



HANDBOOK FOR PROCESSING INFRARED DATA

IBATCH, IPLANET, ISTAR, ICOMET, AUTOMATOR
(22,000 IDL source lines of code, including ad-hoc developed routines)

**Data analysis methods and
algorithms developed by**

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INTRODUCTION

The processing of infrared data requires the organization of the observational raw files in a certain structure. This scheme allows keeping an organized hierarchical organization of the configuration, raw and resulting files.

The data are grouped in dates, and further in settings. As shown in Fig. 1, on “dec01”, two settings were acquired “kl1” and “kl2”. For each setting, the data have been grouped into object data (“kl1” and “kl2” directories) and stellar data (“kl1_star” and “kl2_star” directories).

	<p>Dec/01/2010 directory</p> <p>Object data with the KL1 setting</p> <p>Stellar data with the KL1 setting</p> <p>Automator input file for the KL2 setting</p> <p>Object data with the KL2 setting</p> <p>Stellar data with the KL2 setting</p> <p>Automator input file for the KL2 setting</p> <p>Automator log of the “ibatch” section</p> <p>Automator log of the plugin-object section</p> <p>Dec/02/2009 directory</p> <p>Dec/03/2009 directory containing images</p> <p>Dec/11/2009 directory</p> <p>Dec/12/2009 directory</p>
--	---

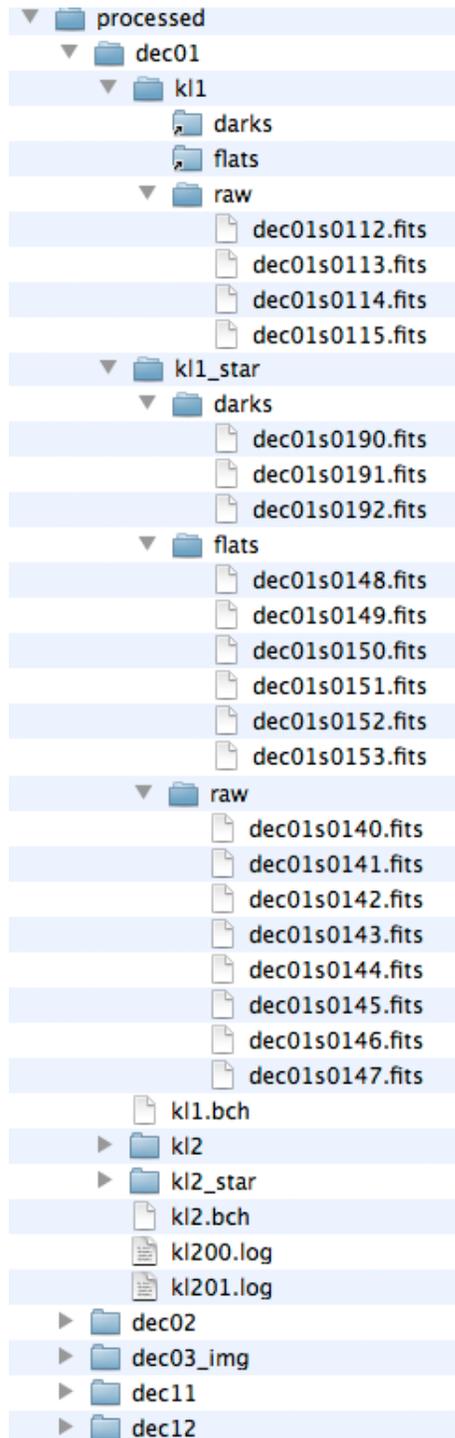
In each setting directory, three directories are mandatory for the functioning of automator. The “raw” directory containing the raw files of the object ordered following an ABBA sequence; the “flats” directory containing the raw flats files; and the “darks” directory containing the dark files.

In most cases, the calibration frames (flats & darks) are the same for the star and for the object. In order to optimize the memory use and the reciprocity between the datasets, one should use the command “ln” to create symbolink links.

- 1) Create the directory “flats” and “darks” in the kl1_star directory.
- 2) Copy the calibration frames into these directories
- 3) In a terminal window, execute the following commands:

```
~/data/obs/2009_mars/keck/processed/dec01/kl1> ln -s ../kl1_star/darks darks
~/data/obs/2009_mars/keck/processed/dec01/kl1> ln -s ../kl1_star/flats flats
```

Typical directory structure



IBATCH

DOCUMENTATION FILE

This document serves to provide the user with information regarding each input in each line of the 'results.bch' file used to run IBATCH.

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0 – READ Section

```

; -----
* READ.
; -----
; The program is case-sensitive.
; Do you want to run this section interactively?
; The present values will be the defaults. 's' as input.
; will skip this section, this is valid for all the sections.
0 n.
; 4 entries should be provided for ABBA sets and.
; 1 for flats and 1 for darks. If the entry is.
; a directory, the program will organize the files in.
; sets. If it is a file, it will run batch for.
; a single ABBA set.
1 ../raw/.
2 ../raw/.
3 ../raw/.
4 ../raw/.
5 ../flats/.
6 ../darks/.
;
; Enter the number of AB pairs per set?.
; Valid entries are: 1,2,4,...,2(N-1), all; where N is the.
; number of ABBA sets.
7 all.
;

```

In this section, you define the data directories where the frames, flats, and darks are located. Based on the header info, the program will identify to which instrument these correspond: CSHELL (0), NIRSPEC (1), PHOENIX (2), or CRIRES (3). After you input the number of AB pairs per set, the program stacks the data frames and organizes them per number of ABBA sets. The program then stacks and reads the flats, as well as the darks. (For PHOENIX data, the frames are rotated to set the x-y dimensions to spectral-spatial identities respectively).

0 – Interactive Keyword

P Q R S

Example:

n 1 0.0 0.0

P-entry (n)

‘y’: will make it interactive

‘n’: will run without user interaction

‘s’: will skip the whole section and go to the next (CROP)

‘w’: will wait for click when showing the frames

Q-entry (1)

This entry indicates the detector number, used only for CRIRES.

R- and S-entries (0.0 0.0)

These entries define the jitter of the A and B spatial solutions. Used only with CRIRES data.

1-6 - Directories of Files

In this section, you input the files/directories to be read. Line 1 corresponds to the A1 file. Line 2 corresponds to the B1 file. Line 3 corresponds to the B2 file. Line 4 corresponds to the A2 file. If you input a "raw" directory for the first four lines, the program will organize the data into ABBA sets, beginning with the first file.

Line 5 corresponds to the directory containing the flats. Line 6 corresponds to the directory containing the darks.

An additional optional entry in line 1 defines the maximum number of files to be read. For example './raw/ 4' will read only a maximum of 4 files from the directory './raw'.

7 - Number of AB Pairs

In this section, you decide how to stack the data.

If you select 'all', then all of the raw files are stacked into a single ABBA set.

If you select '1', each set will correspond to one AB pair, meaning $A1=A2=A$ and $B1=B2=B$. In this case, the cleaning procedure will not clean $dA = A1 - A2$, or $dB = B1 - B2$, but $dF = A - B$ instead.

If you select '2', then each set is one ABBA.

1 – CROP Section

```

; -----
; * CROP & FLAT.
; -----
; Do you want to run this section interactively?.
0 n.
; Enter the center pixel to the left, to the right,
; and the desired section size for the vertical dimension..
1 83 83 150 .
; Enter the horizontal pixel range.
2 0 255 .
; Errors in the zero level of the AD converters on.
; the CCD chip could lead to offsets in the frames. s.
; To remove this, one should indicate regions in the.
; chip which are constant in time. The frames will.
; be tied to the mean of this region..
; Enter the center pixel to the left, the section size..
3 202 104.
;

```

In this section, you input the portion of the image you want to crop (the signal from the object viewed). If you run the section interactively, you will be asked to manually crop the frame by clicking first on the **upper-left** corner of the portion to crop, then the **lower-left**, then the **lower-right**, then the **upper-right** corner. Next, it will ask you for the upper and lower limits of the dead section (for CSHELL only). The interactive run will provide values for lines 1, 2 and 3.

0 – Interactive Keyword

- 'y': will make it interactive
- 'n': will run without user interaction
- 's': will skip the whole section and go to the next (CLEAN)

1 – Vertical Crop Parameters

P Q R
 Example: 83 83 150

P-entry (83)

This number designates at which pixel you separate the two halves (vertically) of the frame into a top, "A", and bottom, "B", from the left side of the frame. You count upwards from zero, beginning at the bottom.

Q-entry (83)

This number designates at which pixel you separate the two halves of the frame (vertically) into a top, "A", and bottom, "B", from the right side of the frame. You count upwards from zero, beginning at the bottom.

R-entry (150)

This number designates the vertical height of the section to be cropped. The range of this value will be split between the two halves as designated above.

For example, if P-entry = Q-entry = 83, and R-entry = 150, then the section to be cropped will range from (83-75) to (83+75) in height.

2 – Horizontal Pixel Range

S T

Example: 0 255

S-entry (0)

This number designates the position to crop from the left, horizontally. The zero position is on the left and values increase to the right.

T-entry (255)

This number designates the position to crop from the right, horizontally. The zero position is on the left and values increase to the right, ending at value 255.

3 – Remove Offsets Range

U V

Example: 240 20

U-entry (240)

This entry corresponds to the center vertical pixel (to the left, like the P-entry of Line 1) of where the “dead” area is located. A value of ‘no’ will disable this functionality.

V-entry (20)

This entry corresponds to the vertical height of the “dead” section (like the R-entry of Line 1).

2 – CLEAN Section

```

; -----
* CLEAN.
; -----
; Do you want to run this section interactively?.
0 s.
; Graphically show the results?.
1 y.
; Are both beams in the section?.
2 y.
; Enter the total number of rows to clean.
3 140 .
; Enter the threshold and order of the polynomial for the cleaning..
; These are 6 consecutive entries for these sets: B1,B2,A1,A2,dA,dB.
4 4.0 7.
5 4.0 7.
6 4.0 7.
7 4.0 7.
8 5.0 7.
9 5.0 7.

```

In this section, the data are cleaned of bad pixels. Inputs include whether or not both beams are in the section, the total number of rows to clean, and the threshold and polynomial order for the ABBA frames and the dA and dB frames. The threshold dictates above which sigma-level a pixel will be designated “bad.” The polynomial order refers to the equation used to fit each column at a time.

0 – Interactive Keyword

- ‘y’: will make it interactive
- ‘n’: will run without user interaction
- ‘s’: will skip the whole section and go to the next (SPATIAL)

1 – Graphically Show Results Keyword

- ‘y’: will graphically show results
- ‘n’: will not graphically show results

2 – Both Beams Keyword

- ‘y’: the B-frames have beam data. The telescope was nodded “on” slit.
- ‘n’: only the A-beam have object data. The telescope was nodded “off” slit.
- ‘flip’: this flips the A-frames and the B-frames (A1 becomes B1 and vice-versa)

3 – Total Number of Rows Keyword

This number designates the number of rows to clean. It cannot be greater than the vertical height of the frame (R-entry from Line 1 of the CROP section). It

may be less than the vertical height of the frame if you do not want to include pixels near the edges.

Profile cleaning (particularly useful for narrow sources: i.e. stars) can be activated by adding the word 'profile' after the number of rows. By default, a difference of 6-sigma between the profile and the data are masked. A different value can be given by using 'profile x', where x is the sigma value.

4 - 9 - Threshold and Polynomial Orders Keywords

Line 4: H I

Line 5: J K

Line 6: L M

Line 7: N O

Line 8: P Q

Line 9: R S

Example:

4.0 7

4.0 7

4.0 7

4.0 7

5.0 7

5.0 7

In this section, the first column of numbers refers to the threshold, or the sigma-level above which a pixel will be considered "bad." The second column of numbers refers to the polynomial order used to fit the data. The first four rows of numbers correspond to the B1, B2, A1, and A2 frames, respectively. The last two rows correspond to the dA and dB frames, respectively.

When you graphically show the cleaning, if both beams are in the frame, they should be evenly spaced in each half of the frame. For example, the majority of each beam (A or B) should be within each half (top or bottom). If any portion of the beam is cut off in one frame, the same amount should be cut off in the other half. If the halves aren't evenly spaced, adjust the cropping parameters (Line 1 in the CROP section).

If you run the CLEAN section interactively, it will first ask if you want to graphically show the results. Next, it will ask if both beams are in the section. Next, it will ask the number of rows to clean. The next six lines will ask you to input the threshold and polynomial order (ndim) for B1, B2, A1, A2, dA, and dB (if there is only one beam in the frame, the program will only ask you for the threshold and polynomial order for B1, B2, dA, and dB). After the program cleans the frames, it will tell you the total number of pixel hits in each masking procedure. If you are getting too many bad pixels (e.g. greater than 200 for CSHELL, or more than 2%), then either your threshold or polynomial order may be incorrect, or your crop may be incorrect. Return to the previous sections to

fix these parameters. Next, the program will ask if you want to re-run the cleaning with new parameters. If you are unhappy with the clean (and want to change the input threshold or polynomial), type 'y' to re-run the cleaning (the program tells you the input options ('y' or 'n') and also tells you which one is the default ('def=')). If you are happy with the cleaning, the program will ask if you want to show the cleaning plots for the subsequent sets (as with the previous question, the program gives you the possible inputs and which one is the default).

An optional keyword at the bottom of the threshold parameters can be given to save or read the masks. For instance, one could write a mask based on ABBA data (2 AB pairs in Line 7 of the READ section), and these masks will have corresponding dA and dB masks. Then, these dA and dB masks can be used to correct AB data (1 AB pair in Line 7 of the READ section), which don't have their own dA and dB masks. Use the keyword '**write**' to save the masks, or '**write double**' to save the masks obtained from ABBA datasets to be applied to AB datasets. In order to read the masks (and not compute them) use the keyword '**read**'.

Cleaning Scheme

In all cleaning procedures, what is actually done is identification of the bad pixels, not correction; or simply creation of a "mask" of bad pixels (binary array). In the correction phase, all bad pixels are replaced with nearby averages. The search for nearby "good" pixels is done in a spiral search mode starting in the center of the bad pixel.

3 – SPATIAL Section

```

; -----
; * SPATIAL ALIGNMENT.
; -----
; Do you want to run this section interactively?.
0 y.
; Graphically show the results?.
1 y.
; Do you have a spatial straightening solution?.
2 n.
3 39.89862 5.7771E-03 -1.1627E-05.
4 104.66173 3.4985E-03 -5.5437E-06.
;
;

```

In this section, the data are “straightened” along the spatial direction (y-axis), so that each row of pixels has the same y-value on the sky.

0 – Interactive Keyword

- 'y': will make it interactive
- 'n': will run without user interaction
- 's': will skip the whole section and go to the next (SPECTRAL)

1 – Graphically Show Results Keyword

- 'y': will graphically show results
- 'n': will not show results

An optional second keyword can be given to deactivate the correction of spatial anamorphicity. By default, the entry is 'y' (i.e. correct for anamorphicity).

Entry example: 'y y'

2 – 4 – Solution Keyword

Line 2: T
 Line 3: U V W
 Line 4: X Y Z
 Example:
 n
 39.89862 5.771E-03 -1.1627E-05
 104.66173 3.4985E-03 -5.5437E-06

Line 2
T-entry (n)

'y': yes, there is a solution

'n': no, a solution will be computed using the current sets

An optional second keyword can be given to provide the default signal-to-noise ratio used to filter results. By default, the entry is '10' (i.e. all fits with SNR higher than 10 are considered).

Entry example: 'n 10'

Line 3

U-, V-, and W-entries (39.89862 5.771E-03 -1.1627E-05)

These entries correspond to the A-beam spatial-straightening coefficients (2nd order polynomial).

Line 4

X-, Y-, and Z-entries (104.66173 3.4985E-03 -5.5437E-06)

These entries correspond to the B-beam spatial-straightening coefficients (2nd order polynomial).

If you run this section interactively, the program will first ask if you want to graphically show the results. Next, it will ask if you have a solution and a signal-to-noise ratio (SN ratio).

If you don't have a solution, the program will provide a fit visually, along with three coefficients of the 2nd order polynomial fit (ex. $U + VX + WX^2$ for the A-beam, as above). You then have four options: accept the fit (hit return or type in '1'), manually adjust the fit (type '2'), rerun the curve-fitting modules (type '3') or change the signal-to-noise (SN) ratio (type '4').

'1': If you accept the fit for the A-beam, the program moves on to provide or ask for the coefficients for the B-beam. If you accept the fit for the B-beam, the program will ask if the results are good enough.

'2': If you opt to manually adjust the fit, the program will ask you to input the coefficients in a line of three numbers.

'3': If you re-run the modules, the program will re-run the fit but will weigh the points based on their difference to the previous fit ($\sigma = Y - YFIT$). If run sequentially (type '3' repeatedly), the program should converge to an optimum fit.

'4': If you opt to change the SN ratio, the program will ask you to enter the new SN ratio. The program also visually provides a graph illustrating the SN ratios per pixel column.

After you accept the fit for the A-beam, the program will provide a fit visually, and give you three coefficients for the B-beam, along with the same four options above.

Once you have accepted the fits for both the A- and B-beams, the program will provide a 'spatial straightening control plot'. The upper panel shows all spatial profiles with colors progressing from left to right. All profiles should look aligned. In the lower panel, an image based on the difference of every column to a middle column is shown. Incorrect spatial solutions will provide "dispersion"-like images, with horizontal white lines progressing to black lines.

Next, the program will ask if the results are good enough. If you type 'n', then the section starts over again asking if you would like to graphically show the results. If you type 'y', the program continues to the next section (SPECTRAL).

If you have more than one set, the program will ask if you want to apply the solution to the remaining sets.

The program will print the A and B solutions if in interactive mode. If not in interactive mode, the results will be stored in the file "spatialsolutions.txt".

4 – SPECTRAL Section

This section contains four sub-sections.

Sub-section One:

```

; -----
; * SPECTRAL ALIGNMENT & CALIBRATION.
; -----
; Do you want to run this section interactively?.
0 y.
; Graphically show the results?.
1 y.
; Enter the multiplier for the residuals.
2 5.0.
; Do you have a spectral straightening solution?.
; The following entry specifies the order of the fit,.
; and the next the file containing the solution.
3 y.
4 3.
5 wd_out.dat.
; Please enter the rows to process, 'all' will process all.
; You can also specify single rows (i.e. 61 62 63 ..) and ranges (60-140).
6 all.
; Estimated frequency range [cm-1].
; 'show' will show the spectrum and ask again.
7 3000.487 2993.533.

```

In this sub-section, you can opt to have the program run interactively or not, can chose to graphically show results, must provide values for the residual multiplier, and tell the program whether or not you already have a spectral solution.

0 – Interactive Keyword

- 'y': will make it interactive
- 'n': will run without user interaction
- 's': will skip the whole section and go to the next (STORE)

1 – Graphically Show Results Keyword

- 'y': will graphically show results
- 'n': will not show results

2 – Multiplier Keyword

This keyword is used to define the multiplier of the difference between the atmospheric model and the data. It is only for graphical purposes.

3 – 5 – Solution Keyword

Line 3: L
Line 4: M
Line 5: N
Example:
y
3
wd_out.dat

Line 3

L-entry (y)

'y': yes, there is a solution
'n': no, there is not a solution

Optional keywords:

'**combine X**': The program can combine sets to reduce the number of sets stored. The X keyword corresponds to the number of sets to combine. For example, having 24 sets, and setting the keyword '**combine 6**' will produce 4 independent sets. By default, each is spectrally aligned and spatially registered before combining. The keyword '**combine X noshift**' will disable the spatial registration.

Line 4

M-entry (3)

This entry corresponds to the order of the dispersion fit applied to the center wavenumber (CWN). The other four dispersion quantities (DL1, DL2, DR1, DR2) are fitted to a polynomial of order M-1. For example, M=3 will fit CWN with order 3 and DL1, DL2, DR1, DR2 with order 2.

An optional extra keyword is the number of rows to skip in the dispersion fit. Normally the first dispersion fits (of the first rows) are not the most optimum ones, because they are based on limited information. To avoid these initial fits, M-entry could be '3 X', where X is the number of rows (or fits) to skip.

Line 5

N-entry (wd_out.dat)

This corresponds to the file that contains a pre-determined solution for the fit, or the file where the solution is saved.

6 – Row Process Keyword

This number corresponds to the number of rows you want to process. If you select '**all**', all "clean" rows will be processed. You can also enter certain rows (60 61 62) or intervals (60-140).

The entry **'all cont'** will select all rows with object flux (i.e. rows with at least 50% flux of the maximum of the spatial profile).

7 – Frequency Range Keyword

F G

Example: 3000.487 2993.533

For the F- and G-entries, you provide the frequency range (in cm^{-1}) over which the data was taken (this will correspond to the x-axis of the frame). The F-entry is the left edge of the range (corresponding to the S-entry (0) of Line 2 in the CROP section on the left side of the frame). The G-entry is the right edge of the range (corresponding to the T-entry (255) of Line 2 in the CROP section on the right side of the frame).

The entry **'show'** will show the emission spectrum of the data.

Sub-section Two: Straightening

```

; Straightening -----
; Do you want to use model data (model) or a data-row as reference (data #)?
; where # indicates the row number. In order to improve the
; matching between the model and the observed data, when comparing
; to the model, a 4th order baseline is removed to the data, and
; it is also calibrated for a 2nd order gain function including
; scatter-light contributions..
8 model.
; Do you want to fit radiance or absorption spectra?
9 radiance.
; The fit is an iterative process, with a defined
; number of steps and defined boundaries.
; Enter the number of steps and range for.
; the search of the wavenumber, first order dispersion.
; coefficient and second order correction..
10 400 100 0 5 1.0 1 1 1.
11 0.1 0.001 0.0.

```

In this section, you designate whether to use a model or a data-row as a reference, as well as whether you want to use radiance or absorption spectra. You also enter a number of fit parameters.

8 – Reference Keyword

This entry defines whether you want to use a model (keyword = **'model'**), a solar spectrum (keyword = **'solar'**) or a data-row (keyword = **'data #'**; where # is the row number) as a reference for straightening the frame.

If the additional keyword **'retrieve'** is added (e.g. **'model retrieve'**), the program will retrieve the atmospheric water abundance by comparing to the data.

9 – Spectra Keyword

This entry defines whether you want to use a radiance or absorption spectrum.

10, 11 – Fit Parameters Keyword

Line 10: H I J K L M N O S

Line 11: P Q R

Example:

```
400      100 0 5 1.0      1 1 1
0.01 0.001 0.0
```

Line 10

Dispersion solution is: LEFT: $CWN + DL1x + DL2x^2$ RIGHT: $CWN + DR1x + DR2x^2$, where 'x' is the horizontal pixel distance from the center of the frame. For the center pixel "x=0".

H-entry (400)

This is the number of steps used to search for the center wavenumber (CWN)

I-entry (100)

This is the number of steps used to search for the first dispersion coefficient (DL1, DR1)

I-entry (0)

This is the number of steps used to search for the second dispersion coefficient (DL2, DR2)

Examples for H I J:

'**100 50 50**': will use 100 steps to search CWN and 50 to fit the dispersion coefficients

'**100 50 0**': will disable the search for second order dispersion coefficients.

K-entry (5)

This is the divider of steps for sequential fits. For the first row, the solution is fitted using H, I, and J steps, while the sub-sequent rows are done using H/K, I/K and J/K steps.

L-entry (1.0)

This is the fractional size of the search space for CWN. L=1.0 would mean all the spectral points, 0.5 would mean the center half, or 0.1 the middle 10% of the array.

M-, N-, and O-entries (1 1 1)

These entries are flags that define the fitting scheme, where M is the flag for fitting CWN, N for fitting the left part of the array, and O for fitting the right

part. A zero value will deactivate that section of the fit. The default value is '1 1 1'.

Examples for M N O:

'1 1 1': will fit everything

'1 0 0': will only fit the center wavenumber (CWN)

'1 0 1': will fit CWN and the right part of the array

'1 2 2': will force LEFT = RIGHT (DL1=DR1), and DL2=0, DR2=0.

'1 3 1': will fit the only using the 1st coeff for the left solution

S-entry

This entry defines the repetition and plot sequence. A negative value will repeat the fit using as a-priori the previous fit for 'S' times. A value of '1' will show the search for CWN, a value of '2' will show the search for the LEFT dispersion, a value of '3' will show the search for the RIGHT dispersion, a value for '4' will fit and then ask for user input, and a value of '6' will not fit but ask for user input (there is no option for a value of '5').

Line 11

P-, Q-, and R-entries (0.1 0.001 0.0)

These entries establish the search space for the variables around the a-priori solution. As a-priori, the program uses:

$$\text{CWN: } (\text{Keyword7(G)} + \text{Keyword7(F)}) / 2$$

$$\text{DL1=DR1: } (\text{Keyword7(G)} - \text{Keyword7(F)}) / \text{x-pixels}$$

$$\text{DL2=DR2=0}$$

The spectral precision of the fit is then P/H for the CWN, and Q/I and R/J for the dispersion coefficients. A big P, Q or R number will expand the search, but produce low precision results or lead to artificial solutions. Too small P, Q, or R values will restrict the search, and may not allow the program to achieve the optimum solution.

Typical Values:

CSHELL (IBATCH):

400 100 0 5 1.0 1 2 2
0.1 0.001 0.0

CSHELL (IPLANET/ICOMET/ISTAR):

100 50 50 1 1.0 1 1 1
5e-3 5e-4 5e-6

NIRSPEC:

400 100 100 5 0.3
4e-2 2e-4 2e-6

CRIRES (IBATCH):

400 100 0 5 0.3
3e-2 3e-4 0.0

CRIRES (IPLANET/ICOMET/ISTAR):

100 50 50 1 0.3 1 1 1 -2
3e-3 3e-5 3e-7

Sub-section Three: Atmospheric Parameters

```

; Atmospheric parameters.
; 1) Do you want to calculate the transmittance and radiance(run) or read.
;    a previous run (read)?
; 2) Air mass and telescope altitude [m].
; 3) Abundances relative to a tropical atm: H2O,CO2,O3,N2O,CO,CH4.
; 4) Temperature factors for T(0-16km),T(16-85km),T(85-up).
; 5) Resolving power.
; 6) Filestem of transmittance (.trn) and radiance (.rad).
12 run.
13 2.0000 4200.0000.
14 0.3000 1.0000 1.0000 1.0000 1.0000 1.0000 1.0000 1.0000 1.0000 1.0000.
15 1.0000 1.0000 1.0000 1.0000 1.0000 1.0000 1.0000 1.0000 1.0000.
16 40000.
17 ../atm/lblrtmdl.
    
```

In this section, you enter atmospheric parameters based on observing conditions.

12 - 17 - Atmospheric Parameters

- Line 12: C
- Line 13: D E
- Line 14: F G H I J K L M N O P
- Line 15: Q R S T U V W X
- Line 16: Y
- Line 17: Z

Example:

```

run
2.0000 4200.0000
0.3000 1.0000 1.0000 1.0000 1.0000 1.0000 1.0000 1.0000 1.000 1.000 1.000
1.0000 1.0000 1.0000 1.0000 1.0000 1.0000 1.000 1.000 1.000
40000
../atm/lblrtmdl
    
```

Line 12
C-entry (run)

Here you opt whether to calculate the transmittance and radiance (keyword = 'run') to read a previous run (keyword = 'read'), or retrieve the abundances (keyword = 'retrieve') by comparing the data to the model.

The additional keyword '**nolines**' will disable the generation of the lineatlas. This can be done when the lineatlas has been already calculated for this spectral interval.

Line 13

D- and E-entries (2.0000 4200.0000)

The D-entry is the airmass, and the E-entry is the telescope altitude in meters.

Line 14

F-, G- H-, I-, J-, and K-entries (0.3000 1.0000 1.0000 1.0000 1.0000 1.0000)

These entries correspond to the relative abundances of six gases relative to a tropical atmosphere. The six gases are: H₂O, CO₂, O₃, N₂O, CO and CH₄ (which correspond to F through K, respectively).

L-, M-, N-, O-, and P-entries (1.0000 1.0000 1.0000 1.0000 1.0000)

These correspond to the gases O₂, NH₃, C₂H₆, and HCl, respectively. The fifth entry is not currently implemented.

Line 15

Q-, R-, and S-entries (1.0000 1.0000 1.0000)

These entries correspond to temperature factors for T(lower atmosphere), T(stratosphere), and surface pressure scaler, respectively. All these numbers are relative to the "standard tropical profile".

T-, U-, V-, W-, and X-entries (1.0000 1.0000 1.0000 1.0000 1.0000)

These entries are not implemented yet.

Line 16

Y-entry (40000)

This entry corresponds to the instrument resolving power.

Line 17

Z-entry (./atm/lblrtmdl)

This entry defines the filestem for the transmittance (.trn) and radiance (.rad) files.

Sub-section Four: Frequency Calibration

After the frame has been spatially and spectrally straightened, the program will stack all rows and produce a high signal-to-noise ratio spectrum that can be used to obtain a high precision frequency vector. In this step, this high precision spectrum is compared to a model.

```

; Frequency calibration -----
; Do you have a spectral calibration solution (y/n/s)?
; A 's' will skip this sub-section and will use the
; values derived from the straightening. This calibration
; is however more precise, because it uses a set with all the
; rows integrated having higher S/N.
18 y.
19 freqdsolutions.dat.
.
; Do you want to fit radiance or absorption spectra?
20 radiance.
; Enter the number of steps and range for
; the search of the wavenumber, first order dispersion.
; coefficient and second order correction..
21 400 100 0 5 1.0 1 1 1.
22 0.1 0.001 0.0.
.

```

18.19 – Solution Keyword

Line 18: L

Line 19: M

Example:

y
freqdsolutions.dat

Line 18

L-entry (y)

‘y’: there is a solution

‘s’: will skip to “spectral calibration” without forming a frequency solution vector

Line 19

M-entry (freqdsolutions.dat)

This entry specifies the file of frequency solutions.

20 – Spectra Keyword

This entry defines whether you want to use a radiance or absorption spectrum.

21.22 – Fit Parameters Keyword

Line 21: N O P Q R S T U

Line 22: V W X

Example:

400 100 0 5 1.0 1 1 1

0.01 0.001 0.0

Lines 21 and 22 as Lines 10 and 11. The corresponding V, W and X keywords can be smaller here to allow for higher precision.

5 – STORE Section

```

; -----
* STORE RESULTS.
; -----
; Do you want to run this section interactively?.
; The present values will be the defaults.
0 s.
; Graphically show the results?.
; The second parameter (optional) defines the number of terms.
; used when fitting the gauss-curve to the profile (3: minimum, 4: gauss + offset, ...).
1 y 3.
; Do you want to shift the beams to the center of the object.
2 i.
; Please define the output directory.
3 ./
;
; Level of recording.
; 1: All msets,mskys,mdats,mbeams files.
; 2: Only the mbeams files.
; In all cases, It will store the stacked frame and the config files.
4 2.
; Do you want to save the interactive inputs to the init file.
5 n.

```

In this section, you define which files you want saved and where you want them saved. Also, you can re-center the beam if desired.

0 – Interactive Keyword

- 'y': will make it interactive
- 'n': will run without user interaction
- 's': will skip the whole section and go to the next (PLUG-IN)

1 – Graphically Show Results Keyword

E F
 Example: y 3

E-entry (y)

- 'y': will graphically show results
- 'n': will not show results

F-entry (3)

This is an optional parameter that defines the number of terms used when fitting the gauss-curve to the profile. Possible inputs include: '3' (minimum), '4' (gauss + offset), etc. A value of '0' will not fit a Gaussian but will search for the maximum point in the profile. The default is '3'. The data will be saved with the center of the profile organized in row = 128, where all frames have 256 pixels vertically.

2 – Shift Beam Keyword

G H

Example: 'n' or 'i vcent.dat'

G-entry (i)

This entry determines whether or not you want to re-center the beams.

'n': beams will not be re-centered

'y': will center the beams using fractional pixels (interpolation).

'i': use integers to re-center beam

H-entry (vcent.dat)

This is an optional parameter to allow reading the positions of the beams from a file. The file has 5 columns: set#, A-center, B-center, A-shift, and B-shift. The program only uses the shift entries to shift the data from the center position. The center position is defined by the spatial solution.

3 – Output Directory Keyword

This entry defines the output directory.

4 – Level of Recording Keyword

This entry determines which files get saved.

'1': all msets, mskys, mdats, mbeams files are saved.

'2': only mbeams files are saved.

'3': only the A-beams are stored

'4': only the B-beams are stored

5 – Interactive Inputs Keyword

This entry writes the interactive inputs into the file session if desired.

'y': writes interactive inputs into file session

6 – PLUG-IN Section

```

; -----
* PLUG-IN.
; -----
; Do you want to run this section interactively?.
; The present values will be the defaults.
0 s.
; Enter the IDL plug-in procedure.
1 istar.
; Enter the init file for the procedure.
2 results.pln.
.

```

0 – Interactive Keyword

- 'y': will make it interactive
- 'n': will run without user interaction
- 's': will skip the whole section and end the program

1 – IDL Plug-in Keyword

This entry specifies the name of the IDL plug-in.

2 – Configuration File Keyword

This entry specifies the configuration file for the IDL plug-in.

IPLANET

DOCUMENTATION FILE

This document serves to provide the user with information regarding each input in each line of the 'results.pln' file used to run IPLANET.

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Appendix for IPLANET Documentation File

This document serves to provide the user with information regarding the graphical outputs of the IPLANET program.

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0 – DATA Section

This section reads the output from IBATCH and reorganizes the data. In this section, you designate the input and output directories for the files, and determine how you would like to process the data. You can view and process each set individually to check for errors, and then stack all the sets to achieve higher signal-to-noise.

```

results.ses.
; -----
* DATA.
; -----
; The program is case-sensitive.
; Do you want to run this section interactively?.
; The present values will be the defaults. 's' as input.
; will skip this section, this is valid for all the sections.
0 n.
; Enter the directory where the input files are located.
1 ./
; Enter the resulting directory.
2 ./
; Enter the sets you want to analyze. First has index 0..
; 'stack' will stack all the available sets, and 'all' will
; process all available sets.
; stack: will stack all available sets.
; stack X Y .... Z: will stack X and Y and ... Z.
; X-Y: will stack from X to Y.
; all: will read all available sets.
; X Y ... Z: will read X and Y and ... Z.
3 all.

```

0 – Interactive Keyword

'y': will make it interactive

'n': will run without user interaction

's': will skip the whole section and go to the next (GEOMETRY)

1, 2 – Directory Keywords

Line 1 designates where the input files are located. Line 2 designates where the results from processing will be saved.

3 – Sets/Stack Keyword

This entry designates which sets you want to analyze. The numbering of sets begins at '0' (thus, the first set is actually set '0'). You can analyze each set individually by entering the number of the set you want to analyze.

'all': will process all sets individually

'2': will process set 2

'2 3 5 7': will process only sets 2, 3, 5, and 7

You can also stack sets.

'stack': will stack all available sets for processing

'stack 2 3 5 7': will stack only sets 2, 3, 5, and 7 for processing

'stack 2-7': will stack sets 2 through 7 for processing

1 – GEOMETRY Section

In this section, you adjust parameters such as the thermal scalar, the shift along the slit in pixels, and the deviation from the center of the slit in planetary radii in order to determine exactly where the slit is situated on the object (planet). Basically, you are adjusting the x- and y-positions of the slit on the planet. This is accomplished by matching the profile of the data with that of a model. For Mars, the model used is a General Circulation Model (GCM) that predicts weather on Mars at each instant associated with each set. The model retrieves information from JPL Horizons to generate ephemerides for each instant. Ultimately, this information will tell you exactly where on the planet the slit is viewing, while the season and weather on the planet is retrieved using the Mars Climate Database (MCD).

```

; -----
* GEOMETRY.
; -----
; Do you want to run this section interactively?.
0 n.
; Do you want a black or white background?.
1 black.
; Enter slit-width, length and seeing (arcsec), and thermal scalar.
2 0.500 30.0 0.8.
; Enter the spatial scale [arcsec/pixel] and center offset [pixel].
a 0.200 1 0.0 0.2.
b 0.200 0 0.0 0.2.
c 0.200 1 0.0 0.2.
3 d 0.200 0 0.0 0.2.
e 0.200 1 0.0 0.2.
f 0.200 0 0.0 0.2.
g 0.200 1 0.0 0.2.
h 0.200 0 0.0 0.2.
; Define the atmospheric input file.
4 ../atm/lmdgcm.
;

```

0 – Interactive Keyword

- ‘y’: will make it interactive
- ‘n’: will run without user interaction
- ‘s’: will skip the whole section and go to the next (residuals analysis)

1 – Background Keyword

- ‘white’: the background will be white
- ‘black’: the background will be black

2 – Slit-width, Slit-length, Seeing and Thermal Scalar Keywords

C D E F

Example:

0.500 30.0 0.8 1.0

C-entry (0.500)

This entry is the slit-width in arcseconds.

D-entry (30.0)

This entry is the slit-length in arcseconds.

E-entry (0.8)

This entry is the seeing in arcseconds for the observation run.

F-entry (1.0)

This entry is the thermal scalar for the planet and is generally lower than 1.0. This number needs to be adjusted because the albedo and emissivity of the planet at the specific frequency of observation are calculated with certain assumptions made, and so are not precise. If no number is given, the default entry is '1.0'.

3 – Pixel Scale, Slit Position and Slit Orientation Keywords

G H I J

Example:

0.200 1 0.0 0.2

The Lines 3a through 3h correspond to each different set the data was combined into in IBATCH. If you have ten sets, you will have ten different lines corresponding to each set. Having a single line will assume the same values for all sets. To analyze just one set at a time, you put the corresponding set number (starting from 0) in Line 3 in the DATA section above. Thus, Line 3a corresponds to set 0, while Line 3h corresponds to set 9, for a total of ten sets.

G-entry (0.200)

This is the pixel scale in arcseconds per pixel ("/pix) of the detector. This number is the same for all sets.

H-entry (1)

This entry corresponds to the shift along the slit in pixels. This number can be positive or negative, in integer increments.

I-entry (0.0)

This entry corresponds to the rotation of the slit on the planet. This number should be retrieved from the observing log for the observation run.

'0.0': The slit is aligned exactly North-South with the planet

'90.0': The slit is aligned exactly East-West with the planet.

J-entry (0.2)

This entry is the deviation from the center of the slit in planetary radii. Generally, it should not vary more than +/- 0.2 planetary radii from the center (0.0), unless noted in the observation log. This number may vary from set to set.

4 – Atmospheric Input File

This entry designates the atmospheric input file for the planet for use in the General Circulation Model.

Ephemerides Sub-Section

This sub-section generates the ephemerides from JPL Horizons specifically for the planet and the observation site at the time of observation.

```

; Ephemeris -----
; Enter the planet name.
5 mars.
; Enter the file with ephemeris. If the file does not.
; exist, the program will obtain the values from.
; the Horizons On-Line Ephemeris System..
6 ../atm/ephm.txt.
; Enter the observatory name. Only Horizons' recognized names.
7 568 mauna kea.
; Enter the representative time of the first selected set.
8 airmasses.txt.
; Enter the representative time of the last selected set.
9 airmasses.txt.

```

5 – Planet Name Keyword

In this entry, you designate the name of the object being analyzed. The possible entries include the eight planets (ex. **'mars'**) as well as **'sun'**, **'moon'**, and **'pluto'**.

For Mars, there are a variety of other keywords that specify different images of the planet.

'mars': generates a visible, true color image of Mars

'mars-topo': generates a topographical image of Mars

'mars-albedo': generates an image depicting surface albedo on Mars

'mars-grs': generates an image depicting subsurface (within 1 meter) hydrogen on Mars (red = more hydrogen)

'mars-magnetic': generates an image depicting the magnetic field at the surface of Mars

'mars-shade': generates an image depicting a 3D rendering of the Martian surface

The albedo and magnetic images utilize data from Mars Global Surveyor. For examples of the different images, see the Appendix for IPLANET. Also, the images are provided in the idl/glv/extras folder.

6 – Ephemeris File Keyword

In this entry, you designate the ephemeris file for use with the General Circulation Model. If no file exists, the program will retrieve the necessary information from the JPL Horizons Online Ephemeris System.

You can select what values are retrieved from JPL Horizons by designating the quantities by their respective codes:

```

; Select output quantities using the codes below, SEPARATED BY COMMAS:.
; 1. Astrometric RA & DEC 15. Sun sub-long & sub-lat 29. Constellation ID.
;*2. Apparent RA & DEC 16. Sub Sun Pos. Ang & Dis 30. Delta-T (CT - UT).
; 3. Rates; RA & DEC 17. N. Pole Pos. Ang & Dis *31. Obs eclip. lon & lat.
;*4. Apparent AZ & EL 18. Helio eclip. lon & lat 32. North pole RA & DEC.
; 5. Rates; AZ & EL 19. Helio range & rng rate 33. Galactic latitude.
; 6. Sat. X & Y, pos. ang 20. Obsrv range & rng rate 34. Local app. SOLAR time.
; 7. Local app. sid. time 21. One-Way Light-Time 35. Earth->Site lt-time.
; 8. Airmass 22. Speed wrt Sun & obsrvr >36. RA & DEC uncertainty.
; 9. Vis mag. & Surf Brt 23. Sun-Obsrvr-Target angl >37. POS error ellipse.
;10. Illuminated fraction 24. Sun-Target-Obsrvr angl >38. POS uncertainty (RSS).
;11. Defect of illumin. 25. Targ-Obsrv-Moon/Illum% >39. Range & Rng-rate sig..
;12. Sat. angle separ/vis 26. Obsr-Primary-Targ angl >40. Doppler/delay sigmas.
;13. Target angular diam. 27. Pos. Ang;radius & -vel.
;14. Obs sub-lng & sub-lat 28. Orbit plane angle.
    
```

If an ephemeris file exists, the program will automatically read it. If you want to re-generate the ephemerides for the data, you will need to delete the file from the directory.

7 – Observatory Keyword

Here you designate the JPL Horizons name of the observatory where the data was taken. If no name is specified, the default is ‘568 Mauna Kea’. This entry must be one of the JPL Horizons recognized names for observatories.

8, 9 – Time of Observation Keywords

In Lines 8 and 9, you designate the time of the first observation and last observation, respectively. If you are only using select sets, these entries refer to the time of the first and last observation of the specific set or sets.

It is convenient to use the “airmasses.txt” output from IBATCH.

2 – RESIDUALS ANALYSIS Section

In this section, you define the sections of the images to analyze, and define atmospheric parameters in order to correctly model the terrestrial atmosphere. Thus, you can separate the terrestrial atmosphere and that of the planet. There are five subsections in this section.

Subsection One: Row/Column Analysis

In this subsection, you designate the columns and rows to analyze.

```

; -----
* RESIDUALS ANALYSIS.
; -----
; Do you want to run this section interactively? .
0 s.
; Do you want to save postscript copies of the results? .
1 y.
; Enter the scale for the residuals, a following plot-title is optional.
2 5.0.
; Enter the column range to analyze. 'all' will analyze all cols.
3 all.
.
; Enter the four parameters defining the rows to analyze.
; 1) First row (ra).
; 2) Last row (rb).
; 3) Row spacing (rc).
; 4) Number of rows aside to integrate (dr).
; ri = ra + i*(ra-rb)/rc +- dr.
4 128 128 10 2.
    
```

0 – Interactive Keyword

- 'y': will make it interactive
- 'n': will run without user interaction
- 's': will skip the whole section and go to the next (RETRIEVAL)

1 – Save Postscript Copies Keyword

This entry designates whether or not you would like to save copies of the results in .ps (postscript) files.

- 'y': will save copies of results in .ps files
- 'n': will not save copies of results

2 – Residuals Scale and Plot Title Keywords

C D
 Example: 5.0 Residuals Plot

C-entry (5.0)

This entry designates the multiplier for the residuals when graphed.

D-entry (Residuals Plot)

This is an optional entry where you can specify a title for the plot.

3 – Analysis Column Range Keyword

This line determines the range of columns to be analyzed by the program. For example, if you have bad pixels in the border columns of the data, you may want to remove these columns from analysis.

'all': all columns will be included in analysis

'10 250': only columns 10 through 250 will be included in the analysis.

4 – Row Analysis Parameters

In this section, you designate which rows you would like to analyze.

E F G H

Example: 128 128 10 2

E- and F-entries (128 128)

These entries designate the minimum and maximum rows, respectively, that you would like to analyze. For instance, the input **'128 128'** means that only the center row, row 128, will be analyzed. However, the input **'100 150'** means that all rows from row 100 to row 128 will be analyzed.

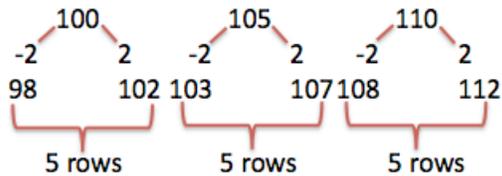
G- and H-entries (10 2)

The G-entry designates the spacing between the rows, while the H-entry designates how many rows to add (stack).

For example, if your input reads **'100 150 5 2'**, then the program will analyze rows '100' through '150', with a spacing of '5' rows. The '2' means that the program will stack two rows to the left of the central row, the central row, and two rows to the right of the central row, for a total of five rows stacked. The higher the number in the H-entry, the greater the signal-to-noise of the stacked data (because more rows are stacked). However, if the number of rows to add is greater than the spacing between the rows, the data will no longer be independent (since the "stacks" overlap). Typically, the G-entry should be twice as big as the H-entry, plus one ($G = 2H + 1$).

The image below illustrates the idea behind row-spacing and row-stacking. If you want rows 100 through 150 analyzed, with a spacing of '5' and a stacking of '2', then the program will stack sets of 5 rows, centered on row 100 through 150 (in increments of five). Thus, all rows from 98 to 152 are analyzed, and no rows are overlapped, so the sets are independent.

Line 4: 100 150 5 2



There are two additional keywords for this line. The keyword **'all #'** analyzes all possible rows, with a spacing of #. Also, IDL will print the four entries in the terminal prompt to enter into the input file. The keyword **'center #'** will analyze only the center row (row 128) and the number of rows above and below the center row, as designated by '#'. However, '#' designates how many total rows you would like analyzed. For example, **'center 5'** means that the program will analyze the center row, plus two rows above and two rows below, for a total of five rows (rows 126 to 130 will be analyzed).

Subsection Two: Lines of Interest/Column Ranges

```

; Enter the lines of interest at their rest-frequency [cm-1].
5 2999.060257 2991.971040 2992.653750 2993.735940 2994.446430 2995.455090 3003.474230 3003.838080
;CH4: 2999.060257.
;CO2: 2985.007427 2985.007840 2985.719233 2985.719640 2986.426117 2986.426520 2987.128076 2987.128
;H2O: 2991.971040 2992.653750 2993.735940 2994.446430 2995.455090 3003.474230 3003.838080.
;
; Enter the col-ranges which contain information of.
; the source, and should be avoided in the retrieval.
; of the baseline. If 'ask' is entered, the program.
; will ask for the values interactively.
6 0 0.
    
```

5 – Lines of Interest Keywords

In this line, you input the rest-frequency of the spectral lines you expect to observe in the spectra (they are later corrected for Doppler-shift by the program). The main purpose is graphical, but these numbers can later be used by Line 6 (Column Ranges Keywords), below, to mask pixels where lines of the object are located.

6 – Column Ranges Keywords

In this line, you designate which columns should not be used when comparing the terrestrial transmittance model and the observed spectra (continuum + object lines + solar lines, affected by telluric transmittance). For example, the entry **'23 28 59 63'** will skip columns 23 through 28 and 59 through 63 when determining the baseline (only columns 0 through 23, 28 through 59, and 63 to the last column will be used to determine the baseline).

This is useful if you know that a detector has a series of bad pixels ranging over several columns and you want these columns skipped in analysis.

There are two optional keywords. If the keyword **'ask'** is designated, the program will ask for the values interactively. If the keyword **'lines #'** is designated, the program will use the pointers from Line 5 above and create a gap of '#' pixels around the spectral line position to be skipped in analysis. For example, the entry **'lines 7'** would create symmetrical spacing around the spectral line position (three pixels on each side, with one pixel for the spectral line position, totaling a gap seven pixels wide). The '#' should be odd so that the spacing around the spectral line is symmetrical (ex. 3, 5, 7, etc.).

Further inputs can be specified. For example,

```
lines 5  x5 f2993.835940 f2993.635940 f2995.555090 f2995.355090 | x3 r2994.546430 r2994.346430 r2998.1 r2997.8
```

The **'x5'** or **'x3'** keywords specify the weighting function. If **'x5'** is designated, then the program will weigh all lines following the keyword five times more than the model (until the line hits another weight). If no weight is specified, then the weight default is **'x0'** which means the lines have the same weight as the model.

If the spectral line frequency has an "f" in front of it (ex. f2993.835940), the feature is in the object's (Doppler-shifted) reference frame. Thus, this feature will move with the object.

If the spectral line frequency has an "r" in front of it (ex. r2994.546430), then the frequency is a rest frequency (the frequency of the telescope, i.e. Earth). Including this entry tells the program that this feature is "fixed" and should be weighted accordingly.

Note that the frequencies are in pairs. Each pair specifies the frequency range to skip in analysis. The program converts each frequency to a pixel number to create a pixel range to skip in analysis.

Subsection Three: Baseline Removal/Reference/Frequency Solution

```

; Input the parameters for the removal of the baseline..
; These are 'flags' enabling(1) or disabling(0) the.
; components of the removal. .
; 0-6: Polynomial background baseline.
; 7-9; Polynomial gain .
; A: Residual sky removal.
; B: Scatter-light removal.
; C: Correction for Fraunhofer lines.
; D: Removal of spectral fringing (D indicates number of fringes to remove).
; E: Variable resolving power.
;0 1 2 3 4 5 6      7 8 9 A   B C D E.
7 1  1 1 1 1 0 0    1 1 1 0   0 0 0 0.
.
; Do you want to use model (model) or data as reference (data #1 #2)?
; where #1 #2 indicates the row range..
8 model.
.
; Do you want to fine-tune the frequency solution (y/n)?
; If you obtain a better result for the freq-scale, please.
; correct the solution values in the batch configuration file.
9 n.

```

7 – Baseline Removal Input Parameters Keywords

In this line, you can enable or disable selected components of the baseline removal. To enable the removal of a component, put a '1'. To disable the removal of a component, put a '0'.

0 1 2 3 4 5 6 7 8 9 A B C D E
 Example: 1 1 1 1 1 0 0 1 1 1 0 0 0 0 0

0 – 6 entries

These entries correspond to the polynomial background baseline.

7 – 9 entries

These entries correspond to the polynomial gain.

A-entry

This entry corresponds to the residual sky removal.

B-entry

This entry corresponds to the scatter-light removal.

C-entry

This entry corresponds to the correction for the Fraunhofer lines.

D-entry

This entry corresponds to the removal of spectra fringing. The number entered here corresponds to the number of fringes to remove.

E-entry

This entry corresponds to the variable resolving power.

8 – Reference Keyword

This entry defines whether you want to use a model (keyword = **'model'**) or data (keyword = **'data #1 #2'**; where **'#1 #2'** is the row number range) as a reference.

9 – Frequency Solution Keyword

In this line, you designate whether you would like to adjust the frequency solution or not. If you choose to adjust the frequency, the program will use the parameters designated in Lines 19 and 20 below.

'y': adjust frequency solution

'n': do not adjust frequency solution

'y save': the program will adjust the frequency and save the results into the 'iplanet' session, the freqdXX.dat file and freqdsolutions.dat file. (There is no need to re-run IBATCH again with the new frequency solution).

'y save ahead': the program will adjust the frequency and save the results for this set and the upcoming sets. For instance, when running set #2, it will fit the frequency to set 2 and save it for sets 2, 3, 4...N.

The **'y save ahead'** keyword is useful because it provides the program with a starting point to find the frequency solution. Since the solutions won't vary greatly from one set to the next, this keyword lessens the number of possible iterations the program has to compute in order to find the next solution.

Subsection Four: Atmospheric Parameters

```

; Atmospheric parameters.
; 1) Do you want to calculate the transmittance and radiance(run), read .
;    a previous run (read), or retrieve the values (retrieve)?.
; 2) Air mass and telescope altitude [m].
; 3) Abundances relative to a tropical atm: H2O,CO2,O3,N2O,CO,CH4  O2,NH3,C2H6,HCl.
; 4) Temperature and pressure factors, T1factor, T2factor, Pfactor.
; 5) Resolving power a value or a file.
; 6) Filestem of transmittance (.trf).
; 7) file containing the solar-atlas.
; 8) Solar contribution.
10 read nlines multiple (atms.txt).
11 1.0000 2635.0000.
12 0.2000 1.0000 1.0000 1.0000 1.0000 1.0000 1.0000 1.0000 1.0000 1.0000.
13 1.0000 1.0000 1.0000 1.0000 1.0000 1.0000 1.0000 1.0000 1.0000.
14 95000.
15 ../atm/lblrtm.
16 1.000.
17 solaratlas.dat.

```

This subsection is similar to Subsection Three: Atmospheric Parameters in the SPECTRAL section of IBATCH, but does have some differences.

10 – Read/Run/Retrieve Keyword

This line designates whether or not you calculate the transmittance and radiance (**'run'**), read a previous run (**'read'**), or retrieve the values through comparison of the data and model (**'retrieve'**).

'run': the program will calculate the transmittance and radiance

'read': the program will read the results from a previous run*

'retrieve': the program will retrieve results the values through comparison**

*When **'read'** is selected, the program reads previous results from the file atm/lblrtn

When **'retrieve' is selected, the program compares the data and model and aims to minimize error between the two to get the best match. It will use the values in Line 18 (Fit Parameters Keywords), below, to determine which parameters to fit and in which order it should be done.

Optional Keywords:

'nolines': this keyword will disable the generation of the lineatlas. This can be done when the lineatlas has been already calculated for this spectral interval.

'multiple': this keyword creates a separate atmosphere for each set of data (this is useful when the airmass changes greatly throughout the night). The resulting model files for this atmosphere will be stored in the "stem" directory with the addition of "-X" where X is the set number.

'(atms.txt)': when this keyword is input, the program goes to each set of data and modifies the atmospheric abundances. When in **'read'** mode, the values are read from the file, while in **'retrieve'** mode, the values are read from the file and then used as a-priori for fitting the atmosphere. The results are saved into the file.

11 – Airmass and Telescope Altitude Keywords

F G

Example: 1.0000 2635.0000

F-entry (1.0000)

This entry designates the airmass.

By default, the program will read the file "airmasses.txt" to determine the airmass of the current set.

G-entry (2635.0000)

This entry corresponds to the altitude of the telescope, in meters.

12 – Relative Abundances Keywords

H I J K L M N O P Q R

Example:

0.2000 1.0000 1.0000 1.0000 1.0000 1.0000 1.0000 1.0000 1.000 1.000 1.000

H-, I-, J-, K-, L-, and M-entries (0.2000 1.0000 1.0000 1.0000 1.0000 1.0000)

These entries correspond to the relative abundances of six gases relative to a tropical atmosphere. The six gases are: H₂O, CO₂, O₃, N₂O, CO and CH₄ (which correspond to F through K, respectively).

N-, O-, P-, Q-, and R-entries (1.0000 1.0000 1.0000 1.0000 1.0000)

These correspond to the gases O₂, NH₃, C₂H₆, and HCl, respectively. The fifth entry is not currently implemented.

These entries are the same as entries F through P in Line 14 in the Atmospheric Parameters subsection in the SPECTRAL section of the IBATCH document (IbatchDoc.docx).

13 – Temperature and Pressure Factors Keywords

S T U V W X Y Z

Example: 1.0000 1.0000 1.0000 1.0000 1.0000 1.000 1.000 1.000

S-, T-, and U-entries (1.0000 1.0000 1.0000)

These entries correspond to temperature factors for T(lower atmosphere), T(stratosphere), and surface pressure scaler, respectively. All these numbers are relative to the “standard tropical profile”.

V-, W-, X-, Y-, and Z-entries (1.0000 1.0000 1.0000 1.0000 1.0000)

These entries are not implemented yet.

These entries are the same as entries Q through X in Line 15 in the Atmospheric Parameters subsection in the SPECTRAL section of the IBATCH document (IbatchDoc.docx).

14 – Resolving Power Keyword

This entry corresponds to the instrument resolving power. Additional entries are allowed when processing data measured with complex instrumental kernels (e.g. CRIRES with scattered light).

CSHELL: 40000
 NIRSPEC: 35000
 CRIRES: 13000 3 1.00

This entry is the same as the Y-entry of Line 16 in the Atmospheric Parameters subsection in the SPECTRAL section of the IBATCH document (IbatchDoc.docx).

15 – Filestem Keyword

This entry defines the filestem for the transmittance (.trn) and radiance (.rad) files.

This entry is similar to the Z-entry of Line 17 in the Atmospheric Parameters subsection in the SPECTRAL section of the IBATCH document (IbatchDoc.docx).

16 – Solar Contribution Keyword

This entry specifies the depth of the solar lines relative to the model values. A value of '1.0' would mean use the model values, while a factor of '0.6' would mean that the solar lines in the spectra are 60% deep as in the model. A value of 60% would mean that the observed flux is 60% solar reflected sunlight, and 40% thermal emission.

17 – Solar Atlas File Keyword

This entry specifies the file that contains the solar atlas. This keyword is no longer used.

Subsection Five: Atmospheric/Frequency Fits

```

; Parameters of the atmospheric fit.
; 0 - Resolving power.
; 1 - T1-factor.
; 2 - T2-factor.
; 3 - Psurf-factor.
; 4 - H2O-factor.
; 5 - CO2-factor.
; 6 - O3-factor.
; 7 - N2O-factor.
; 8 - CO-factor.
; 9 - CH4-factor.
;10 - XX-factor.
;11 - XX-factor.
;12 - XX-factor.
;13 - XX-factor.
;14 - XX-factor.
;15 - O2-factor.
;16 - NH3-factor.
;17 - C2H6-factor.
;18 - HCl-factor.
;19 - XX-factor.
;20 - Solar factor.
; Then define the frequency fit parameters: steps(3) scale center_fraction fita showplot.
; Then define the frequency fit limits: limits(3).
;0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20.
18 3 2 0 2 1 0 1 0 0 1 0 0 0 0 0 0 0 0 1 0 0 1.
19 100 50 50 1 0.3 1 1 1 -2.
20 3e-3 3e-5 3e-7.
    
```

18 – Fit Parameters Keywords

This entry defines the parameters to include for the atmospheric fit, and in which order to consider the parameters for analysis.

- '0': do not consider this parameter
- '1': consider this parameter first
- '2': consider this parameter second
- '3': consider this parameter third

Typically, you run the program by first assuming values for temperature and pressure in order to obtain abundances for the specified components (marked with a '1'). Next, you use the abundances just obtained to determine more accurate values for temperature and pressure (marked with a '2'). Lastly, you use the abundances and value for temperature and pressure to modify the values of the instrument (marked with a '3'). Thus, you mark the desired atmospheric constituents with a '1' (entries 4 through 20), the pressure and temperature factors with a '2' (entries 1 through 3), and any telescope parameters with a '3' (entry 0).

19, 20 – Frequency Fit Parameters

Line 19: H I J K L M N O S

Line 20: P Q R

Example:

400 100 0 5 1.0 1 1 1

0.1 0.001 0.0

Line 19

Dispersion solution is: LEFT: $CWN + DL1x + DL2x^2$ RIGHT: $CWN + DR1x + DR2x^2$, where 'x' is the horizontal pixel distance from the center of the frame. For the center pixel "x=0".

H-entry (400)

This is the number of steps used to search for the center wavenumber (CWN).

I-entry (100)

This is the number of steps used to search for the first dispersion coefficient (DL1, DR1).

I-entry (0)

This is the number of steps used to search for the second dispersion coefficient (DL2, DR2)

Examples for H I J:

'100 50 50': will use 100 steps to search CWN and 50 to fit the dispersion coefficients.

'100 50 0': will disable the search for second order dispersion coefficients.

K-entry (5)

This is the divider of steps for sequential fits. For the first row, the solution is fitted using H, I, and J steps, while the sub-subsequent rows are done using H/K, I/K and J/K steps.

L-entry (1.0)

This is the fractional size of the search space for CWN. L= **'1.0'** would mean all the spectral points, **'0.5'** would mean the center half, or **'0.1'**, the middle 10% of the array.

M-, N-, and O-entries (1 1 1)

These entries are flags that define the fitting scheme, where M is the flag for fitting CWN, N for fitting the left part of the array, and O for fitting the right part. A **'0'** value will deactivate that section of the fit. Default is **'1 1 1'**.

Examples for M N O:

'1 1 1': will fit everything

'1 0 0': will only fit the center wavenumber (CWN)

'1 0 1': will fit CWN and the right part of the array

'1 2 2': will force LEFT = RIGHT (DL1=DR1), and DL2=0, DR2=0.

'1 3 1': will fit the only using the 1st coeff for the left solution

S-entry

This entry defines the repetition and plot sequence. A negative value will repeat the fit using as a-priori the previous fit for 'S' times. A value of '1' will show the search for CWN, a value of '2' will show the search for the LEFT dispersion, a value of '3' will show the search for the RIGHT dispersion, a value for '4' will fit and then ask for user input, and a value of '6' will not fit but ask for user input (there is no option for a value of '5').

Line 20

P-, Q-, and R-entries (0.1 0.001 0.0)

These entries establish the search space for the variables around the a-priori solution.

The spectral precision of the fit is then P/H for the CWN, and Q/I and R/J for the dispersion coefficients. A big P, Q or R number will expand the search, but produce low precision results or lead to artificial solutions. Too small P, Q, or R values will restrict the search, and may not allow the program to achieve the optimum solution.

Typical Values

CSHELL (IPLANET/ICOMET/ISTAR):

100 50 50 1 1.0 1 1 1
5e-3 5e-4 5e-6

NIRSPEC:

400 100 100 5 0.3
4e-2 2e-4 2e-6

CRIRES (IPLANET/ICOMET/ISTAR):

100 50 50 1 0.3 1 1 1 -2
3e-3 3e-5 3e-7

Lines 19 and 20 are the same as Lines 10 and 11 in the Straightening subsection in the SPECTRAL section of the IBATCH document (IbatchDoc.docx).

3 – RETRIEVAL Section

```

; -----
* RETRIEVAL.
; -----
; Do you want to run this section interactively? .
0 s.
; Do you want a graphical output .
1 y.
; Enter a keyword, defining what to retrieve
; 0: Will retrieve all data available (every row, and totals).
; 1: Will retrieve only the sets and global totals.
; 2: Will retrieve only the global total.
; 3: Will retrieve only the rows of the global total.
2 3.
; Enter the col ranges to skip in the retrieval.
3 0 0.
; Specify the type of retrieval.
; retrieve: will create models until chi-square is minimized, "fast/full" and "noline" keywords.
; scale: it will scale the line areas based on the latest model.
4 retrieve.
5 H2O(1) CH4(6) CO2(2).
6 200.0 50.0 1.0.
7 1 1 1.

```

0 – Interactive Keyword

- 'y': will make it interactive
- 'n': will run without user interaction
- 's': will skip the whole section and go to the next (end of program)

1 – Graphically Show Results Keyword

- 'y': will graphically show results
- 'n': will not graphically show results

2 – Retrieval Keyword

This line defines what to retrieve.

- '0': will retrieve all data available (every row and totals)
- '1': will retrieve only the sets and global totals
- '2': will retrieve only the global total
- '3': will retrieve only the rows of the global total

3 – Retrieval Column Range Keyword

This entry designates which columns to skip in the retrieval.

4 – Retrieval Type Keyword

- 'retrieve': will create models until the chi-squared value is minimized

'noline': this keyword will disable the generation of the planetary lineatlas. This can be done when the lineatlas has been already calculated for this spectral interval.

5 – Fit Parameters Keyword

Gases are provided as **'NNN(X)'**, where NNN is gas name and X is the molecule number in the HITRAN database:

<http://www.cfa.harvard.edu/hitran/molecules.html>

Other parameters available are **'TSURF'**, **'TAIR'**, **'PSURF'** and **'RESPOWER'**.

6 – A-priori Fit Values Keywords

This keyword defines the a-priori values of the parameters in Line 5 (Fit Parameters Keyword), above. A value of **'-1'** for **'TSURF'**, **'TAIR'**, **'PSURF'** and **'RESPOWER'** will force the program to use the defaults from the GCM.

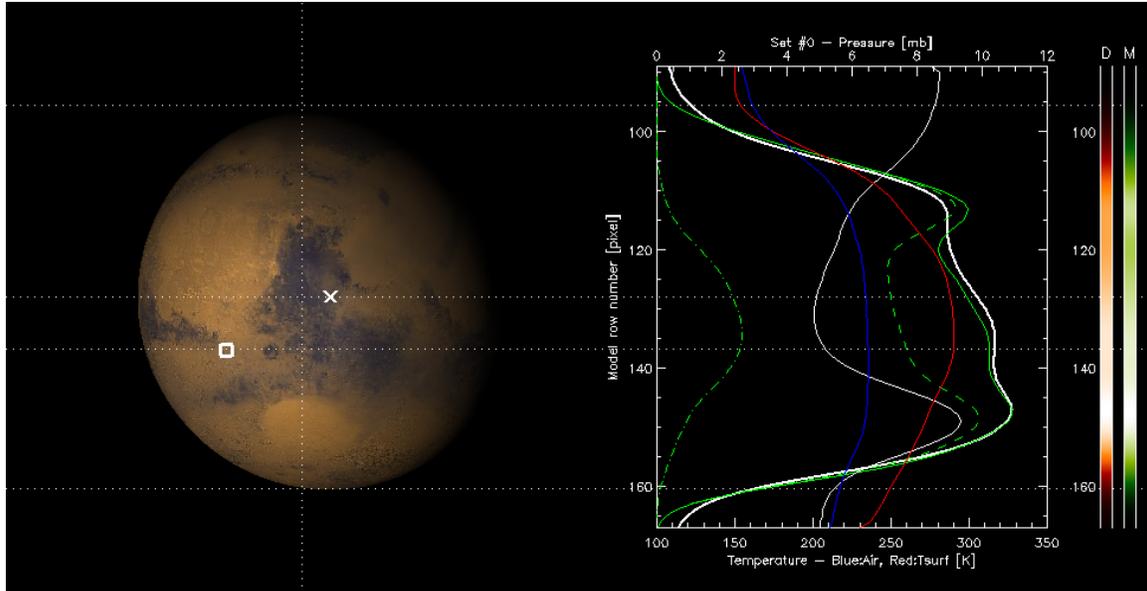
7 – Parameter Flags Keyword

A value of **'1'** will mean that this parameter is to be fitted, while **'0'** will set the parameter to a constant value as defined in Line 6 (A-priori Fit Values Keywords), above.

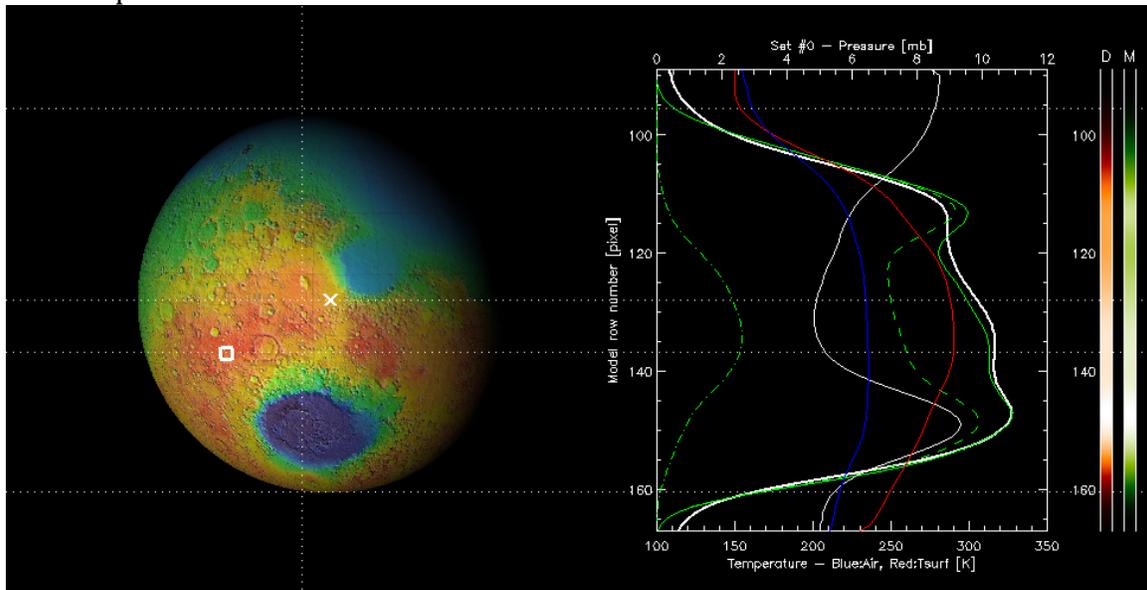
GEOMETRY section, Line 5: Planet Name Keyword (page 5)

Examples of Images of Mars

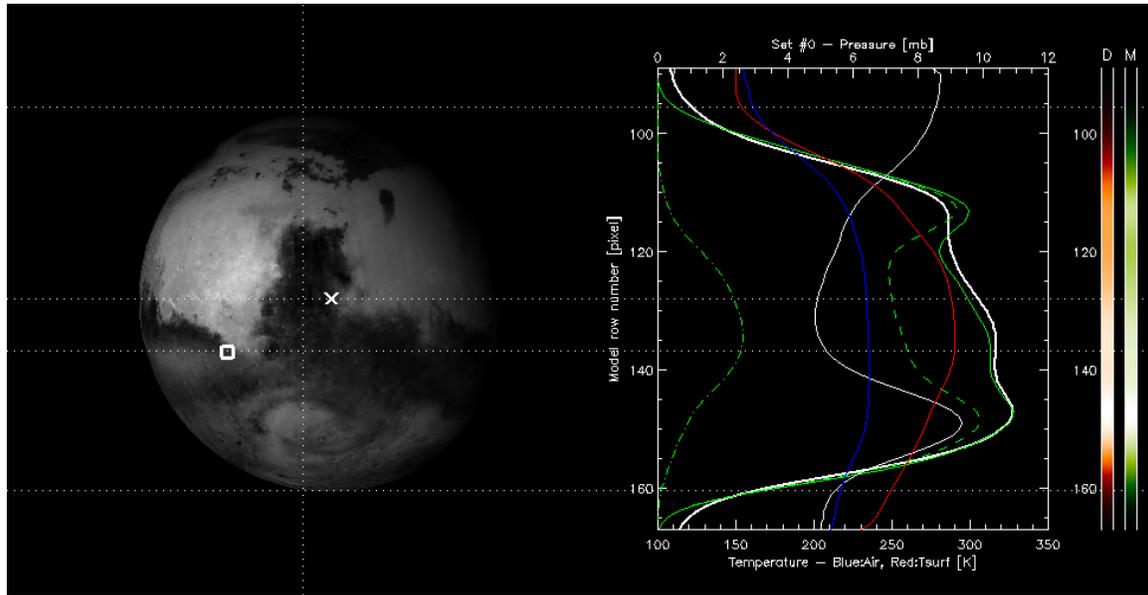
'mars'



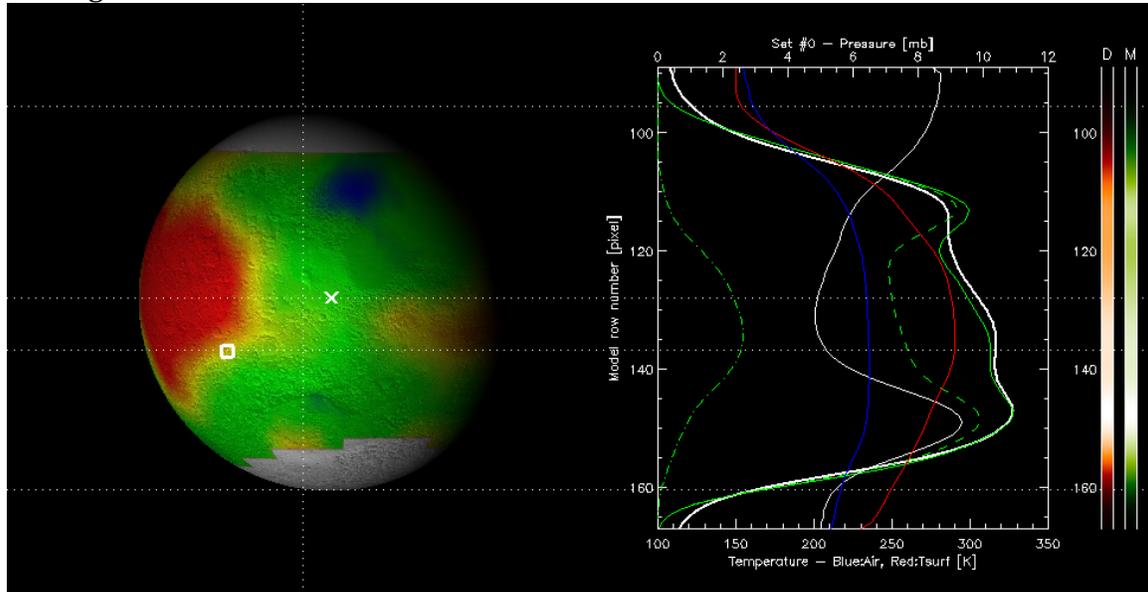
'mars-topo'



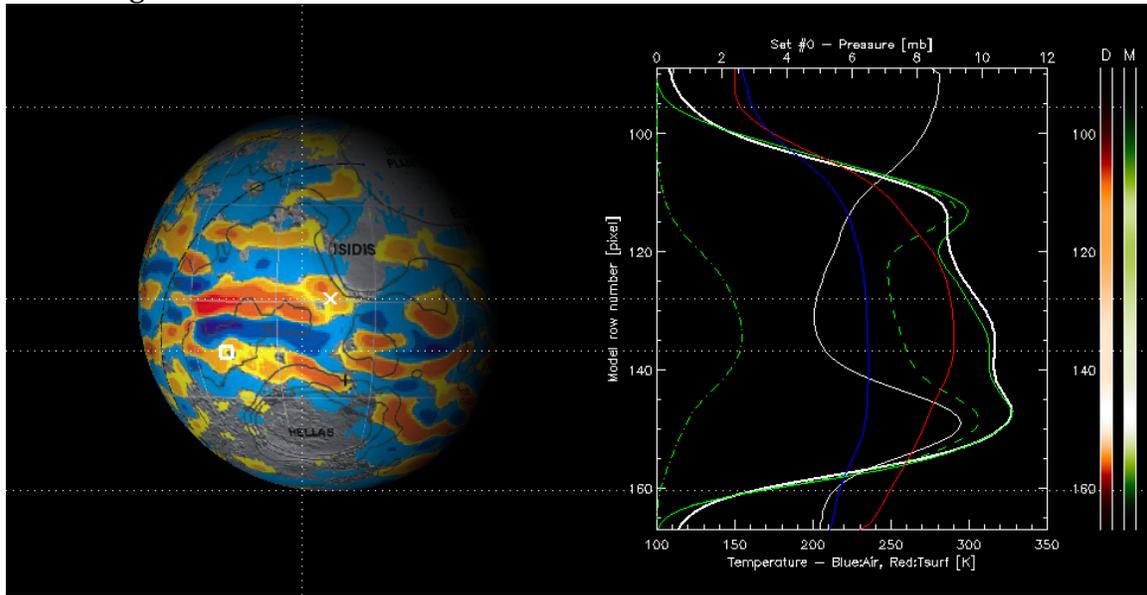
'mars-albedo'



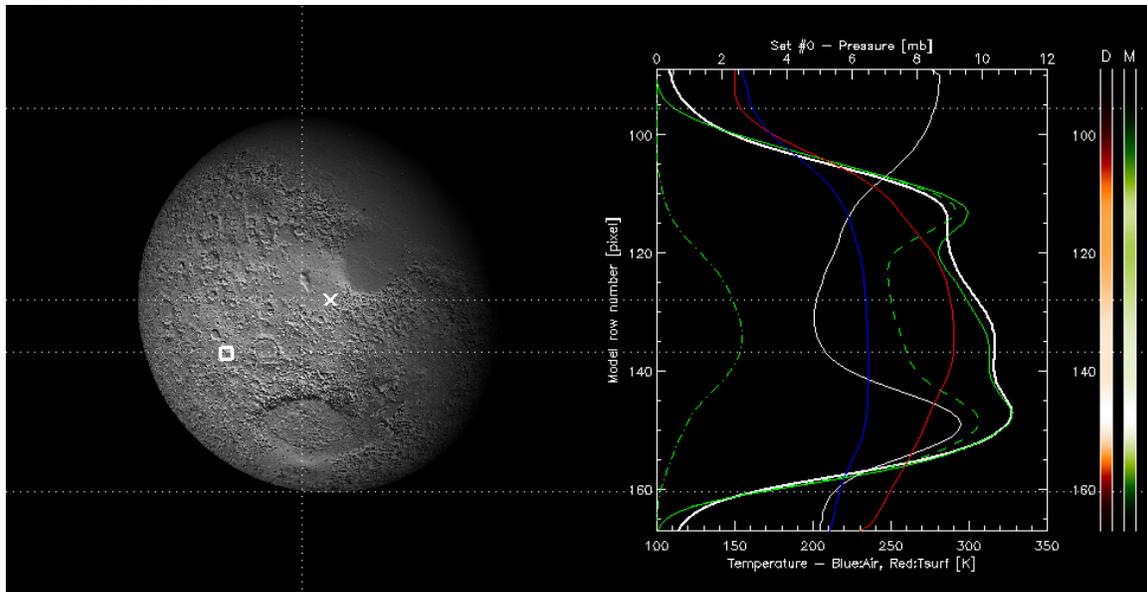
'mars-grs'



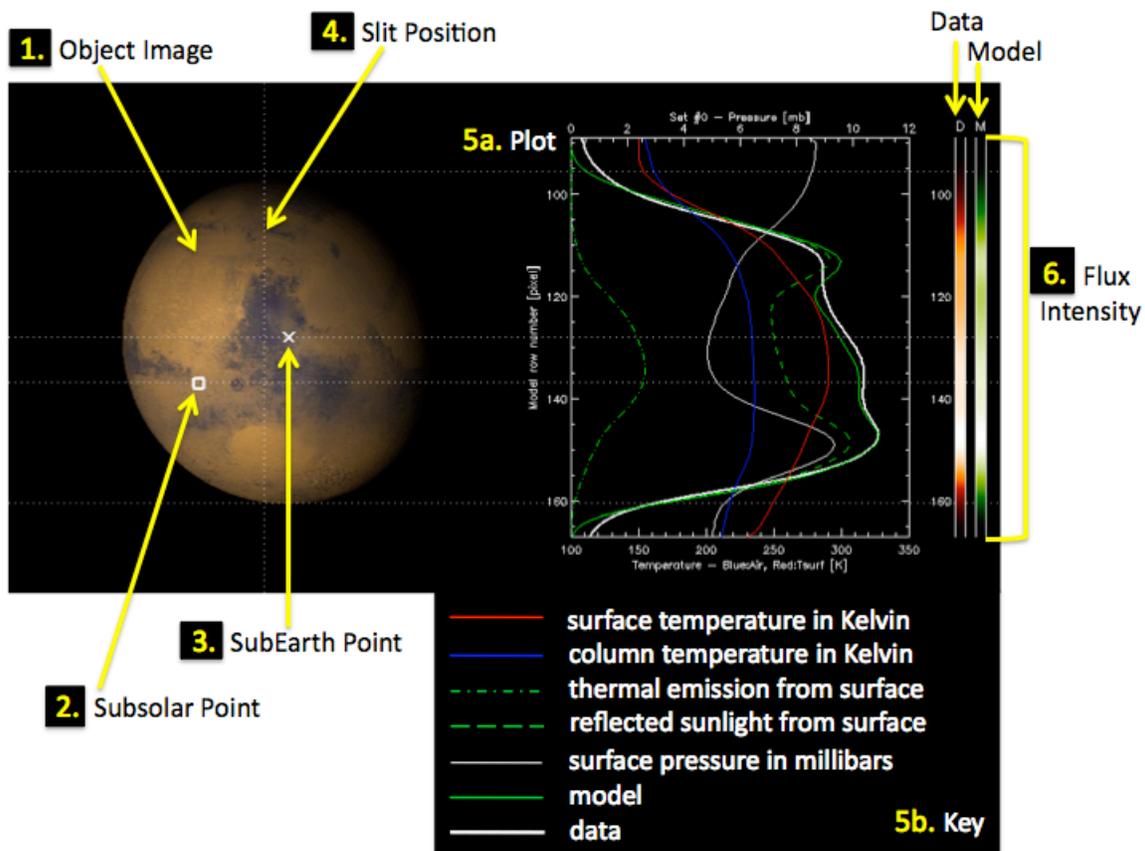
'mars-magnetic'



'mars-shade'



GEOMETRY Section, Graphic Display Explanation



1. Object Image

This is the image of the object you designated in Line 5 above (Planet Name Keyword). The image shown is a geographic image of Mars. A topographic image of Mars is also available.

2. Subsolar Point

This square marks the spot on the object where the Sun is directly overhead.

3. SubEarth Point

This 'x' marks the spot on the object where the Earth is directly overhead.

4. Slit Position

This dotted line marks the location of the slit on the object.

5. Plot and Key

There are seven traces plotted on this graph. The vertical axis of the plot corresponds to the row number (in pixels) that contains object flux. The horizontal axis along the top of the plot is the pressure in millibars (for the thin **white** trace). The horizontal axis along the bottom of the plot is the temperature in Kelvin (for the **red** and **blue** traces).

The Traces

Thin White Trace

The thin **white** trace shows the surface pressure (in millibars) of the object as a function of position along the slit.

Red Trace

The **red** trace shows the surface temperature of the object (in Kelvin) as a function of position along the slit. Surface temperature can often vary greatly along the Martian year and between day and night. The values are retrieved from the MCD-GCM.

Blue Trace

The **blue** trace shows the column temperature of the object (in Kelvin) as a function of position along the slit. This 'air temperature' is calculated as the effective temperature of the whole atmosphere column, weighted by pressure:

$$T_{col} = \frac{\sum_{i=1}^{Nalt} \rho(i)T(i)}{\sum \rho(i)}$$

Where,

- = column temperature
- = number of altitude steps*
- = pressure at the ith atmospheric layer (from MCD-GCM)
- = temperature at the ith atmospheric layer (from MCD-GCM)

*The General Circulation Model for Mars separates the atmosphere into 50 layers. Each layer corresponds to each altitude step when calculating the column temperature.

Dot Dash Green Trace

 The '**dot dash green**' trace shows the thermal emission from the surface of the object as a function of position along the slit. This trace is proportional to the emissivity, ϵ , of the planet, as well as to the temperature to the fourth power.

Thermal emission $\sim \epsilon T^4$

Additionally,

$$\epsilon \sim (1 - A),$$

Where,

A = albedo (visible/near-infrared reflectance as measured by the Mars-Global-Surveyor Thermal-Emission-Spectrometer, MGS-TES, in the 0.3-2.9 μm spectral range)

Also, the 'dot dash' green trace corresponds to the thermal scalar designated in the F-entry of Line 2 in the GEOMETRY section above.

Dashed Green Trace

 The 'dashed' green trace corresponds to the reflected sunlight from the surface of the object. The surface of Mars is modeled as a Lambertian surface, where the intensity of the reflectance in any one location is proportional to the cosine of the incidence angle of the Sun on the surface. The reflected sunlight is also proportional to the albedo of the surface.

Solid Green Trace

The solid green trace results from the addition of the 'dot dash' green trace and the 'dashed' green trace. This trace represents the model against which you compare the data.

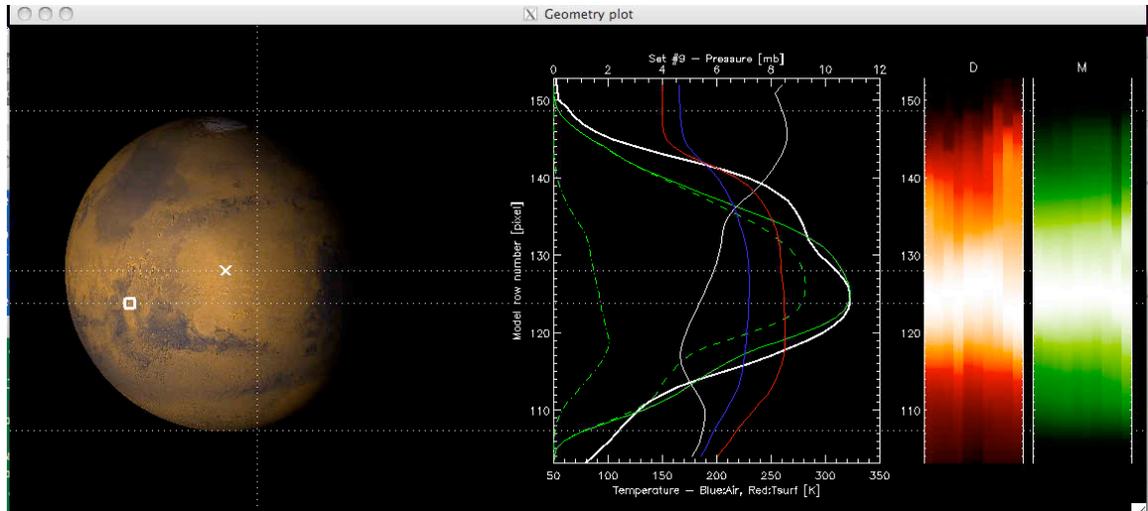
Thick White Trace

The thick white trace corresponds to the flux from the object.

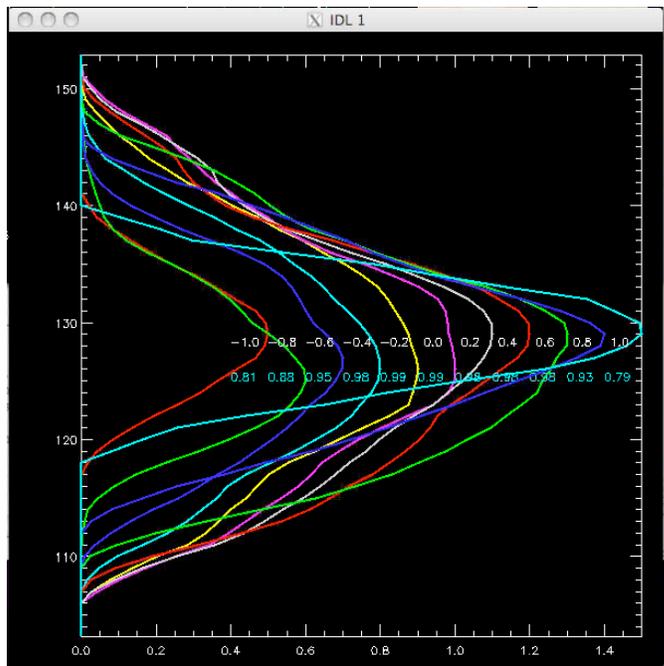
All three green traces and the thick white trace are plotted in units of relative flux.

6. Flux Intensity

This section of the plot illustrates the relative flux intensity for the model and the data as a function of row number (position along the slit). The goal is to get the model and data to agree as closely as possible by manipulating the entries in Lines 2 and 3 in the GEOMETRY section above. The green plot refers to the model, and the red plot refers to the data. The brighter the plot, the higher the flux.

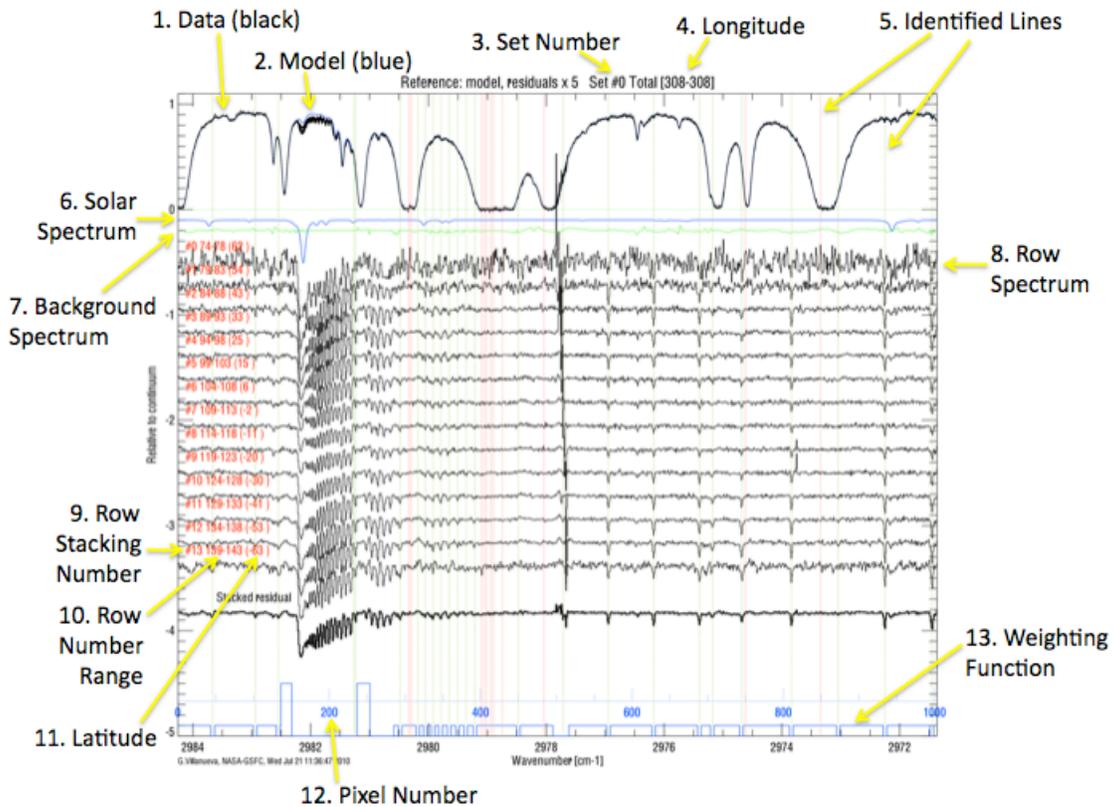


If you run 'all' of the sets, IPLANET will produce the above plot, where each set is shown in the 'flux intensity' section. The first set (set 0) is on the far right, and progresses to set N-1 (of N sets) on the left. The above plot has 10 sets, with set 0 on the right, and set 9 on the left.



The plot shows spatial profiles for different slit positions across the planet in planetary radii. The white number indicates the "shift" (Line 3 (Pixel Scale, Slit Position and Slit Orientation Keywords), J-entry), while the light blue number the correlation to the current measured spatial profile. A higher correlation would mean a better match to the data. The different traces are the different modeled spatial profiles scaled to peak near the white numbers.

RESIDUALS ANALYSIS, Graphic Display Explanation



1. Data (black)

This black trace represents the spectrum of the data. All rows are overplotted.

2. Model (blue)

This blue trace represents the model fitted to the data.

3. Set Number

This number corresponds to the set number of the data.

4. Longitude

This number identifies the longitude of the object (where the slit is positioned).

5. Identified Lines

These dotted lines correspond to the spectral lines identified in Line 5 (Lines of Interest Keyword) in the RESIDUALS ANALYSIS section of IPLANET.

A red dotted line signifies that the transmission of this line is less than 3%. A green dotted line signifies that the transmission of this line is greater than 3%.

6. Solar Spectrum

This blue trace represents the solar spectrum.

7. Background Spectrum

This green trace represents the background spectrum.

8. Row Spectrum

This spectrum is that of the row range specified by the spacing and stacking parameters in Line 4 (Row Analysis Parameters) in the RESIDUALS ANALYSIS section of IPLANET.

9. Row Stacking Number

This number represents the 'Row Stacking' set number. This is not the set number of the data set.

10. Row Number Range

This range represents the rows stacked according to the spacing and stacking parameters in Line 4 (Row Analysis Parameters) in the RESIDUALS ANALYSIS section of IPLANET.

11. Latitude

This number specifies the latitude on the object at which the 'Row Stacking' set is positioned.

12. Pixel Number

The blue numbers along the bottom of the image represent the column pixel numbers.

13. Weighting Function

This blue trace illustrates the weighting function applied to each frequency.

ISTAR

DOCUMENTATION FILE

This document serves to provide the user with information regarding each input in each line of the 'results.pln' file used to run ISTAR.

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Appendix for ISTAR Documentation File

This document serves to provide the user with information regarding the graphical outputs of the ISTAR program.

<u>Section</u>	<u>Page Number</u>
Graphical Output Explanation	13

0 – DATA Section

This section reads the output from IBATCH and reorganizes the data. In this section, you designate the input and output directories for the files, and determine how you would like to process the data. You can view and process each set individually to check for errors, and then stack all the sets to achieve higher signal-to-noise.

```
results.ses.  
; -----  
* DATA.  
; -----  
; The program is case-sensitive.  
; Do you want to run this section interactively?  
; The present values will be the defaults. 's' as input.  
; will skip this section, this is valid for all the sections.  
0 n.  
; Enter the directory where the input files are located.  
1 ./.  
; Enter the resulting directory.  
2 ./.  
; Enter the sets you want to analyze. First has index 0..  
; 'stack' will stack all the available sets, and 'all' will.  
; process all available sets.  
3 all.
```

0 – Interactive Keyword

'y': will make it interactive

'n': will run without user interaction

's': will skip the whole section and go to the next (residual analysis)

1, 2 – Directory Keywords

Line 1 designates where the input files are located. Line 2 designates where the results from processing will be saved.

3 – Sets/Stack Keyword

This entry designates which sets you want to analyze. The numbering of sets begins at '0' (thus, the first set is actually set '0'). You can analyze each set individually by entering the number of the set you want to analyze.

'2': will process set 2

'2 3 5 7': will process only sets 2, 3, 5, and 7

'all': will process all sets individually

You can also stack sets.

- 'stack': will stack all available sets for processing
- 'stack 2 3 5 7': will stack only sets 2, 3, 5, and 7 for processing
- 'stack 2-7': will stack sets 2 through 7 for processing

1 – RESIDUALS ANALYSIS Section

In this section, you define the sections of the images to analyze, and define atmospheric parameters in order to correctly model the terrestrial atmosphere. Thus, you can separate the terrestrial atmosphere and that of the star. There are three subsections in this section.

Subsection One:

```

; -----
* RESIDUAL ANALYSIS.
; -----
; Do you want to run this section interactively?.
0 n.
; Graphically show the results?.
1 y 10.
; Enter the column range to analyze. 'all' will analyze all cols.
2 all.
; Enter the rows relative to the center to analyze.
3 -2 2.
; Enter the slit size [pixels], and plate scales.
4 5 0.200 0.200.
;
; Enter the col-ranges which contain continuum.
; information. If 'ask' is entered, the program.
; will ask for the values interactively.
5 0 319 329 last.
;
; Input the degree of the polynomial fit for the continuum.
6 4.
    
```

In this section, you define which parts of the image you want to analyze.

0 – Interactive Keyword

- 'y': will make it interactive
- 'n': will run without user interaction
- 's': will skip the whole section and go to the next (end of program)

1 – Graphically Show Results Keyword

C D
 Example: y 10

C-entry (y)

- 'y': will graphically show results
- 'n': will not show results

D-entry (10)

This entry designates the multiplier of the residuals.

2 – Analysis Column Range Keyword

This line determines the range of columns to be analyzed by the program. For example, if you have bad pixels in the border columns of the data, you may want to remove these columns from analysis.

‘all’: all columns will be included in analysis

‘10 250’: only columns 10 through 250 will be included in the analysis.

This is similar to Line 3 in the RESIDUALS ANALYSIS section of the IPLANET document (IplanetDoc.docx).

3 – Analysis Row Range Keyword

E F

Example: -2 2

This line determines which rows to be analyzed by the program. The program centers the beam at row 128. In this line, you designate how many rows relative to the center row (0) you would like analyzed. For example, ‘-2 2’ means that you would like to analyze two rows below the center to two rows above the center (rows 126 to 130).

4 – Slit Size and Plate Scales Keywords

G H I

Example: 5 0.198 0.144

G-entry (5)

This entry refers to the slit-width in pixels. This number is calculated by dividing the slit-width in arcseconds by the plate x-scale (in arcseconds/pixel). For example, if your slit-width is 0.720”, and your plate x-scale is 0.144 “/pixel, then the slit-width in pixels is $0.720'' / 0.144''/\text{pixel} = 5$ pixels.

H-entry (0.198)

This entry refers to the plate scale (in arcseconds/pixel) in the y-direction (spatial), also known as the y-pixel pitch.

I-entry (0.144)

This entry refers to the plate scale (in arcseconds/pixel) in the x-direction (spectral), also known as the x-pixel pitch.

5 – Column Ranges Continuum Keywords

In this line, you designate which columns contain continuum for use in determining the baseline. For example, the entry ‘0 319 329 last’ will include

only columns 0 through 319 and 329 through the last column when determining the baseline (columns 320 through 328 will be skipped).

If the keyword 'ask' is designated, the program will ask for the values interactively.

The optional keyword 'g' (for gamma) allows you to determine which columns you would like to use in order to calculate "gamma" or instrument conversion efficiency. For example, the entry '0 319 329 last g 0 100 123 last' would include only columns 0 through 319 and 329 through the last column when determining the baseline, and would include only columns 0 through 100, and 123 through the last column to calculate the gain (columns 101 through 122 would be skipped). By default and if the entry 'g' is not provided, any columns that contain 80% flux or greater are used to calculate the gamma. If only one number is given after the 'g' keyword, this will be used to define the threshold.

This is similar to Line 6 in the RESIDUALS ANALYSIS section of the IPLANET document (IplanetDoc.docx), except that here you designate which columns to use, and in IPLANET you designate which columns not to use.

Example 1: all or 0 1000 --> this will use the cols in the specified range (e.g. all or 0 1000) to fit the continuum and use 80% threshold for gamma.

Example 2: all g 90 --> this will use the cols in the specified range to fit the continuum and 90% threshold for gamma.

Example 3: all g 90 100 200 210 600 630 --> this will use the cols in the specified range to fit the continuum and self-defined gamma points.

In example 3 it recognizes that gammas are self-defined (i.e. no transmittance threshold is used) by the fact there is more than one number after "g"

In all cases if spectral ranges are excluded from fitting the continuum (needed in the case of stellar absorptions), they are also excluded for gamma, even when self-defined gamma points are not used.

6 – Degree of Polynomial Keyword

In this line, you designate the degree of the polynomial used to fit the continuum.

Subsection Two: Atmospheric Parameters, Frequency Adjust, Star Properties

```

; Atmospheric parameters.
; 1) Do you want to calculate the transmittance and radiance(run), read.
;    a previous run (read), or retrieve the values (retrieve)?.
; 2) Air mass and telescope altitude [m].
; 3) Abundances relative to a tropical atm: H2O,CO2,O3,N2O,CO,CH4  O2,NH3,C2H6,HCl.
; 4) Temperature and pressure factors, T1factor, T2factor, Pfactor.
; 5) Resolving power a value or a file.
; 6) Filestem of transmittance (.trf).
7 retrieve multiple (atms.txt).
8 1.300 4200.0000.
9 0.2000 1.0000 1.0000 1.0000 1.0000 1.0000 1.0000 1.0000 1.0000 0.1500 1.0000.
10 1.0000 1.0000 1.0000 1.0000 1.0000 1.0000 1.0000 1.0000 1.0000.
11 95000.
12 ../atm/lblrtnD1.
.
.
; Do you want to adjust the frequency?.
13 y save ahead.
.
; Enter the effective temperature (Teff), magnitude and integration time (s).
14 10000 5 20.0.

```

In this section, you designate the atmospheric parameters, adjust the frequency solution if desired, and identify properties of the star and the integration time of the images.

7 – 12 – Atmospheric Parameters

Lines 7 through 13 are similar to Subsection Four: Atmospheric Parameters in the RESIDUALS ANALYSIS section of IPLANET, as well as Subsection Three: Atmospheric Parameters in the SPECTRAL section of IBATCH, but there are some differences.

7 – Read/Run/Retrieve Keyword

This line designates whether or not you calculate the transmittance and radiance (run), read a previous run (read), or retrieve the values through comparison of the data and model (retrieve).

‘run’: the program will calculate the transmittance and radiance

‘read’: the program will read the results from a previous run*

‘retrieve’: the program will retrieve results the values through comparison**

*When ‘read’ is selected, the program reads previous results from the file atm/lblrtn

**When ‘retrieve’ is selected, the program compares the data and model and aims to minimize error between the two to get the best match. It will use the values in Line 16 (Fit Parameters Keyword), below, to determine which parameters to fit and in which order it should be done.

Optional Keywords:

'nolines': this keyword will disable the generation of the lineatlas. This can be done when the lineatlas has been already calculated for this spectral interval.

'multiple': this keyword creates a separate atmosphere for each set of data (this is useful when the airmass changes greatly throughout the night). The resulting model files for this atmosphere will be stored in the "stem" directory with the addition of "-X" where X is the set number.

'(atms.txt)': when this keyword is input, the program goes to each set of data and modifies the atmospheric abundances. When in "read" mode, the values are read from the file, while in "retrieve" mode, the values are read from the file and then used as a-priori for fitting the atmosphere. The results are saved into the file.

This line is the same as Line 10 (Read/Run/Retrieve Keyword) in the RESIDUALS ANALYSIS section of the IPLANET document (IplanetDoc.docx).

8 – Airmass and Telescope Altitude Keywords

J K

Example: 1.3000 4200.0000

J-entry (1.3000)

This entry designates the airmass.

By default, the program will read the file "airmasses.txt" to determine the airmass of the current set.

K-entry (4200.0000)

This entry corresponds to the altitude of the telescope, in meters.

This line is the same as Line 11 (Airmass and Telescope Altitude Keywords) in the RESIDUALS ANALYSIS section of the IPLANET document (IplanetDoc.docx).

9 – Relative Abundances Keywords

L M N O P Q R S T U V

Example:

0.2000 1.0000 1.0000 1.0000 1.0000 1.0000 1.0000 1.0000 1.000 1.000 1.000

L-, M-, N-, O-, P- and Q-entries (0.2000 1.0000 1.0000 1.0000 1.0000 1.0000)

These entries correspond to the relative abundances of six gases relative to a tropical atmosphere. The six gases are: H₂O, CO₂, O₃, N₂O, CO and CH₄ (which correspond to L through Q, respectively).

R-, S-, T-, U-, and V-entries (1.0000 1.0000 1.0000 1.0000 1.0000)

These correspond to the gases O₂, NH₃, C₂H₆, and HCl, respectively. The fifth entry is not currently implemented.

These entries are the same as entries H through R in Line 12 in the RESIDUALS ANALYSIS section of the IPLANET document (IplanetDoc.docx), as well as entries F through P in Line 14 in the Atmospheric Parameters subsection in the Spectral section of the IBATCH document (IbatchDoc.docx).

10 – Temperature and Pressure Factors Keywords

W X Y Z C D E F
 Example: 1.0000 1.0000 1.0000 1.0000 1.0000 1.000 1.000 1.000

W-, X-, and Y-entries (1.0000 1.0000 1.0000)

These entries correspond to temperature factors for T(lower atmosphere), T(stratosphere), and surface pressure scaler, respectively. All these numbers are relative to the “standard tropical profile”.

Z-, C-, D-, E-, and F-entries (1.0000 1.0000 1.0000 1.0000 1.0000)

These entries are not implemented yet.

These entries are the same as entries S through Z in Line 13 (Temperature and Pressure Factors Keyword) in the RESIDUALS ANALYSIS section of the IPLANET document (IplanetDoc.docx), as well as entries Q through X in Line 15 in the Atmospheric Parameters subsection in the Spectral section of the IBATCH document (IbatchDoc.docx).

11 – Resolving Power Keyword

This entry corresponds to the instrument resolving power.

Examples using the narrow slits:

CSHELL: 40000
 NIRSPEC: 35000
 CRIRES: 90000

12 – Filestem Keyword

This entry defines the filestem for the transmittance (.trn) and radiance (.rad) files.

This entry is the same as Line 15 (Filestem Keyword) in the RESIDUALS ANALYSIS section of the IPLANET document (IplanetDoc.docx), as well as the Z-entry of Line 17 in the Atmospheric Parameters subsection in the Spectral section of the IBATCH document (IbatchDoc.docx).

13 – Frequency Solution Keyword

In this line, you designate whether you would like to adjust the frequency solution or not. If you choose to adjust the frequency, the program will use the parameters designated in Lines 17 and 18 below.

'y': adjust frequency solution

'n': do not adjust frequency solution

'y save': the program will adjust the frequency and save the results into the 'iplanet' session, the freqdXX.dat file and freqdsolutions.dat file. No need to re-run ibatch again with the new frequency solution.

'y save ahead': the program will adjust the frequency and save the results for this set and the upcoming sets. For instance, when running set #2, it will fit the frequency to set 2 and save it for sets 2, 3, 4...N.

The 'y save ahead' keyword is useful because it provides the program with a starting point to find the frequency solution. Since the solutions won't vary greatly from one set to the next, this keyword lessens the number of possible iterations the program has to compute in order to find the next solution.

This line is the same as Line 9 (Frequency Solution Keyword) in the RESIDUALS ANALYSIS section of the IPLANET document (IplanetDoc.docx).

14 - Effective Temperature, Magnitude and Integration Time Keywords

G H I

Example: 10000 5 20.0

G-entry (10000)

This is the effective temperature of the star.

H-entry (5)

This is the magnitude of the star.

The G- and H-entries must be determined from knowing the spectral type of the star. Since the spectral type is known, the effective temperature and magnitude of the star can be looked up using an online database (ex. Simbad) or in a table. The magnitude of the star depends on the frequency of the observation, and this must be accounted for. A convenient table to determine the magnitude and temperature of a star is given in the idl/glv/extras folder, named spectraltype.pdf.

I-entry (20.0)

This entry designates the TOTAL integration time (in seconds, i.e. COADDS x INT_TIME) of the observations. This must be looked up in the observation log from the night of observation.

Subsection Three: Fit Parameters

```

; Parameters of the atmospheric fit.
; 0 - Resolving power.
; 1 - T1-factor.
; 2 - T2-factor.
; 3 - Psurf-factor.
; 4 - H2O-factor.
; 5 - CO2-factor.
; 6 - O3-factor.
; 7 - N2O-factor.
; 8 - CO-factor.
; 9 - CH4-factor.
;10 - XX-factor.
;11 - XX-factor.
;12 - XX-factor.
;13 - XX-factor.
;14 - XX-factor.
;15 - O2-factor.
;16 - NH3-factor.
;17 - C2H6-factor.
;18 - HCl-factor.
;19 - XX-factor.
;20 - Solar factor.
; Then define the frequency fit parameters: steps(3) scale center_fraction fita showplot.
; Then define the frequency fit limits: limits(3).
;0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20.
15 0 2 0 2 1 0 1 0 0 1 0 0 0 0 0 0 0 0 0 0 1.
16 100 50 50 1 0.3 1 1 1 -2.
17 3e-3 3e-5 3e-7.
18 1 1 1 1 0 0 0 1 1 1 0 0 0 0 0.

```

15 – Fit Parameters Keywords

This entry defines the parameters to include for the atmospheric fit, and in which order to consider the parameters for analysis.

- '0': do not consider this parameter
- '1': consider this parameter first
- '2': consider this parameter second
- '3': consider this parameter third

Typically, you run the program by first assuming values for temperature and pressure in order to obtain abundances for the specified components (marked with a '1'). Next, you use the abundances just obtained to determine more accurate values for temperature and pressure (marked with a '2'). Lastly, you use the abundances and value for temperature and pressure to modify the values of the instrument (marked with a '3'). Thus, you mark the desired atmospheric constituents with a '1' (entries 4 through 20), the pressure and temperature factors with a '2' (entries 1 through 3), and any telescope parameters with a '3' (entry 0).

This is the same as Line 18 (Fit Parameters Keyword) in the RESIDUALS ANALYSIS section of the IPLANET document (IplanetDoc.docx).

16, 17 – Frequency Fit Parameters

Line 17: H I J K L M N O S
 Line 18: P Q R

Example:

100 50 50 1 0.3 1 1 1 -2
 3e-3 3e-5 3e-7

Line 16

Dispersion solution is: LEFT: $CWN + DL1x + DL2x^2$ RIGHT: $CWN + DR1x + DR2x^2$, where 'x' is the horizontal pixel distance from the center of the frame. For the center pixel 'x=0'.

H-entry (100)

This is the number of steps used to search for the center wavenumber (CWN)

I-entry (50)

This is the number of steps used to search for the first dispersion coefficient (DL1, DR1)

I-entry (50)

This is the number of steps used to search for the second dispersion coefficient (DL2, DR2)

Examples for H I J:

100 50 50 will use 100 steps to search CWN and 50 to fit the dispersion coeffs.

100 50 0 will disable the search for second order dispersion coefficients.

K-entry (1)

This is the divider of steps for sequential fits. For the first row, the solution is fitted using H, I and J steps, while the sub-sequent rows are done using H/K, I/K and J/K steps.

L-entry (0.3)

This is the fractional size of the search space for CWN. L=1.0 would mean all the spectral points, 0.5 would mean the center half, or 0.1 the middle 10% of the array.

M-, N-, and O-entries (1 1 1)

These entries are flags that define the fitting scheme, where M is the flag for fitting CWN, N for fitting the left part of the array, and O for fitting the right part. A zero value will deactivate that section of the fit. Default is "1 1 1"

Examples for M N O:

1 1 1 will fit everything

1 0 0 will only fit the center wavenumber (CWN)

1 0 1 will fit CWN and the right part of the array

1 2 2 will force LEFT = RIGHT (DL1=DR1), and DL2=0, DR2=0.

S-entry (-2)

This entry defines the repetition and plot sequence. A negative value will repeat the fit using as a-priori the previous fit for S times. A value of 1 will show the search for CWN, a value of 2 will show the search for the LEFT dispersion, a value of 3 will show the search for the RIGHT dispersion, a value for 4 will fit and then ask for user input, a value of 6 will not fit but ask for user input.

Line 17

P-, Q-, and R-entries (3e-3 3e-5 3e-7)

These entries establish the search space for the variables around the a-priori solution. As a-priori, the program uses:

CWN: $(\text{Keyword7(G)} + \text{Keyword7(F)}) / 2$
 DL1=DR1: $(\text{Keyword7(G)} - \text{Keyword7(F)}) / x\text{-pixels}$
 DL2=DR2=0

The spectral precision of the fit is then P/H for the CWN, and Q/I and R/J for the dispersion coefficients. A big P, Q or R number will expand the search, but produce low precision results or lead to artificial solutions. Too small P, Q, or R values will restrict the search, and may not allow the program to achieve the optimum solution.

Typical values for:

CSHELL (IPLANET/ICOMET/ISTAR):

100 50 50 1 1.0 1 1 1

5e-3 5e-4 5e-6

NIRSPEC:

400 100 100 5 0.3

4e-2 2e-4 2e-6

CRIRES (IPLANET/ICOMET/ISTAR):

100 50 50 1 0.3 1 1 1 -2

3e-3 3e-5 3e-7

Lines 16 and 17 are the same as Lines 19 and 20 (Frequency Fit Parameters) in the RESIDUALS ANALYSIS section of the IPLANET document (IplanetDoc.docx) and Lines 10 and 11 in the Straightening subsection in the Spectral section of the IBATCH document (IbatchDoc.docx).

18 – Baseline Removal Input Parameters Keywords

In this line, you can enable or disable selected components of the baseline removal. To enable the removal of a component, put a '1'. To disable the removal of a component, put a '0.'

0 1 2 3 4 5 6 7 8 9 A B C D E
 Example: 1 1 1 1 1 0 0 1 1 1 0 0 0 0 0

0 – 6 entries

These entries correspond to the polynomial background baseline.

7 – 9 entries

These entries correspond to the polynomial gain.

A-entry

This entry corresponds to the residual sky removal.

B-entry

This entry corresponds to the scatter-light removal.

C-entry

This entry corresponds to the correction for the Fraunhofer lines.

D-entry

This entry corresponds to the removal of spectra fringing. The number entered here corresponds to the number of fringes to remove.

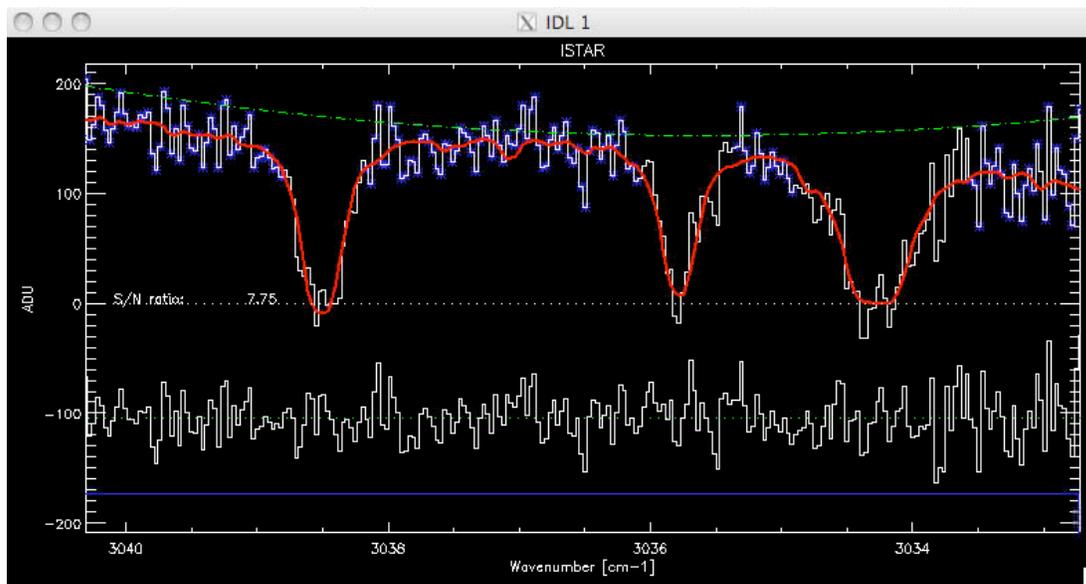
E-entry

This entry corresponds to the variable resolving power.

This is the same as Line 7 (Baseline Removal Input Parameters Keyword) in the RESIDUALS ANALYSIS section of the IPLANET document (IplanetDoc.docx).

ISTAR APPENDIX:

Graphical Output Explanation



Green dot dash = Continuum model (2nd order polynomial)

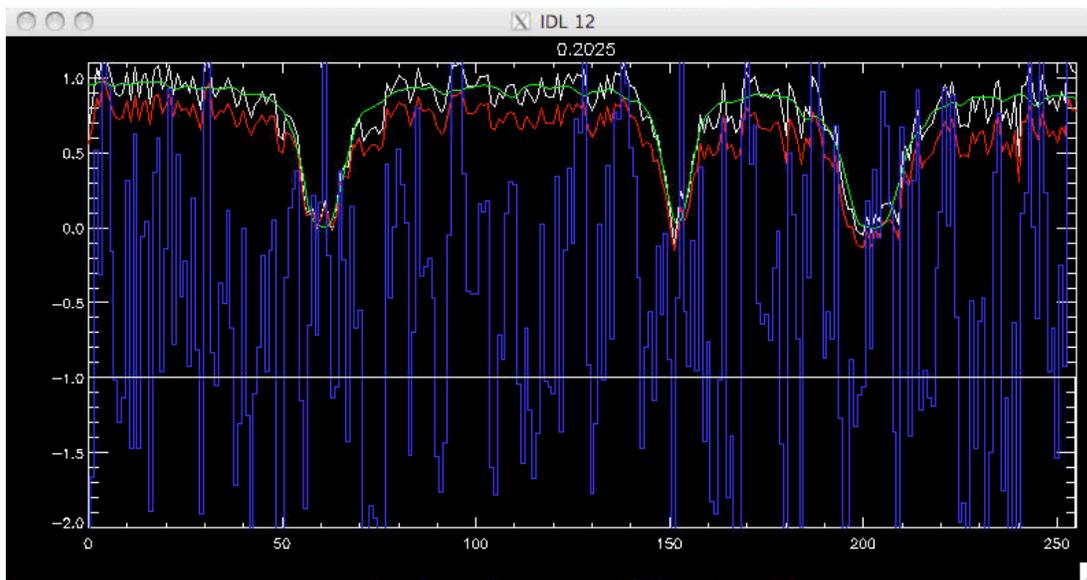
Top white square = data

Top blue square = data points used to compute gamma

Red = continuum model affected by transmittance

Bottom white square = residuals spectrum (data – model, i.e. white – red)

Bottom blue straight = weighting function used for fitting the model and baseline.

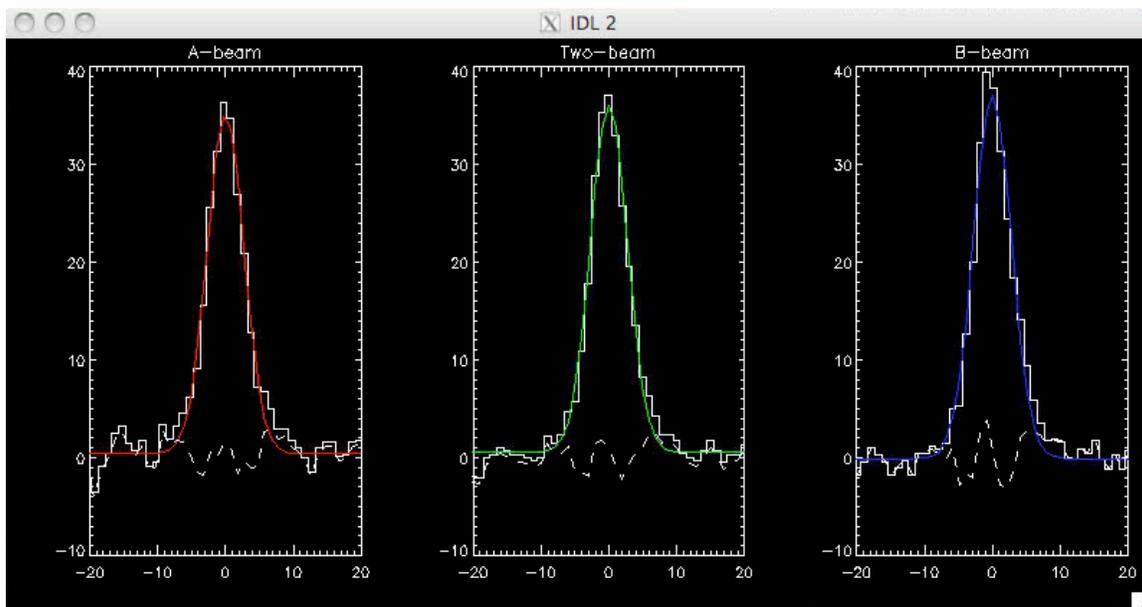


Blue = data – model (white – green) multiplied by residuals multiplier

Green = continuum model affected by transmittance

Red = transmittance model

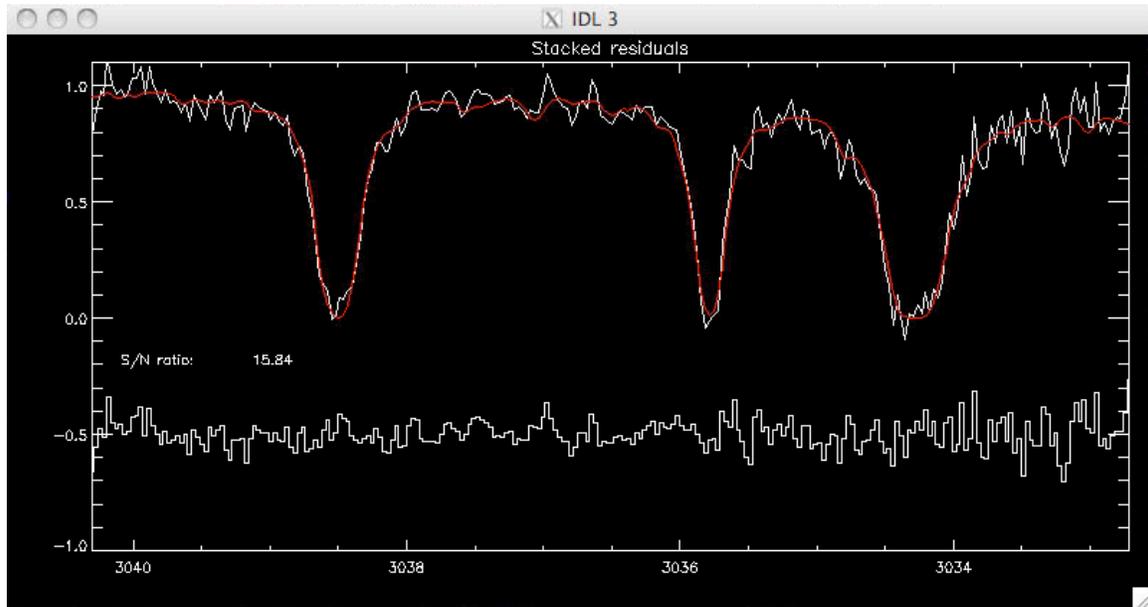
White = data



White = spatial profile

Red/green/blue = Gaussian fits to the spatial profiles (A/A+B/B)

Dashed white = data – gaussian



Top white spectrum = stacked data of all sets and beams

Red = continuum model affected by transmittance

Bottom white square = residuals spectrum (data – model, i.e. white – red)

ICOMET

DOCUMENTATION FILE

This document serves to provide the user with information regarding each input in each line of the 'results.pln' file used to run ICOMET.

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For information regarding the graphical outputs of the ICOMET program, see the ISTAR appendix.

0 – DATA Section

This section reads the output from IBATCH and reorganizes the data. In this section, you designate the input and output directories for the files, and determine how you would like to process the data. You can view and process each set individually to check for errors, and then stack all the sets to achieve higher signal-to-noise.

```

results.ses.
; -----
* DATA.
; -----
; The program is case-sensitive.
; Do you want to run this section interactively?
; The present values will be the defaults. 's' as input.
; will skip this section, this is valid for all the sections.
0 n.
; Enter the directory where the input files are located.
1 ./
; Enter the resulting directory.
2 ./
; Enter the sets you want to analyze. First has index 0..
; 'stack' will stack all the available sets, and 'all' will.
; process all available sets.
3 all.

```

0 – Interactive Keyword

'y': will make it interactive

'n': will run without user interaction

's': will skip the whole section and go to the next (plugin-object)

1, 2 – Directory Keywords

Line 1 designates where the input files are located. Line 2 designates where the results from processing will be saved.

3 – Sets/Stack Keyword

This entry designates which sets you want to analyze. The numbering of sets begins at '0' (thus, the first set is actually set '0'). You can analyze each set individually by entering the number of the set you want to analyze.

'2': will process set 2

'2 3 5 7': will process only sets 2, 3, 5, and 7

'all': will process all sets individually

You can also stack sets.

'stack': will stack all available sets for processing

'stack 2 3 5 7': will stack only sets 2, 3, 5, and 7 for processing

'stack 2-7': will stack sets 2 through 7 for processing

1 – RESIDUALS ANALYSIS Section

In this section, you define the sections of the images to analyze, and define atmospheric parameters in order to correctly model the terrestrial atmosphere. Thus, you can separate the terrestrial atmosphere and that of the star. There are three subsections in this section.

Subsection One:

```

; -----
* RESIDUAL ANALYSIS.
; -----
; Do you want to run this section interactively?.
0 n.
; Graphically show the results?.
1 y 10.
; Enter the column range to analyze. 'all' will analyze all cols.
2 all.
; Enter the rows relative to the center to analyze.
3 -2 2.
; Enter the slit size [pixels], and plate scales.
4 5 0.200 0.200.
;
; Enter the col-ranges which contain continuum.
; information. If 'ask' is entered, the program.
; will ask for the values interactively.
5 0 319 329 last.
;
; Input the degree of the polynomial fit for the continuum.
6 4.

```

In this section, you define which parts of the image you want to analyze.

0 – Interactive Keyword

- 'y': will make it interactive
- 'n': will run without user interaction
- 's': will skip the whole section and go to the next (end of program)

1 – Graphically Show Results Keyword

C D
 Example: y 10

C-entry (y)

- 'y': will graphically show results
- 'n': will not show results

D-entry (10)

This entry designates the multiplier of the residuals.

2 – Analysis Column Range Keyword

This line determines the range of columns to be analyzed by the program. For example, if you have bad pixels in the border columns of the data, you may want to remove these columns from analysis.

‘all’: all columns will be included in analysis

‘10 250’: only columns 10 through 250 will be included in the analysis.

This is similar to Line 3 in the RESIDUALS ANALYSIS section of the IPLANET document (IplanetDoc.docx).

3 – Analysis Row Range Keyword

E F

Example: -2 2

This line determines which rows to be analyzed by the program. The program centers the beam at row 128. In this line, you designate how many rows relative to the center row (0) you would like analyzed. For example, ‘-2 2’ means that you would like to analyze two rows below the center to two rows above the center (rows 126 to 130).

4 – Slit Size and Plate Scales Keywords

G H I

Example: 5 0.198 0.144

G-entry (5)

This entry refers to the slit-width in pixels. This number is calculated by dividing the slit-width in arcseconds by the plate x-scale (in arcseconds/pixel). For example, if your slit-width is 0.720”, and your plate x-scale is 0.144 “/pixel, then the slit-width in pixels is $0.720'' / 0.144''/\text{pixel} = 5$ pixels.

H-entry (0.198)

This entry refers to the plate scale (in arcseconds/pixel) in the y-direction (spatial), also known as the y-pixel pitch.

I-entry (0.144)

This entry refers to the plate scale (in arcseconds/pixel) in the x-direction (spectral), also known as the x-pixel pitch.

5 – Column Ranges Continuum Keywords

In this line, you designate which columns contain continuum for use in determining the baseline. For example, the entry ‘0 319 329 last’ will include

only columns 0 through 319 and 329 through the last column when determining the baseline (columns 320 through 328 will be skipped).

If the keyword 'ask' is designated, the program will ask for the values interactively.

6 - Degree of Polynomial Keyword

In this line, you designate the degree of the polynomial used to fit the continuum.

Subsection Two: Atmospheric Parameters, and Frequency Adjust

```

; Atmospheric parameters.
; 1) Do you want to calculate the transmittance and radiance(run), read .
;    a previous run (read), or retrieve the values (retrieve)?.
; 2) Air mass and telescope altitude [m].
; 3) Abundances relative to a tropical atm: H2O,CO2,O3,N2O,CO,CH4  O2,NH3,C2H6,HCl.
; 4) Temperature and pressure factors, Tlfactor, T2factor, Pfactor.
; 5) Resolving power a value or a file.
; 6) Filestem of transmittance (.trf).
7 read noline multiple (atms.txt).
8 1.0000 2635.0000.
9 0.2000 1.0000 1.0000 1.0000 1.0000 1.0000 1.0000 1.0000 1.0000 1.0000.
10 1.0000 1.0000 1.0000 1.0000 1.0000 1.0000 1.0000 1.0000 1.0000.
11 95000.
12 ../atm/lblrtm.
.
; Do you want to adjust the frequency?.
13 n.

```

In this section, you designate the atmospheric parameters, adjust the frequency solution if desired, and identify properties of the star and the integration time of the images.

7 - 12 - Atmospheric Parameters

Lines 7 through 13 are similar to Subsection Four: Atmospheric Parameters in the RESIDUALS ANALYSIS section of IPLANET, as well as Subsection Three: Atmospheric Parameters in the SPECTRAL section of IBATCH, but there are some differences.

7 - Read/Run/Retrieve Keyword

This line designates whether or not you calculate the transmittance and radiance (run), read a previous run (read), or retrieve the values through comparison of the data and model (retrieve).

'run': the program will calculate the transmittance and radiance

'read': the program will read the results from a previous run*

'retrieve': the program will retrieve results the values through comparison**

*When 'read' is selected, the program reads previous results from the file atm/lblrtn

**When 'retrieve' is selected, the program compares the data and model and aims to minimize error between the two to get the best match. It will use the values in Line 16 (Fit Parameters Keyword), below, to determine which parameters to fit and in which order it should be done.

Optional Keywords:

'**nolines**': this keyword will disable the generation of the lineatlas. This can be done when the lineatlas has been already calculated for this spectral interval.

'**multiple**': this keyword creates a separate atmosphere for each set of data (this is useful when the airmass changes greatly throughout the night). The resulting model files for this atmosphere will be stored in the "stem" directory with the addition of "-X" where X is the set number.

'**(atms.txt)**': when this keyword is input, the program goes to each set of data and modifies the atmospheric abundances. When in "read" mode, the values are read from the file, while in "retrieve" mode, the values are read from the file and then used as a-priori for fitting the atmosphere. The results are saved into the file.

This line is the same as Line 10 (Read/Run/Retrieve Keyword) in the RESIDUALS ANALYSIS section of the IPLANET document (IplanetDoc.docx).

8 - Airmass and Telescope Altitude Keywords

J K

Example: 1.3000 4200.0000

J-entry (1.3000)

This entry designates the airmass.

By default, the program will read the file "airmasses.txt" to determine the airmass of the current set.

K-entry (4200.0000)

This entry corresponds to the altitude of the telescope, in meters.

This line is the same as Line 11 (Airmass and Telescope Altitude Keywords) in the RESIDUALS ANALYSIS section of the IPLANET document (IplanetDoc.docx).

9 - Relative Abundances Keywords

L M N O P Q R S T U V

Example:

0.2000 1.0000 1.0000 1.0000 1.0000 1.0000 1.0000 1.0000 1.000 1.000 1.000

L-, M-, N-, O-, P- and Q-entries (0.2000 1.0000 1.0000 1.0000 1.0000 1.0000)

These entries correspond to the relative abundances of six gases relative to a tropical atmosphere. The six gases are: H₂O, CO₂, O₃, N₂O, CO and CH₄ (which correspond to L through Q, respectively).

R-, S-, T-, U-, and V-entries (1.0000 1.0000 1.0000 1.0000 1.0000)

These correspond to the gases O₂, NH₃, C₂H₆, and HCl, respectively. The fifth entry is not currently implemented.

These entries are the same as entries H through R in Line 12 in the RESIDUALS ANALYSIS section of the IPLANET document (IplanetDoc.docx), as well as entries F through P in Line 14 in the Atmospheric Parameters subsection in the Spectral section of the IBATCH document (IbatchDoc.docx).

10 – Temperature and Pressure Factors Keywords

W X Y Z C D E F
 Example: 1.0000 1.0000 1.0000 1.0000 1.0000 1.000 1.000 1.000

W-, X-, and Y-entries (1.0000 1.0000 1.0000)

These entries correspond to temperature factors for T(lower atmosphere), T(stratosphere), and surface pressure scaler, respectively. All these numbers are relative to the “standard tropical profile”.

Z-, C-, D-, E-, and F-entries (1.0000 1.0000 1.0000 1.0000 1.0000)

These entries are not implemented yet.

These entries are the same as entries S through Z in Line 13 (Temperature and Pressure Factors Keyword) in the RESIDUALS ANALYSIS section of the IPLANET document (IplanetDoc.docx), as well as entries Q through X in Line 15 in the Atmospheric Parameters subsection in the Spectral section of the IBATCH document (IbatchDoc.docx).

11 – Resolving Power Keyword

This entry corresponds to the instrument resolving power.

Examples using the narrow slits:
 CSHELL: 40000
 NIRSPEC: 35000
 CRIRES: 90000

12 – Filestem Keyword

This entry defines the filestem for the transmittance (.trn) and radiance (.rad) files.

This entry is the same as Line 15 (Filestem Keyword) in the RESIDUALS ANALYSIS section of the IPLANET document (IplanetDoc.docx), as well as the Z-entry of Line 17 in the Atmospheric Parameters subsection in the Spectral section of the IBATCH document (IbatchDoc.docx).

13 – Frequency Solution Keyword

In this line, you designate whether you would like to adjust the frequency solution or not. If you choose to adjust the frequency, the program will use the parameters designated in Lines 17 and 18 below.

'y': adjust frequency solution

'n': do not adjust frequency solution

'y save': the program will adjust the frequency and save the results into the 'iplanet' session, the freqdXX.dat file and freqdsolutions.dat file. No need to re-run ibatch again with the new frequency solution.

'y save ahead': the program will adjust the frequency and save the results for this set and the upcoming sets. For instance, when running set #2, it will fit the frequency to set 2 and save it for sets 2, 3, 4...N.

The 'y save ahead' keyword is useful because it provides the program with a starting point to find the frequency solution. Since the solutions won't vary greatly from one set to the next, this keyword lessens the number of possible iterations the program has to compute in order to find the next solution.

This line is the same as Line 9 (Frequency Solution Keyword) in the RESIDUALS ANALYSIS section of the IPLANET document (IplanetDoc.docx).

Subsection Three: Fit Parameters

```

; Parameters of the atmospheric fit.
; 0 - Resolving power.
; 1 - T1-factor.
; 2 - T2-factor.
; 3 - Psurf-factor.
; 4 - H2O-factor.
; 5 - CO2-factor.
; 6 - O3-factor.
; 7 - N2O-factor.
; 8 - CO-factor.
; 9 - CH4-factor.
;10 - XX-factor.
;11 - XX-factor.
;12 - XX-factor.
;13 - XX-factor.
;14 - XX-factor.
;15 - O2-factor.
;16 - NH3-factor.
;17 - C2H6-factor.
;18 - HCl-factor.
;19 - XX-factor.
;20 - Solar factor.
; Then define the frequency fit parameters: steps(3) scale center_fraction fita showplot.
; Then define the frequency fit limits: limits(3).
:0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20.
14 3 2 0 2 1 0 1 0 0 1 0 0 0 0 0 0 0 0 1 0 0 0.
15 100 50 50 1 0.3 1 1 1 -2.
16 3e-3 3e-5 3e-7.
17 1 1 1 1 1 0 0 1 1 1 0 0 0 0 0.

```

14 - Fit Parameters Keywords

This entry defines the parameters to include for the atmospheric fit, and in which order to consider the parameters for analysis.

- '0': do not consider this parameter
- '1': consider this parameter first
- '2': consider this parameter second
- '3': consider this parameter third

Typically, you run the program by first assuming values for temperature and pressure in order to obtain abundances for the specified components (marked with a '1'). Next, you use the abundances just obtained to determine more accurate values for temperature and pressure (marked with a '2'). Lastly, you use the abundances and value for temperature and pressure to modify the values of the instrument (marked with a '3'). Thus, you mark the desired atmospheric constituents with a '1' (entries 4 through 20), the pressure and temperature factors with a '2' (entries 1 through 3), and any telescope parameters with a '3' (entry 0).

This is the same as Line 18 (Fit Parameters Keyword) in the RESIDUALS ANALYSIS section of the IPLANET document (IplanetDoc.docx).

15, 16 - Frequency Fit Parameters

Line 15: H I J K L M N O S

Line 16: P Q R

Example:

100 50 50 1 0.3 1 1 1 -2
 3e-3 3e-5 3e-7

Line 15

Dispersion solution is: LEFT: $CWN + DL1x + DL2x^2$ RIGHT: $CWN + DR1x + DR2x^2$, where 'x' is the horizontal pixel distance from the center of the frame. For the center pixel 'x=0'.

H-entry (100)

This is the number of steps used to search for the center wavenumber (CWN)

I-entry (50)

This is the number of steps used to search for the first dispersion coefficient (DL1, DR1)

J-entry (50)

This is the number of steps used to search for the second dispersion coefficient (DL2, DR2)

Examples for H I J:

100 50 50 will use 100 steps to search CWN and 50 to fit the dispersion coeffs.
 100 50 0 will disable the search for second order dispersion coefficients.

K-entry (1)

This is the divider of steps for sequential fits. For the first row, the solution is fitted using H, I and J steps, while the sub-sequent rows are done using H/K, I/K and J/K steps.

L-entry (0.3)

This is the fractional size of the search space for CWN. L=1.0 would mean all the spectral points, 0.5 would mean the center half, or 0.1 the middle 10% of the array.

M-, N-, and O-entries (1 1 1)

These entries are flags that define the fitting scheme, where M is the flag for fitting CWN, N for fitting the left part of the array, and O for fitting the right part. A zero value will deactivate that section of the fit. Default is "1 1 1"

Examples for M N O:

1 1 1 will fit everything
 1 0 0 will only fit the center wavenumber (CWN)
 1 0 1 will fit CWN and the right part of the array
 1 2 2 will force LEFT = RIGHT (DL1=DR1), and DL2=0, DR2=0.

S-entry (-2)

This entry defines the repetition and plot sequence. A negative value will repeat the fit using as a-priori the previous fit for S times. A value of 1 will show the search for CWN, a value of 2 will show the search for the LEFT dispersion, a value of 3 will show the search for the RIGHT dispersion, a value for 4 will fit and then ask for user input, a value of 6 will not fit but ask for user input.

Line 16

P-, Q-, and R-entries (3e-3 3e-5 3e-7)

These entries establish the search space for the variables around the a-priori solution. As a-priori, the program uses:

CWN: (Keyword7(G) + Keyword7(F)) / 2
 DL1=DR1: (Keyword7(G) - Keyword7(F)) / x-pixels
 DL2=DR2=0

The spectral precision of the fit is then P/H for the CWN, and Q/I and R/J for the dispersion coefficients. A big P, Q or R number will expand the search, but produce low precision results or lead to artificial solutions. Too small P, Q, or R values will restrict the search, and may not allow the program to achieve the optimum solution.

Typical values for:

CSHELL (IPLANET/ICOMET/ISTAR):

100 50 50 1 1.0 1 1 1
 5e-3 5e-4 5e-6

NIRSPEC:

400 100 100 5 0.3
 4e-2 2e-4 2e-6

CRIRES (IPLANET/ICOMET/ISTAR):

100 50 50 1 0.3 1 1 1 -2
 3e-3 3e-5 3e-7

Lines 17 and 18 are the same as Lines 19 and 20 (Frequency Fit Parameters) in the RESIDUALS ANALYSIS section of the IPLANET document (IplanetDoc.docx) and Lines 10 and 11 in the Straightening subsection in the Spectral section of the IBATCH document (IbatchDoc.docx).

17 - Baseline Removal Input Parameters Keywords

In this line, you can enable or disable selected components of the baseline removal. To enable the removal of a component, put a '1'. To disable the removal of a component, put a '0.'

0 1 2 3 4 5 6	7 8 9 A	B C D E
Example: 1 1 1 1 1 0 0	1 1 1 0	0 0 0 0

0 – 6 entries

These entries correspond to the polynomial background baseline.

7 – 9 entries

These entries correspond to the polynomial gain.

A-entry

This entry corresponds to the residual sky removal.

B-entry

This entry corresponds to the scatter-light removal.

C-entry

This entry corresponds to the correction for the Fraunhofer lines.

D-entry

This entry corresponds to the removal of spectra fringing. The number entered here corresponds to the number of fringes to remove.

E-entry

This entry corresponds to the variable resolving power.

This is the same as Line 7 (Baseline Removal Input Parameters Keyword) in the RESIDUALS ANALYSIS section of the IPLANET document (IplanetDoc.docx).

2 – EMISSION SPATIAL PROFILE Section

```

; -----
* EMISSION SPATIAL PROFILE.
; -----
; Do you want to run this section interactively? .
0 s.
; Graphically show the results?.
1 y.
; Enter the col-ranges which contain emission lines.
2 42 54 208 220 261 277 282 297 417 434 550 561 786 800.
; Enter offset between the gas and continuum profiles [pixels].
3 0.
; Enter the terminal pixels and pixels aside (in units of slit-size).
4 1 5 1.
; Enter offset of profile in counts.
5 0.
; Enter object observing parameters.
; 1) Relative velocity of the comet [km/s].
; 2) Geocentric distance [AU].
; 3) Heliocentric distance [AU].
6 24.76 0.508 1.0271 ; 27/Jan/2008 1:50 UT.
; Enter the molecular lifetime.
7 7.7d4.

```

0 – Interactive Keyword

- 'y': will make it interactive
- 'n': will run without user interaction
- 's': will skip the whole section and go to the next (end of program)

1 – Graphically Show Results Keyword

C
 Example: y

C-entry (y)

- 'y': will graphically show results
- 'n': will not show results

2 – Column Ranges Keyword

In this line, you designate the column ranges that contain emission lines.

3 – Offset Keyword

This entry designates the offset, in pixels, between the gas and continuum profiles.

4 – Terminal and Aside Pixels Keywords

E F G

Example: 1 5 1

E- and F-entries (1 5)

These entries designate the terminal pixels, in units of slit-size.

G-entry (1)

This entry designates the aside pixel, in units of slit-size.

5 – Profile Offset Keyword

This entry designates the offset of the profile, in counts.

6 – Observing Parameters Keywords

H I J

Example: 24.76 0.508 1.0271

H-entry (24.76)

This entry designates the relative velocity of the comet, in kilometers/second.

I-entry (0.508)

This entry designates the geocentric distance of the comet, in AU.

J-entry (1.0271)

This entry designates the heliocentric distance of the comet, in AU.

AUTOMATOR

DOCUMENTATION FILE

This document serves to provide the user with information regarding each input in each line of the 'x.bch' file used to run AUTOMATOR.

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0 – IBATCH Automator Section

```

; -----
; * IBATCH.
; -----
; Do you want to run this section interactively?.
0 n.
; Operations to perform (spatial, spectral, store, all).
1 store.
; Define the directory of the 'object' and 'standard'.
2 p2.
3 p2.

```

0 – Interactive Keyword

- 'y': will make it interactive
- 'n': will run without user interaction
- 's': will skip the whole section and go to the next (PLUGIN-OBJECT)

1 – Operations Keyword

Here you designate which operations you would like performed. Options include: spatial, spectral, store, store object, store standard, all, clean all.

- '**spatial**': finds only the spatial solution
- '**spectral**': finds only the spectral solution
- '**store**': stores the results (beams, images, solutions, masks, etc.) of both the object and the star
- '**store object**': stores only the results for the object, not the star
- '**store standard**': stores only the results for the star
- '**all**': finds the spatial and spectral solutions and stores the data

The optional keyword '**clean**' deletes any previous files created and starts a new at the section designated. For example, '**all clean**' deletes any and all files created previously, and runs through all of the sections (spatial, spectral, store, etc.).

By default, the program only runs the sections and solutions still needing to be processed. To override this behavior, the additional keyword '**new**' will re-run every section even if it has been previously successfully accomplished.

2, 3 – Directory Keywords

Line 2 designates the directory of the object. In this directory there should be a “raw” folder containing the raw images of the object. Additionally, there should be a “flats” folder and a “darks” folder, if applicable.

Line 3 designates the directory of the standard (in most instances, a star). If there is no standard, enter the directory for the object.

The standard is used to determine the spatial solution for the data, which is then applied to the object. The object is used to find the spectral solution, which is then applied to the standard. Next, the solutions are applied to both the object and the standard.

```

; Define the extensions, crop parameters (5 params), and frequency ranges.
4 0      85 85 150    0 250    3000.4640 2993.5435.
; Define the number of ab pairs per set, and sets to combine.
; One line for 'object' and one for the 'standard'.
5 1 8.
6 1 8.
; Define the cleaning parameters for 'object' (two beams?, a/b and da,db) and 'standard'.
7 y 5.0 7    5.0 7    show.
8 y 5.0 7    5.0 7    .

```

4 – Crop Parameters and Frequency Range Keywords

C	D E F	G H	I J
Example:			
0	85 85 150	0 250	3000.4640 2993.5435

C-entry (0)

The C-entry designates the FITS extension of the data. For NIRSPEC and CSHELL, the value is 0; for CRIRES, the values are 1, 2, 3, or 4, respectively, for each detector.

D-, E-, and F-entries (85 85 150) (Vertical Crop Parameters)

The D-entry designates at which pixel you separate the two halves (vertically) of the frame into a top, “A”, and bottom, “B”, from the left side of the frame. You count upwards from zero, beginning at the bottom.

The E-entry designates at which pixel you separate the two halves of the frame (vertically) into a top, “A”, and bottom, “B”, from the right side of the frame. You count upwards from zero, beginning at the bottom.

The F-entry designates the vertical height of the section to be cropped. The range of this value will be split between the two halves as designated above. For example, if D-entry = E-entry = 85, and F-entry = 150, then the section to be cropped will range from (85-75) to (85+75) in height.

The optional keyword **'ask'** will graphically plot the total flux from the standard (left screen, title = 'Flux standard') and the total flux from the object (right screen, title = 'Object (click here)'). This can be used to assure that the beams from the standard and the beams from the object are lined up so as to ensure proper cropping. The keyword is inserted into a line above Line 4. For example:

```
; Define the extensions, crop parameters (5 params), and frequency ranges.  
ask.  
0      85 85 150      0 250      3000.4640 2993.5435.
```

Additionally, the **'ask'** keyword will ask for user input by clicking on the object frame. Here you will be asked to manually crop the frame by clicking first on the **upper-left** corner of the portion to crop, then the **lower-left**, then the **lower-right**, then the **upper-right** corner. A value of **'ask 2'** will perform the ask operation for detector 2 (only necessary for multiple extension files, e.g. CRIRES).

These three entries are the same as the P-, Q-, and R-entries in Line 1 of the CROP Section from the IBATCH documentation file ('IbatchDoc.docx').

G- and H-entries (0 250) (Horizontal Crop Parameters)

G-entry (0)

This number designates the position to crop from the left, horizontally. The zero position is on the left and values increase to the right.

H-entry (250)

This number designates the position to crop from the right, horizontally. The zero position is on the left and values increase to the right, ending at value 255.

I- and J-entries (3000.4640 2993.5435) (Frequency Range)

For the I- and J-entries, you provide the frequency range (in cm^{-1}) over which the data was taken (this will correspond to the x-axis of the frame). The I-entry is the left edge of the range (corresponding to the G-entry (0) above). The J-entry is the right edge of the range (corresponding to the H-entry (250) above).

5.6 – AB Pairs and Combine Keywords

Line 5: K L

Line 6: M N

Example:

1 8

1 8

K- and L-entries (1 8)

Line 5 designates the inputs for the object.

The K-entry designates how to stack the data. If you select '**all**', then all of the raw files are stacked into a single ABBA set. If you select '**1**', each set will correspond to a AB pair, meaning $A1=A2=A$ and $B1=B2=B$. In this case, the cleaning procedure will not clean $dA = A1 - A2$, or $dB = B1 - B2$, but $dF = A - B$ instead. If you select '**2**', then each set is one ABBA. This entry is the same as Line 7 in the READ section in the IBATCH documentation file (IbatchDoc.docx).

The L-entry designates how many sets to combine. The program can combine sets to reduce the number of sets stored. For example, having 24 sets, and setting the keyword '**combine 6**' will produce 4 independent sets. By default, each is spectrally aligned and spatially registered before combining. Additionally, the optional keyword '**noshift**' will disable the spatial registration during the combining and storing processes. This entry is associated with the optional keywords '**combine**' and '**noshift**' in Line 3 of the SPECTRAL section in the IBATCH documentation file (IbatchDoc.docx). The additional keyword '**jitter**' will store the files registering based on the reported jitter values in the header (only functional with CRIRES datasets).

M- and N-entries (1 8)

These entries are the same as the K- and L-entries above, respectively, but Line 6 designates inputs for the standard, not the object.

7. 8 - Cleaning Parameters Keywords

Line 7:	O	P	Q	R	S	
Line 8:	T		U	V	W	X
Example:						
y	5.0	7		5.0	7	show
y	5.0	7		5.0	7	

As with Lines 5 and 6 above, Line 7 corresponds to the object, and Line 8 corresponds to the standard.

O- and T-entries (y) (Both Beams Keyword)

These entries designate whether or not both beams are in the frame.

- 'y': the B-frames have beam data. The telescope was nodded "on" slit.
- 'n': only the A-beam have object data. The telescope was nodded "off" slit.
- 'y-flip': this flips the A-frames and the B-frames (A1 becomes B1 and vice-versa)

When you graphically show the cleaning (optional keyword '**show**', see below), if both beams are in the frame, they should be evenly spaced in each

half of the frame. For example, the majority of each beam (A or B) should be within each half (top or bottom); if any of the beam is cut off in one frame, the same amount should be cut off in the other half. If the halves aren't evenly spaced, adjust the cropping parameters (entries D-H in Line 4 above).

These entries are the same as the entry in Line 2 of the CLEAN section in the IBATCH documentation file (IbatchDoc.docx).

P- and U-entries, and R- and W-entries (5.0) (Threshold Keyword)

These entries refer to the threshold, or the sigma-level above which a pixel will be considered "bad".

The P- and U-entries refer to the threshold for the A and B frames, while the R- and W-entries refer to the threshold for the dA and dB frames.

These entries are the same as the first column of entries in Lines 4-9 in the CLEAN section of the IBATCH documentation file (IbatchDoc.docx).

Q- and V-entries and S- and X-entries (7) (Threshold Keyword)

This number refers to the polynomial order used to fit the data.

These entries are the same as the second column of entries in Lines 4-9 in the CLEAN section of the IBATCH documentation file (IbatchDoc.docx).

The optional keyword '**show**' will graphically show the cleaning of each frame and the corresponding mask that is created. This is the same as if you had run the cleaning interactively in IBATCH.

The optional keyword '**profile**' will perform a spatial profile cleaning scheme. This mode is still in developing phase.

If you are getting too many bad pixels (e.g. greater than 200 for CSHELL, or more than 2%), then either your threshold or polynomial order may be incorrect, or your crop may be incorrect; adjust these parameters in the previous lines.

Straightening Parameters (Lines 9 - 14)

```

; Define the straightening parameters.
; 1) Order of the fit, and first rows to skip.
; 2) Rows to process, you can specify single rows (i.e. 61 62 63 ..), ranges (60-140), or 'all'.
; 3) Do you want to use model data (model) or a data-row as reference (data #)?
; 4) Do you want to fit radiance or absorption spectra?
; 5) Brutefit parameters.
9 3.
10 all.
11 model.
12 radiance.
13 400 100 0 5 1.0 1 2 2.
14 0.1 0.001 0.0.

```

9 – Order of Fit and Rows to Skip Keywords

M

Example: 3

This entry corresponds to the order of the dispersion fit applied to the center wavenumber (CWN). The other four dispersion quantities (DL1, DL2, DR1, DR2) are fitted to a polynomial of order M-1. For example, M=3 will fit CWN with order 3 and DL1, DL2, DR1, DR2 with order 2.

An optional extra keyword is the number of rows to skip in the dispersion fit. Normally, the first dispersion fits (of the first rows) are not the most optimum ones, because there are based on limited information. To avoid these initial fits, M-entry could be '**3 X**', where X is the number of rows (or fits) to skip.

This entry is the same as Line 4 in the SPECTRAL section of the IBATCH documentation file (IbatchDoc.docx).

10 – Row Process Keyword

This number corresponds to the number of rows you want to process. If you select '**all**', all "clean" rows will be processed. You can also enter certain rows (60 61 62) or intervals (60-140).

The entry '**all cont**' will select all rows with object flux (i.e. rows with at least 50% flux of the maximum of the spatial profile).

This entry is the same as Line 6 in the SPECTRAL section of the IBATCH documentation file (IbatchDoc.docx).

11 – Reference Keyword

This entry defines whether you want to use a model (keyword = '**model**'), a solar spectrum (keyword = '**solar**') or a data-row (keyword = '**data #**'; where # is the row number) as a reference for straightening the frame.

If the additional keyword '**retrieve**' is added (e.g. '**model retrieve**'), the program will retrieve the atmospheric water abundance by comparing to the data.

This entry is the same as Line 8 in the SPECTRAL section of the IBATCH documentation file (IbatchDoc.docx).

12 - Spectra Keyword

This entry defines whether you want to use a radiance or absorption spectrum.

This entry is the same as Line 9 in the SPECTRAL section of the IBATCH documentation file (IbatchDoc.docx).

13-14 - Fit Parameters Keywords

Line 13: H I J K L M N O S

Line 14: P Q R

Example:

400 100 0 5 1.0 1 2 2

0.1 0.001 0.0

Line 13

Dispersion solution is: LEFT: $CWN + DL1x + DL2x^2$ RIGHT: $CWN + DR1x + DR2x^2$, where 'x' is the horizontal pixel distance from the center of the frame. For the center pixel "x=0".

H-entry (400)

This is the number of steps used to search for the center wavenumber (CWN).

I-entry (100)

This is the number of steps used to search for the first dispersion coefficient (DL1, DR1).

J-entry (0)

This is the number of steps used to search for the second dispersion coefficient (DL2, DR2).

Examples for H I J:

'**100 50 50**': will use 100 steps to search CWN and 50 to fit the dispersion coefficients.

'**100 50 0**': will disable the search for second order dispersion coefficients.

K-entry (5)

This is the divider of steps for sequential fits. For the first row, the solution is fitted using H, I, and J steps, while the sub-sequent rows are done using H/K, I/K and J/K steps.

L-entry (1.0)

This is the fractional size of the search space for CWN. L=1.0 would mean all the spectral points, 0.5 would mean the center half, or 0.1 the middle 10% of the array.

M-, N-, and O-entries (1 2 2)

These entries are flags that define the fitting scheme, where M is the flag for fitting CWN, N for fitting the left part of the array, and O for fitting the right part. A '0' value will deactivate that section of the fit. Default is '1 1 1'.

Examples for M N O:

'1 1 1': will fit everything

'1 0 0': will only fit the center wavenumber (CWN)

'1 0 1': will fit CWN and the right part of the array

'1 2 2': will force LEFT = RIGHT (DL1=DR1), and DL2=0, DR2=0.

'1 3 1': will fit the only using the 1st coeff for the left solution

S-entry

This entry defines the repetition and plot sequence. A negative value will repeat the fit using as a-priori the previous fit for 'S' times. A value of '1' will show the search for CWN, a value of '2' will show the search for the LEFT dispersion, a value of '3' will show the search for the RIGHT dispersion, a value for '4' will fit and then ask for user input, and a value of '6' will not fit but ask for user input (there is no option for a value of '5').

Line 14

P-, Q-, and R-entries

These entries establish the search space for the variables around the a-priori solution.

The spectral precision of the fit is then P/H for the CWN, and Q/I and R/J for the dispersion coefficients. A big P, Q or R number will expand the search, but produce low precision results or lead to artificial solutions. Too small P, Q, or R values will restrict the search, and may not allow the program to achieve the optimum solution.

Typical Values

CSHELL (IBATCH):

```
400 100 0 5 1.0 1 2 2
0.1 0.001 0.0
```

CSHELL (IPLANET/ICOMET/ISTAR):

100 50 50 1 1.0 1 1 1
5e-3 5e-4 5e-6

NIRSPEC:

400 100 100 5 0.3
4e-2 2e-4 2e-6

CRIRES (IBATCH):

400 100 0 5 0.3
3e-2 3e-4 0.0

CRIRES (IPLANET/ICOMET/ISTAR):

100 50 50 1 0.3 1 1 1 -2
3e-3 3e-5 3e-7

Lines 13 and 14 are the same as Lines 10 and 11 in the SPECTRAL section of the IBATCH documentation file (IbatchDoc.docx).

Atmospheric Parameters (Lines 15 - 18)

```

; Atmospheric parameters for the object data.
; 1) Telescope altitude [m].
; 2) Abundances relative to a tropical atm: h2o,co2,o3,n2o,co,ch4.
; 3) Temperature factors for t(0-16km),t(16-85km),t(85-up).
; 4) Resolving power.
15 1.2000 4200.0000.
16 0.2000 1.0000 1.0000 1.0000 1.0000 1.0000 1.0000 1.0000 1.0000 1.0000.
17 1.0000 1.0000 1.0000 1.0000 1.0000 1.0000 1.0000 1.0000 1.0000.
18 40000.
    
```

15 - Airmass and Telescope Altitude Keywords

T U

Example:

1.2000 4200.0000

Entry T (1.2000)

This is the airmass at the observation date and time.

Entry U (4200.0000)

This is the altitude of the telescope in meters.

These entries are the same as Line 13 in the SPECTRAL section of the IBATCH documentation file (IbatchDoc.docx).

16 - Abundance Keywords

V W X Y Z C D E F G H

Example:

0.2000 1.0000 1.0000 1.0000 1.0000 1.0000 1.0000 1.0000 1.0000 1.000 1.000

V-, W-, X-, Y-, Z- and C-entries (0.2000 1.0000 1.0000 1.0000 1.0000 1.0000)

These entries correspond to the relative abundances of six gases relative to a tropical atmosphere. The six gases are: H₂O, CO₂, O₃, N₂O, CO and CH₄ (which correspond to V through C, respectively).

D-, E-, F-, G- and H-entries (1.0000 1.0000 1.0000 1.0000 1.0000)

These correspond to the gases O₂, NH₃, C₂H₆, and HCl, respectively. The fifth entry is not currently implemented.

These entries are the same as Line 14 in the SPECTRAL section of the IBATCH documentation file (IbatchDoc.docx).

17 - Temperature Factors and Surface Pressure Scalar Keywords

I J K L M N O P

Example:

1.0000 1.0000 1.0000 1.0000 1.0000 1.0000 1.0000 1.0000

I- and J-entries (1.0000 1.0000)

These entries correspond to temperature factors for T(lower atmosphere) and T(stratosphere), respectively.

K-entry (1.0000)

This entry corresponds to the surface pressure scalar.

L-, M-, N-, O- and P-entries (1.0000 1.0000 1.0000 1.0000 1.0000)

These entries are not implemented yet.

All these numbers are relative to the “standard tropical profile”. These entries are the same as Line 15 in the SPECTRAL section of the IBATCH documentation file (IbatchDoc.docx).

18 - Resolving Power Keyword

This entry corresponds to the instrument resolving power.

1 – PLUGIN OBJECT Automator Section

```

; -----
* PLUGIN-OBJECT.
; -----
; Do you want to run this section interactively?
0 s.
;
; Name of plugin.
1 iplanet.

```

0 – Interactive Keyword

‘y’: will make it interactive

‘n’: will run without user interaction

‘s’: will skip the whole section and go to the next (PLUGIN-STANDARD)

1 – Plugin Name Keyword

This entry designates the name of the plugin to be used. ‘**icomet**’ is another acceptable plugin.

The plugin parameters are specified in the Appendix for Automator, Plugin Parameters section.

2 – PLUGIN STANDARD Automator Section

```

; -----
* PLUGIN-STANDARD.
; -----
; Do you want to run this section interactively?.
0 s.
; Name of plugin.
1 istar.
; Parameters to the plugin (section, entry, value).
; Section and entries start from 0.
; To run a iteration type 'run X Y ..' where X Y are the sections to run.
2 end.

```

0 – Interactive Keyword

‘y’: will make it interactive

‘n’: will run without user interaction

‘s’: will skip the whole section and go to the next (end of program)

1 – Plugin Name Keyword

This entry designates the name of the plugin to be used. ‘icomet’ is another acceptable plugin.

The functioning of this section is exactly the same as for the PLUGIN OBJECT section.

Plugin Parameters

These parameters correspond to the inputs for the object and standard plugins.

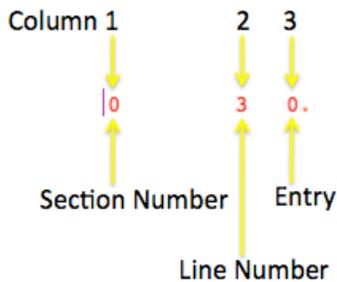
```

; Parameters to the plugin (section, entry, value).
; Section and entries start from 0.
; To run a iteration type 'run X Y ...' where X Y are the sections to run.
0      3  0.
1      2  0.500 30.0 0.6 0.40.
1      3  0.200 -3.0 0.0 0.15.
1      4  ../atm/lmdgcm single.
1      5  Mars-topo.
1      7  568 Mauna Kea.
2      1  y.
2      3  all.
2      4  center 5.
2      5  2993.735940 2994.446430 2995.455090          2992.566450 2993.223940 2993.876470 2994.524040 2995.166650 2995.804290
2      6  lines 5.
2      7  0 0 0 0 0 0 1 1 1 0 0 0 0 0.
2      8  model.
2      9  y save ahead.
2     10  retrieve multiple (atms.txt).
2     11  1.0000 4200.0000.
2     12  0.2000 1.0000 1.0000 1.0000 1.0000 1.0000 1.0000 1.0000 0.4000 1.0000 1.0000.
2     13  1.0000 1.0000 1.0000          1.0000 1.0000 1.0000 1.0000 1.0000.
2     14  40000.
2     15  ../atm/lblrtm.
2     16  0.8000.
2     17  solaratlas.dat.
2     18  0 0 0 0 1 0 0 0 0 1 0 0 0 0 0 0 0 0 0 0 0.
2     19  100 50 0 1 1.0 1 1 1 5.
2     20  2e-2 1e-4 2e-6.
run 0 1 2.
2      9  y save.
2     10  read multiple (atms.txt).
2     19  100 50 0 1 1.0 1 1 1 -4.
2     20  2e-3 1e-4 2e-6.
run 2.
run 2.
run 2.
2      6  lines 5 x5 r2993.835940 r2993.635940 r2995.555090 r2995.355090 x3 r2994.546430 r2994.346430 r2998.1 r2997.8 .
2      7  1 1 1 0 0 0 0 1 1 1 0 1 0 2 0.
2      9  y.
2     10  retrieve multiple (atms.txt).
2     18  0 2 0 0 1 0 1 0 0 1 0 0 0 0 0 0 0 1 0 0 1.
run 2.
2      9  y save.
2     10  read multiple (atms.txt).
2     19  100 50 50 1 0.3 1 1 1 -2.
2     20  2e-3 1e-4 1e-6.
run 2.
run 2.
run 2.
2     10  retrieve multiple (atms.txt).
2     18  1 1 1 1 1 1 0 1 0 0 1 0 0 0 0 0 0 0 1 0 0 1.
run 2.
2     10  read multiple (atms.txt).
run 2.
run 2.
2     10  retrieve multiple (atms.txt).
2     18  1 1 1 1 1 1 0 1 0 0 1 0 0 0 0 0 0 0 1 0 0 1.
run 2.
.

```

The number in the first column refers to the section number in the 'iplanet.pln' file. The number in the second column refers to the line number in the designated section. The third column refers to the entries in the designated line. Note: Sections and line numbers begin with '0' and increase by 1.

For example,



In IPLANET, Section '0' is "DATA" while Line Number '3' is "Sets/Stack Keyword", with Entry '0' indicating that only set 0 should be read.

The program will modify the input file 'results.pln' using these commands in a sequential order, until it reaches the command '**run**' or '**end**'.

Run Line Keyword

The '**run**' keyword tells the program to execute the plugin using the sections designated by the numbers that follow (using the inputs preceding the '**run**' command). For example, '**run 1**' would proceed through only section 1 of the program. However, '**run 0 1 2**' would proceed through sections 0, 1 and 2 of the program.

End Line Keyword

The '**end**' will terminate the execution of the automation process.