10.7 (previous day)
   179.00   F10AVE     : F10.7 (81-day average)
     4.12   AP(1)      : daily Ap
     3.00   AP(2)      : 3-hour Ap
     3.00   AP(3)      : 3-hour Ap
     6.00   AP(4)      : 3-hour Ap
     3.00   AP(5)      : 3-hour Ap
     3.62   AP(6)      : average 3-hour Ap
    13.25   AP(7)      : average 3-hour Ap
```

Figure 7.29 `param.inp` file used to generate the nightglow files.

```
... 800.0000   observer altitude (km)
  106.62693
  106.90376
  107.17626
  107.44464
  107.70907
  107.96974
  108.22680
  108.48042
  108.73067
  108.97781
  109.22185
  109.46293
  109.70119
  109.93674
  110.16962
  110.39993
  110.62783
  110.85331
  111.07648
  111.29744
  111.51624
  111.73293
  111.94756
  112.16026
  112.37101
  112.57990
  112.99226
  113.19585
  113.39777
  113.59805
  113.79675
  113.99388
  114.18950
  114.38366
  114.57635
  114.76768
  114.95760
  115.14618
  115.18375
  115.22125
  115.25871
  115.29611
  115.33347
  115.37077
  115.40801
  115.44521
  115.48236
  115.51947
  115.55650
  115.59350
  115.63044
  115.66734
  115.70418
  115.74098
  115.77774
  115.81444
  115.85109
  115.88768
  115.92425
  115.96075
  115.99722
  116.03363
  116.06999
  116.25110
  116.43108
```

Figure 7.30 `view.inp` file used to generate the nightglow files.

7.18 Ionosphere file name `ionos.dat`

created by **ionos** or **getpim**
modified by none

The ionosphere file contains an altitude grid (km) and electron densities (cm^{-3}). It can be generated by program **ionos** (FAIM model), program **getpim** (PIM model), or supplied by the user. A sample file is shown in Figure 7.31 and a plot in Figure 7.32.

> The altitude grid in this file must be identical to that of the neutral atmosphere file.

```
  100    1
Altitudes (km)
   1000.00    955.94    913.82    873.56    835.07    798.28
    763.11    729.49    697.35    666.62    637.25    609.18
    582.34    556.68    532.15    508.71    486.29    464.87
    444.39    424.81    406.09    388.20    371.10    354.75
    339.12    324.18    309.89    296.24    283.19    270.71
    258.78    247.38    236.48    226.06    216.10    206.58
    197.48    188.78    180.46    172.51    164.91    157.64
    150.70    144.06    137.71    131.64    125.84    120.30
    115.00    114.00    113.00    112.00    111.00    110.00
    109.00    108.00    107.00    106.00    105.00    104.00
    103.00    102.00    101.00    100.00     99.00     98.00
     97.00     96.00     95.00     94.00     93.00     92.00
     91.00     90.00     89.00     88.00     87.00     86.00
     85.00     84.00     83.00     82.00     81.00     80.00
     75.00     70.00     65.00     60.00     55.00     50.00
     45.00     40.00     35.00     30.00     25.00     20.00
     15.00     10.00      5.00      0.00
Electron Density (cm^-3)
[e-]
  6.811E+03  9.791E+03  1.383E+04  1.922E+04  2.626E+04  3.530E+04
  4.668E+04  6.074E+04  7.774E+04  9.787E+04  1.211E+05  1.474E+05
  1.761E+05  2.067E+05  2.380E+05  2.689E+05  2.977E+05  3.229E+05
  3.429E+05  3.564E+05  3.623E+05  3.600E+05  3.484E+05  3.266E+05
  2.946E+05  2.538E+05  2.068E+05  1.577E+05  1.112E+05  7.148E+04
  4.134E+04  2.137E+04  1.008E+04  4.810E+03  2.909E+03  2.477E+03
  2.523E+03  2.665E+03  2.798E+03  2.906E+03  2.996E+03  3.088E+03
  3.214E+03  3.413E+03  3.727E+03  4.182E+03  4.773E+03  5.428E+03
  5.977E+03  6.049E+03  6.105E+03  6.142E+03  6.158E+03  6.148E+03
  6.111E+03  6.042E+03  5.940E+03  5.802E+03  5.627E+03  5.414E+03
  5.163E+03  4.875E+03  4.554E+03  4.202E+03  3.826E+03  3.432E+03
  3.029E+03  2.625E+03  2.230E+03  1.852E+03  1.502E+03  1.185E+03
  9.076E+02  6.727E+02  4.810E+02  3.306E+02  2.176E+02  1.368E+02
  8.177E+01  4.644E+01  2.507E+01  1.295E+01  6.508E+00  3.293E+00
  3.375E-01  6.322E-02  9.089E-03  9.500E-04  6.862E-05  3.231E-06
  9.265E-08  1.496E-09  1.242E-11  4.772E-14  7.508E-17  4.199E-20
  7.088E-24  2.986E-28  2.520E-33  0.000E+00
```

Figure 7.31 Sample ionosphere file.

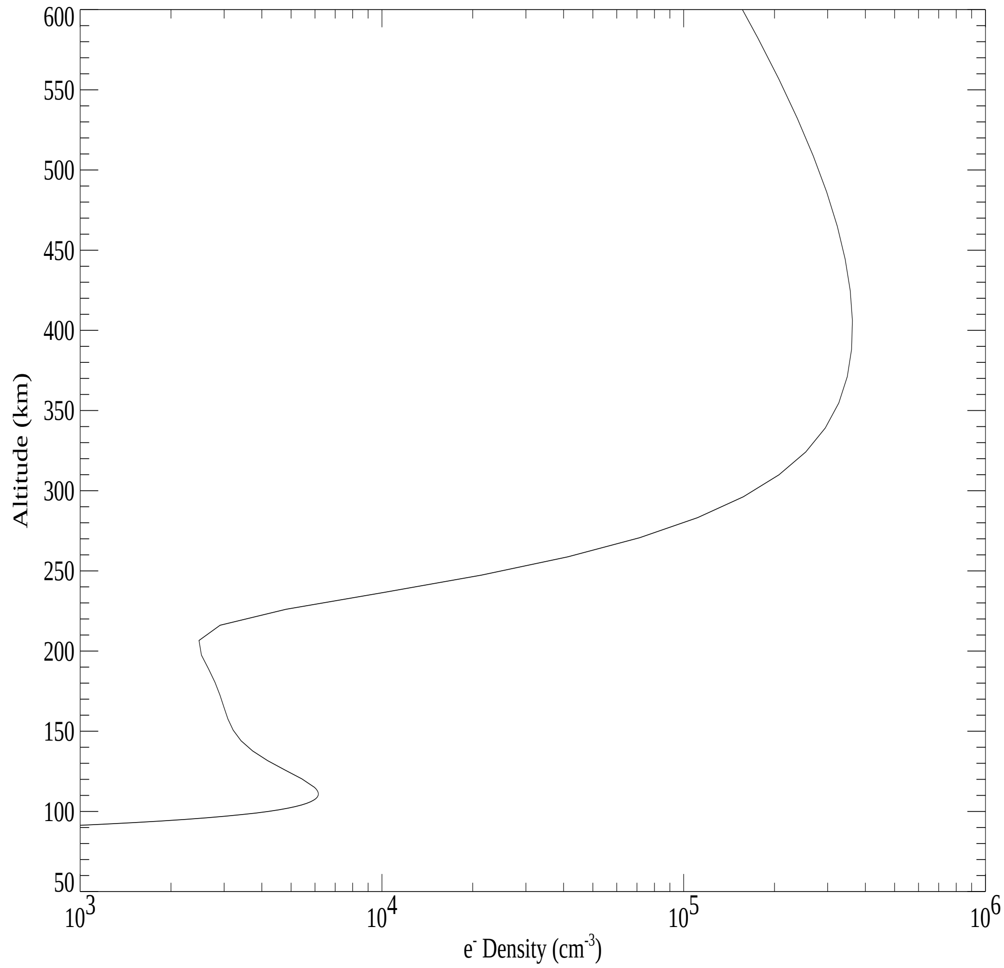


Figure 7.32 Electron density versus altitude.

7.19 Volume Emission Rates

file name `niteglo.ver`
created by **niteglo**
modified by **radtrans**

This file contains the niteglo volume emission rates (cm^{-3} s^{-1}). A sample file is shown in Figure 7.33 and its plots in Figure 7.34.

```
  100   15
Altitudes (km)
   1000.00     955.94     913.82     873.56     835.07     798.28
    763.11     729.49     697.35     666.62     637.25     609.18
    582.34     556.68     532.15     508.71     486.29     464.87
    444.39     424.81     406.09     388.20     371.10     354.75
    339.12     324.18     309.89     296.24     283.19     270.71
    258.78     247.38     236.48     226.06     216.10     206.58
    197.48     188.78     180.46     172.51     164.91     157.64
    150.70     144.06     137.71     131.64     125.84     120.30
    115.00     114.00     113.00     112.00     111.00     110.00
    109.00     108.00     107.00     106.00     105.00     104.00
    103.00     102.00     101.00     100.00      99.00      98.00
     97.00      96.00      95.00      94.00      93.00      92.00
     91.00      90.00      89.00      88.00      87.00      86.00
     85.00      84.00      83.00      82.00      81.00      80.00
     75.00      70.00      65.00      60.00      55.00      50.00
     45.00      40.00      35.00      30.00      25.00      20.00
     15.00      10.00       5.00       0.00
Volume Emission Rates (cm^-3 s^-1)
O(3So) 1304 A (initial)
  1.708E-05  3.536E-05  7.072E-05  1.370E-04  2.568E-04  4.664E-04
  8.208E-04  1.401E-03  2.318E-03  3.718E-03  5.780E-03  8.726E-03
  1.275E-02  1.807E-02  2.480E-02  3.300E-02  4.252E-02  5.304E-02
  6.399E-02  7.458E-02  8.375E-02  9.019E-02  9.231E-02  8.852E-02
  7.825E-02  6.255E-02  4.419E-02  2.694E-02  1.379E-02  5.734E-03
  1.853E-03  4.362E-04  6.925E-05  8.456E-06  1.586E-06  7.339E-07
  5.623E-07  4.766E-07  3.943E-07  3.132E-07  2.405E-07  1.815E-07
  1.381E-07  1.084E-07  8.879E-08  7.456E-08  6.080E-08  4.388E-08
  2.573E-08  2.254E-08  1.951E-08  1.667E-08  1.406E-08  1.166E-08
  9.514E-09  7.622E-09  5.986E-09  4.601E-09  3.455E-09  2.529E-09
  1.800E-09  1.244E-09  8.316E-10  5.363E-10  3.327E-10  1.977E-10
  1.121E-10  6.028E-11  3.063E-11  1.458E-11  6.479E-12  2.660E-12
  1.001E-12  3.422E-13  0.000E+00  0.000E+00  0.000E+00  0.000E+00
  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00
  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00
  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00
  0.000E+00  0.000E+00  0.000E+00  0.000E+00
O(5So) 1356 A (initial)
  3.156E-05    6.531E-05    1.305E-04    2.526E-04    4.727E-04    8.569E-04
  1.505E-03    2.560E-03    4.221E-03    6.743E-03    1.043E-02    1.564E-02
  2.266E-02    3.182E-02    4.317E-02    5.669E-02    7.191E-02    8.815E-02
  1.043E-01    1.191E-01    1.309E-01    1.381E-01    1.385E-01    1.304E-01
  1.134E-01    8.942E-02    6.249E-02    3.778E-02    1.923E-02    7.966E-03
  2.570E-03    6.044E-04    9.593E-05    1.172E-05    2.200E-06    1.018E-06
  7.810E-07    6.627E-07    5.490E-07    4.369E-07    3.362E-07    2.545E-07
  1.943E-07    1.531E-07    1.261E-07    1.066E-07    8.772E-08    6.408E-08
  3.811E-08    3.347E-08    2.905E-08    2.489E-08    2.103E-08    1.748E-08
  1.430E-08    1.148E-08    9.029E-09    6.951E-09    5.228E-09    3.832E-09
  2.731E-09    1.888E-09    1.264E-09    8.154E-10    5.060E-10    3.007E-10
  1.705E-10    9.167E-11    4.656E-11    2.215E-11    9.840E-12    4.037E-12
  1.519E-12    5.188E-13    0.000E+00    0.000E+00    0.000E+00    0.000E+00
  0.000E+00    0.000E+00    0.000E+00    0.000E+00    0.000E+00    0.000E+00
  0.000E+00    0.000E+00    0.000E+00    0.000E+00    0.000E+00    0.000E+00
  0.000E+00    0.000E+00    0.000E+00    0.000E+00    0.000E+00    0.000E+00
  0.000E+00    0.000E+00    0.000E+00    0.000E+00
        .
        .
        .
```

Figure 7.33 Sample nightglow emission rate file.

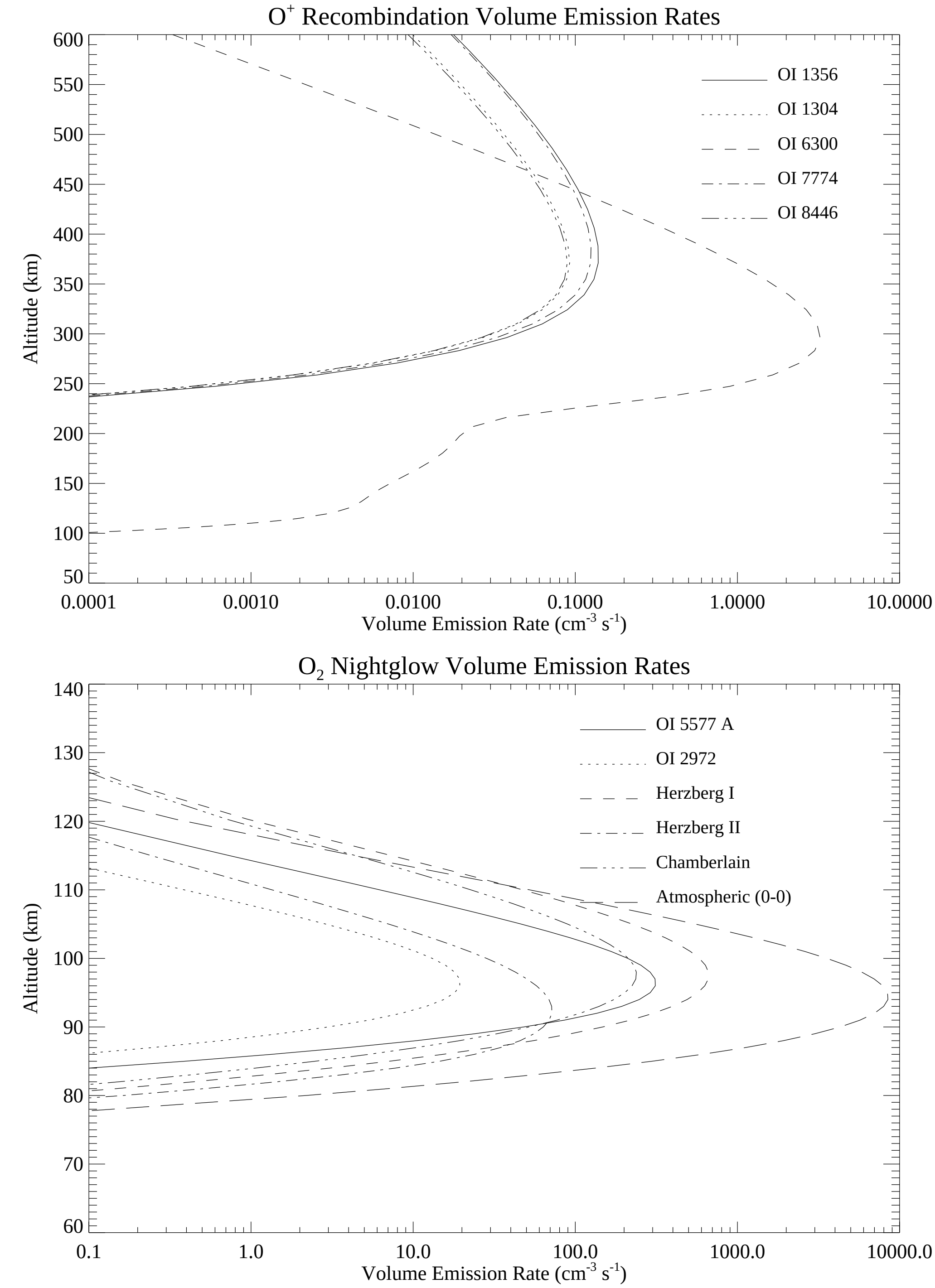


Figure 7.34 Top: O^+ recombination volume emission rates (cm^{-3} s^{-1}). Bottom: O_2 nightglow volume emission rates (cm^{-3} s^{-1}).

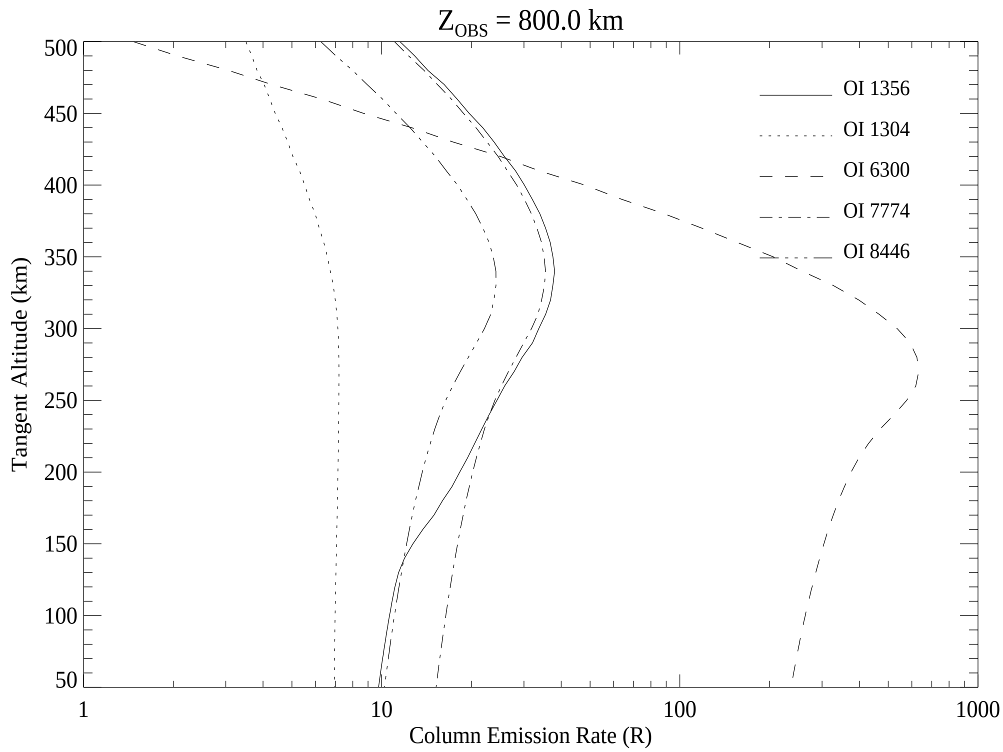
7.20 Line-of-Sight Column file name `niteglo.int`

Emission Rates created by **mergeint**
modified by none

This file contains the line-of-sight column emission rates (R) as a function of look angle. A sample file is shown in Figure 7.35 and its plot in Figure 7.36.

```
    66   14    1
ZOBS = 800.000
Zenith Angles (deg)
    106.63   106.90   107.18   107.44   107.71   107.97
    108.23   108.48   108.73   108.98   109.22   109.46
    109.70   109.94   110.17   110.40   110.63   110.85
    111.08   111.30   111.52   111.73   111.95   112.16
    112.37   112.58   112.79   112.99   113.20   113.40
    113.60   113.80   113.99   114.19   114.38   114.58
    114.77   114.96   115.15   115.18   115.22   115.26
    115.30   115.33   115.37   115.41   115.45   115.48
    115.52   115.56   115.59   115.63   115.67   115.70
    115.74   115.78   115.81   115.85   115.89   115.92
    115.96   116.00   116.03   116.07   116.25   116.43
Column Emission Rates (R)
1304 A
  3.506E+00  3.665E+00  3.821E+00  4.033E+00  4.214E+00  4.393E+00
  4.634E+00  4.838E+00  5.037E+00  5.303E+00  5.517E+00  5.721E+00
  5.982E+00  6.178E+00  6.394E+00  6.576E+00  6.724E+00  6.880E+00
  6.986E+00  7.071E+00  7.132E+00  7.168E+00  7.185E+00  7.193E+00
  7.189E+00  7.185E+00  7.176E+00  7.168E+00  7.157E+00  7.146E+00
  7.133E+00  7.120E+00  7.105E+00  7.089E+00  7.073E+00  7.055E+00
  7.039E+00  7.023E+00  7.006E+00  7.003E+00  7.000E+00  6.997E+00
  6.994E+00  6.991E+00  6.988E+00  6.986E+00  6.983E+00  6.981E+00
  6.978E+00  6.976E+00  6.973E+00  6.971E+00  6.969E+00  6.967E+00
  6.965E+00  6.963E+00  6.962E+00  6.960E+00  6.958E+00  6.956E+00
  6.954E+00  6.953E+00  6.951E+00  6.949E+00  6.942E+00  6.935E+00
1356 A
  1.153E+01  1.289E+01  1.430E+01  1.619E+01  1.791E+01  1.965E+01
  2.186E+01  2.383E+01  2.578E+01  2.811E+01  3.009E+01  3.199E+01
  3.394E+01  3.548E+01  3.676E+01  3.753E+01  3.802E+01  3.752E+01
  3.684E+01  3.546E+01  3.362E+01  3.207E+01  2.957E+01  2.781E+01
  2.586E+01  2.436E+01  2.291E+01  2.169E+01  2.049E+01  1.941E+01
  1.826E+01  1.721E+01  1.601E+01  1.497E+01  1.376E+01  1.271E+01
  1.192E+01  1.139E+01  1.107E+01  1.103E+01  1.098E+01  1.093E+01
  1.088E+01  1.084E+01  1.079E+01  1.075E+01  1.071E+01  1.067E+01
   1.062E+01  1.058E+01  1.054E+01  1.050E+01  1.047E+01  1.043E+01
  1.039E+01  1.035E+01  1.032E+01  1.028E+01  1.024E+01  1.021E+01
  1.017E+01  1.014E+01  1.011E+01  1.007E+01  9.912E+00  9.761E+00
        .
        .
        .
```

Figure 7.35 Sample line-of-sight column emission rates (R).



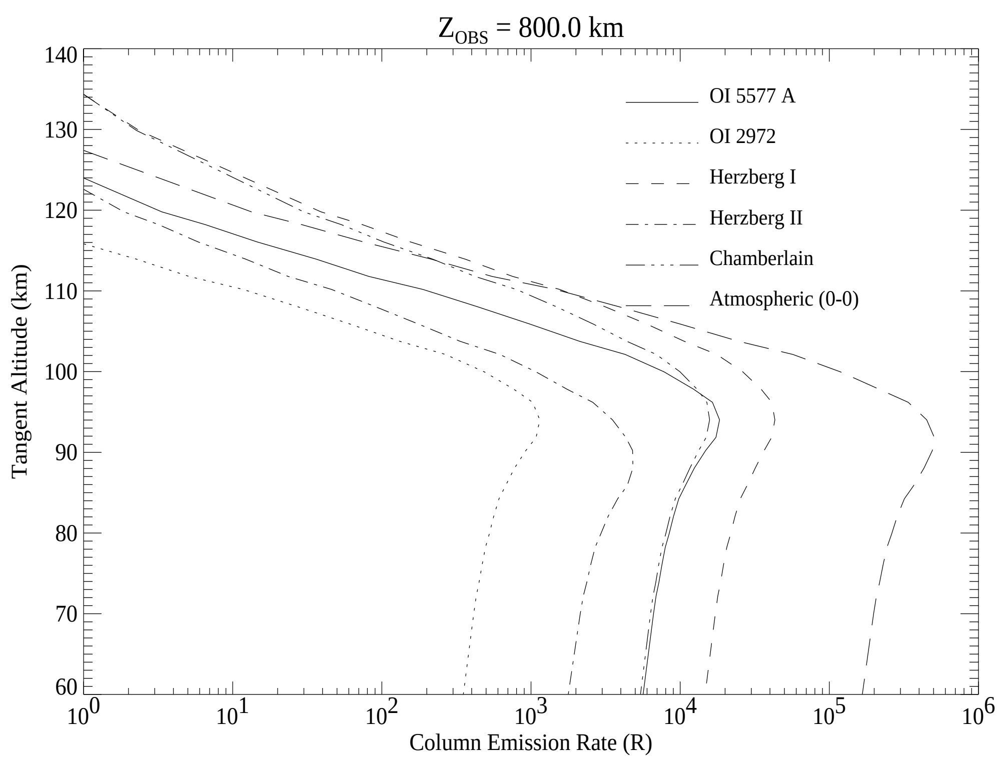


Figure 7.36 Line-of-sight column emission rates versus tangent altitude.

7.21 Synthetic Spectra

The files listed below contain synthetic spectra (R/Å) for the systems identified in the file names.

file name	`o2_nglow.syn`
created by	**syn_o2**
modified by	none
content	O_2 nightglow synthetic spectra (R/Å). A sample file is shown in Figure 7.37 and its plot in Figure 7.38.

file name	`o2_atm.syn`
created by	**syn_atm**
modified by	none
content	O_2 Atmospheric (0-0) band synthetic spectra (R/Å). A sample plot is shown in Figure 7.38.

file name	`merge.syn`
created by	**mergesyn**
modified by	none
content	composite synthetic spectra (R/Å) for all user-specified features. A sample plot is shown in Figure 7.38.

```
  3001    66    2
ZOBS = 800.000
RES  = 1.000
Wavelengths (A)
        .
        .
    2414.00    2415.00    2416.00    2417.00    2418.00    2419.00
    2420.00    2421.00    2422.00    2423.00    2424.00    2425.00
    2426.00    2427.00    2428.00    2429.00    2430.00    2431.00
    2432.00    2433.00    2434.00    2435.00    2436.00    2437.00
    2438.00    2439.00    2440.00    2441.00    2442.00    2443.00
    2444.00    2445.00    2446.00    2447.00    2448.00    2449.00
    2450.00    2451.00    2452.00    2453.00    2454.00    2455.00
    2456.00    2457.00    2458.00    2459.00    2460.00    2461.00
    2462.00    2463.00    2464.00    2465.00    2466.00    2467.00
    2468.00    2469.00    2470.00    2471.00    2472.00    2473.00
        .
        .
Synthetic spectra (R/A)
Zenith Angle = 106.630
        .
        .
  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00
  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00
  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00
  0.000E+00  0.000E+00  0.000E+00  1.084E-20  4.444E-17  9.170E-16
  3.536E-15  3.400E-15  4.412E-15  3.608E-15  1.496E-15  3.460E-15
  1.294E-15  9.021E-16  3.512E-15  3.835E-16  2.722E-15  1.114E-15
  1.065E-16  8.969E-16  2.313E-15  1.576E-16  3.851E-16  2.091E-15
  2.084E-16  2.975E-17  4.856E-16  1.494E-15  1.028E-15  5.623E-15
  6.839E-15  7.678E-15  2.016E-15  6.878E-15  1.695E-15  6.643E-15
  1.495E-15  6.706E-15  4.915E-16  1.496E-15  4.852E-15  7.911E-16
        .
        .
Zenith Angle = 106.900
        .
        .
  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00
  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00
  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00
  0.000E+00  0.000E+00  0.000E+00  1.692E-20  6.940E-17  1.432E-15
  5.523E-15  5.310E-15  6.890E-15  5.635E-15  2.336E-15  5.404E-15
  2.021E-15  1.409E-15  5.485E-15  5.989E-16  4.251E-15  1.740E-15
  1.664E-16  1.401E-15  3.612E-15  2.461E-16  6.014E-16  3.266E-15
  3.254E-16  4.646E-17  7.583E-16  2.333E-15  1.604E-15  8.777E-15
  1.067E-14  1.198E-14  3.147E-15  1.074E-14  2.645E-15  1.037E-14
  2.334E-15  1.047E-14  7.672E-16  2.335E-15  7.573E-15  1.235E-15
        .
        .
```

Figure 7.37 Sample file containing O_2 nightglow synthetic spectra.

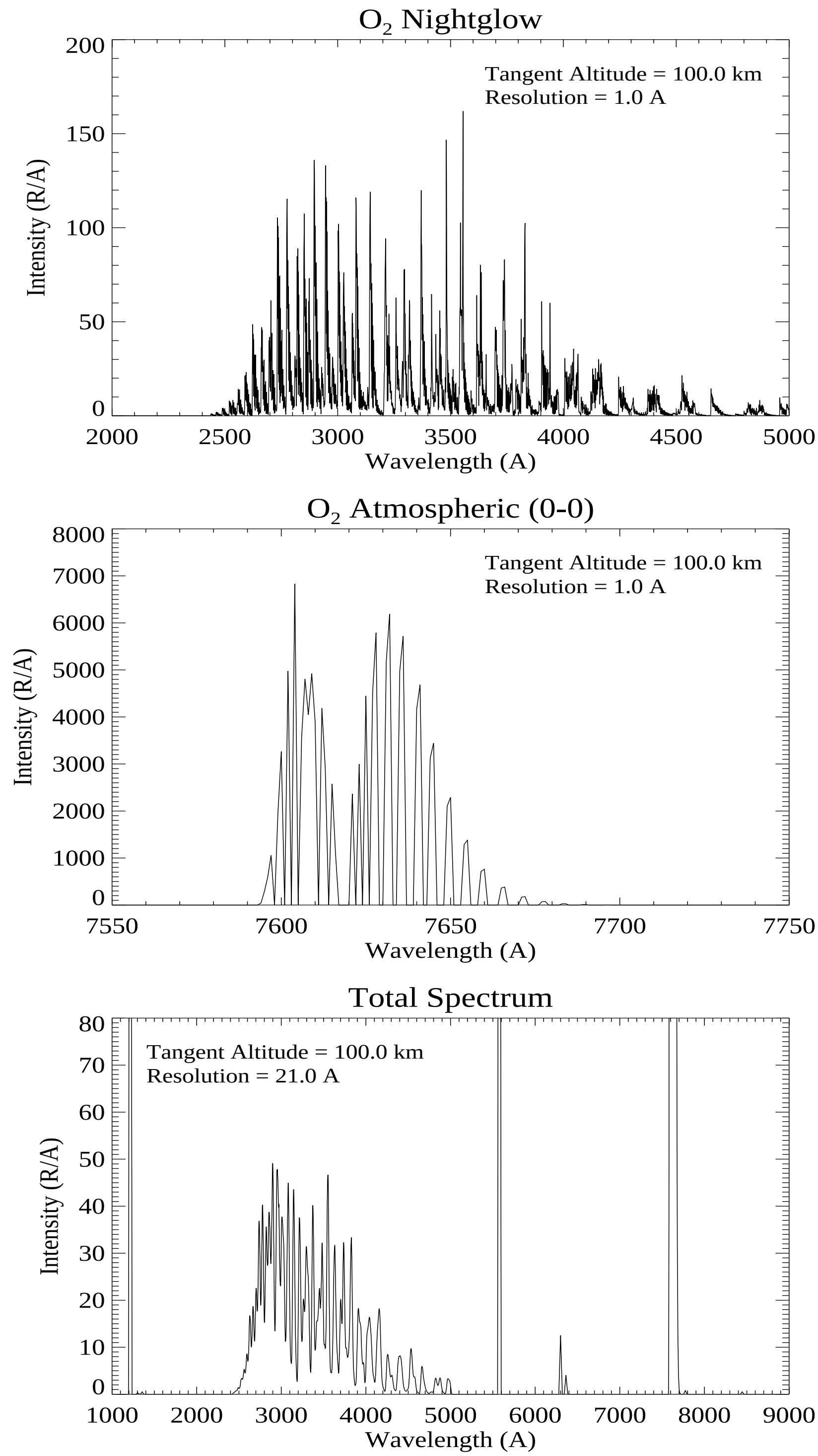


Figure 7.38 Top: An example of an O_2 nightglow spectrum versus wavelength. Middle: An example of an O_2 Atmospheric (0-0) band spectrum versus wavelength. Bottom: An example of the total spectrum versus wavelength.

Appendix A - Emission Features

Emission Features

Dayglow		Nightglow
OII 834 Å	NI 1310 Å	HI 1216 Å
NI 862 Å	NI 1319 Å	OI 1304 Å
NI 870 Å	NI 1327 Å	OI 1356 Å
NI 876 Å	OI 1356 Å	OI 1641 Å
NI 887 Å	NI 1412 Å	OI 2972 Å
NI 906 Å	NI 1493 Å	OI 5577 Å
NI 910 Å	OI 1641 Å	OI 6300 Å
NII 916 Å	NI 1743 Å	OI 6364 Å
NI 953 Å	NII 2139 Å	OI 7774 Å
NI 964 Å	NII 2143 Å	OI 8446 Å
OI 989 Å	OII 2470 Å	O_2 Herzberg I
HI 1025 Å	OI 2972 Å	O_2 Herzberg II
OI 1027 Å	NI 3466 Å	O_2 Chamberlain
OI 1040 Å	OII 3727 Å	O_2 Atmospheric (0-0)
NI 1043 Å	NI 5200 Å	
ArI 1048 Å	OI 5577 Å	
NI 1054 Å	OI 6300 Å	
ArI 1066 Å	OI 6364 Å	
NI 1068 Å	OII 7320 Å	
NII 1085 Å	OII 7330 Å	
NI 1098 Å	OI 7774 Å	
NI 1100 Å	OI 8446 Å	
NI 1134 Å	N_2 BH	
OI 1152 Å	N_2 LBH	
NI 1168 Å	N_2 VK	
NI 1177 Å	N_2 2PG	
NI 1200 Å	N_2 1PG	
HI 1216 Å	N_2^+ 1NG	
NI 1243 Å	N_2^+ Meinel	
OI 1304 Å	NO bands (δ, γ, ε)	

Appendix B - Platforms

Platforms

AURIC V1.2 fully supports the following platforms:

UNIX	Silicone Graphics Inc. IRIX 6.5 Red Hat Linux 6.x
Windows	Cygwin (using GNU g77 compiler)

with a terminal/window that has at least 80 columns and 20 rows.

Appendix C - Installation

Who Should Do It?

For group users, AURIC should be installed by a system administrator to ensure proper protection settings. For a single user, she may install AURIC in her own account.

C.1 On UNIX/Linux

AURIC comes in a tar file called `auric-v1.2-*.tgz (where * represents that operating system of interest)`. To install it, first go to a directory of your choice (can be anywhere), untar the tar file by typing:

```
% tar -zxf auric-v1.2-*.tgz
```

which will create a subdirectories: `bin, database, doc, input, plot, run`. Respectively, they contain the executable files, database files, documentation, sample input files, IDL plotting procedures, and a sample run.

Setup Environment

The AURIC batch file requires that the environment variable AURIC_ROOT is set before AURIC is used. It is strongly suggested that you set this variable in you .login or other appropriate file so that the variable is set each time you log in. At a bash shell command prompt (including Cygwin) you can enter

```
% AURIC_ROOT=/home/jones/auric
```

or in csh shell you can enter

```
% setenv AURIC_ROOT /home/jones/auric
```

We also strongly urge you to add the bin directory appropriate for your operating system to your path so that you can execute AURIC programs without the need for fully qualifying the path to the executables.

Setup Database Address

Go to the subdirectory `bin` and locate the file `auric`. Invoke a text editor to edit this file (it is a C-shell script). Read its internal documentation. You should see a line that mentions *database address*, modify that line so it reflects the true database directory path as installed on <u>your system</u>. Be sure to enter the absolute path, starting with the home directory, and end it with the proper delimiter "/". This will inform AURIC the location of its database files.

Change Protections

While you are in the `bin` directory, change the protection for all of its files to read/execute for your intended users. Note you will probably have to change its parent directories as well. Similarly, go to the `database` directory, change protections for all files there to read-only.

C.2 On Windows

AURIC comes in a zip file called `auric_v1.2-CYGWIN_NT-4.0.zip`. To install it, first go to the directory of your choice (can be anywhere), and unzip the file. Under the root directory there will be the following subdirectories: `bin, database, doc, inputs, plot, run.` Respectively, they contain the executable files, database files, documentation, sample input files, IDL plotting procedures, and a sample run.

Setup Environment

The AURIC batch file requires that the environment variable AURIC_ROOT is set before AURIC is used. In Windows NT 4.0 the environment can be set through the "My Computer" desktop icon (right click on My Computer, select Properties, click the Environment tab, enter variable AURIC_ROOT, enter value appropriate for your environment such as c:/jones/auric for Cygwin or c:\jones\auric for DOS, then click OK). In DOS you can use the command

C:\> `set AURIC_ROOT=c:\jones\auric`

or in Cygwin bash shell you can use the command

```
% AURIC_ROOT=c:/jones/auric
```

We also strongly urge you to add the CYGWIN_NT-4.0 subdirectory of the bin directory to your path so that you can execute AURIC programs without the need for fully qualifying the path to the executables.

Setup Database Address

Go to the subdirectory `bin` and locate the file `auric.sh`. Invoke a text editor to edit this file (it is a Windows batch file). Read its internal documentation. You should see a line that mentions *database address*. Modify that line so it reflects the true database directory path as installed on <u>your system</u>. Be sure to enter the absolute path, starting with the disk drive and ending with the proper delimiter ("\" if using DOS or "/" if using Cygwin). This will inform AURIC the location of its database files.

Change Protections

The files in the `bin` and `database` directories have to be made readable to your intended users.

Add `.exe` extension	If you are running AURIC in DOS then you must add a `.exe` extension to all the executables in the `bin` directory.