GreG
Grenoble Graphic

A **GILDAS** working group software

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The GILDAS working group is a collaborative project of the Observatoire de Grenoble (1,3) and IRAM (2), and comprises: G. Buisson[1], L. Desbats[1], G. Duvert[1], T. Forveille[1], R. Gras[3], S. Guilloteau[1,2], R. Lucas[1,2], and P. Valiron[1].

(1) Laboratoire d'Astrophysique
Observatoire de Grenoble
BP 53 X
414 Rue de la Piscine
F-38402 Saint Martin d'Hères CEDEX

(2) Institut de Radio Astronomie Millimétrique
300 Rue de la Piscine
F-38406 Saint Martin d'Hères

(3) CEPHAG
Observatoire de Grenoble
F-38402 Saint Martin d'Hères CEDEX

Contributions from and invaluable discussions with J. Cernicharo, P. Begou[3], S. Delahaye[3], A. Dutrey[1,2], C. Kahane[1], P. Monger, J.L. Monin[1], R. Neri[2] and all GILDAS users are gratefully acknowledged.

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1 Introduction

1.1 Philosophy

GREG is a graphic utility package whose goal is to help people prepare plots of their data or of the results of theoretical computations. Major goals were device independence as much as possible AND efficient interactive use. It was kept in mind that drawings are usually prepared interactively and then the final result is sent to a good quality printer or saved for later use. Quick look on data is also often wanted. Hence, the design goals were both a simple, fast utility for simple things and a powerful, flexible system producing high quality plots. In addition, it was soon realised that a stand-alone utility was unadapted for complex, repetitive integrated plots as often required in theoretical modelling. Accordingly, the library version became part of the design goals.

With the advent of the X-Window system, GREG has been totally rewritten to take advantage of the multi-window and color facilities of X-Window. This new version also handles bitmap display of images, contour filling, etc..., with hardcopy facilities on PostScript devices.

1.2 Getting started

Beginners should of course read Section 2, the beginner's guide. While doing this, you need only retain the topics with which you are concerned at first view. If anything seems to be lacking, then read the other topics.

After a few trials (say a few days of normal usage or a few drawings), most users will efficiently benefit from reading carefully Section 3. With some more practice, they will soon reach normal proficiency in GREG standard usage and be able to tackle the most funny things.

Section 4, the "advanced" user's guide, is important for those who want to get the best of GREG with colours, images, etc... It is also important for the application programmer who may use these features to provide a top layer for integrated applications.

Section 5,6,7 contains descriptions of all GREG commands on a command by command basis. This is a copy of the internal help. Please keep in mind that because of GREG evolution it may not be completely up to date.

At this stage, model builders (as opposed to observers) will most likely want to go further by using the GREGLIB and thus reading Section 8. This may be done sooner, but it is not recommended to use the GREGLIB before the basic concepts of GREG have been mastered.

The documentation on the SIC monitor is now provided separately in the manual SIC documentation, and at least the first chapter of this manual should be read by the beginners. The monitor offers many flexible capabilities such as procedures, symbols, vector mathematics, and so on.

The other sections concern only programmers of special purpose tasks, or system builders, and their lecture will be almost necessarily complemented by reading the SIC manual also. Note however that if you have some specific graphic problem, it is most likely solved somewhere in the GREG package, so that the answer may well be under these sections.

Know what you want ? Then go ahead, and good luck.

2 GreG CookBook

This chapter is a very simplified introductory manual to GREG designed for occasional user who just want an introduction or better, a recipe. It just describes by means of a commented procedure, how to obtain a standard plot for the most usual cases. A user will often want to do more than described here. This is usually not only possible, but even easy. However, such user will have to understand fully the basic concepts of GREG and to read more or less completely the GREG `MANUAL`.

Before starting, remember that GREG keeps track of all effective commands in an internal buffer for replay capabilities used mostly for repetitive actions and in a log file for post-session control. This log file can be replayed by GREG as any other valid procedure of GREG commands, thus making of GREG a safe system protected against system (or internal...) crashes.

You must know also that GREG uses virtual memory to store all plot coordinates in a device independent way. Hence a plot is entirely independent of any graphic device. You can turn off your graphic device, provided you do not exit from GREG your plot is still available. This Virtual Plot storage also implies that your plot and the way you display it are really two different things. While it may seem confusing at the beginning, this make possible very nice features such as internal Zooming, corrections of erroneous part of the plot and a fast Hardcopy system.

2.1 Starting, Syntax and Help

GREG is started by typing `GREG` on your computer. You should normally get a few text lines, then the prompt `GreG>` by which GREG indicates it is at your service. If that does not work, ask your system manager, he should know.

The command syntax is describe in the SIC manual. Commands have positional arguments, and the argument list can be followed by options (names preceded by a slash /), each of which may also have a list of argument. Arguments and options are separated by spaces. If your are lost, do not hesitate to type `HELP`. GREG is largely self documented, and it is quite a good idea to use this facility rather than always refer to the manual.

2.2 Coordinates

There are several coordinate systems in GREG two of which are the usual basic coordinate systems of any graphic package :

- *the paper or Physical Coordinate System*, whose units are arbitrarily defined as "centimeters" (the size of such "centimeter" may vary from one graphic support to the other, but the dimension is always that of a distance)
- *the User Coordinate System*, whose units may be anything from "Butterflies per Megaparsec cube" to "Molecules per Kelvin degree and per km/s", or anything sensible like this.

Plotting data is only a way to match these two coordinate systems, and additional work such as labelling and annotation may be most conveniently referred to one or the other system. GREG handles the transformation of coordinates and allows access to each system individually.

2.3 Demonstration Procedure for GREG capabilities

All commands given here are followed by a comment area (after the exclamation mark `!`) in which a number refers to the detailed explanation after the text of the procedure. Comment lines are also in the body of the procedure for clarity.

```
!
! Basic plot : a simple curve
DEVICE XLANDSCAPE WHITE                          !1
SET PLOT LANDSCAPE                               !2
SET FONT SIMPLEX                                 !3
COLUMN X 1 Y 2 /FILE gag_demo:greg1.tst          !4
LIMITS                                           !5
BOX                                              !6
LABEL "Offset frequency (s\\U-1\\D)" /X          !7
LABEL "Signal strength (Jy)" /Y                  !8
CONNECT                                          !9
!
! More difficult: Markers and Errorbars
CLEAR PLOT                                       !10
LIMITS -50 50 * *                                !11
SET MARKER 4 1 .1                                !12
POINTS                                           !13
CURVE                                            !14
COLUMN Z 3                                       !15
ERRORBAR Y                                       !16
LABEL "Offset frequency (s\\U-1\\D)" /X          !17
LABEL "Signal strength (Jy)" /Y                  !18
SET CENTERING 5                                  !19
DRAW TEXT 0.0000E+00 10.70 "Demonstration of GREG : Curve and Errorb-
ars" /USER                                       !20
!
HARDCOPY /PRINT                                  !21
```

1. First, define the graphic support to which you want to send all graphic output. Here this is an X-Window terminal in landscape mode, with white background: a new window with the title <GREG will appear. Note that it is not necessary to define a graphic support to begin drawing data. You may define (or change) your graphic support at any moment during the session without losing your plot.

2. Specify the plot page has a "landscape" aspect (30 by 21 cm).

3. Specify the character font is the simplex one (the faster to plot).

4. Then read your data. The data file has a "Table"-like organisation one column describes all the values of a given variable for all the data points, while one line contains the values of all the variables for a given data point. You can access any part of the input table. The data is read in list-directed format, so that values must be written in formatted way, with spaces, tabs or commas as separators. Here, the X value is read in column 1 (the Y value in column 2) from lines 4 to 30 of the input file `gag_demo:greg1.tst`. `gag_demo:` is a *logical name* translated to a directory path by the software, so that `gag_demo:greg1.tst` will be expanded to something like `/users/soft/gag/demo/greg1.tst`.

5. Define the values of the X and Y coordinates at the corners of the plot window. Here, the automatic setting is used; it computes extrema of X and Y values, then add some 10

percent margin to get the plot limits. `LIMITS` is a very fundamental command, because it defines the conversion formula between the user coordinates and the physical coordinates. As GREG almost always plots in User coordinates, no plot action should be issued before command `LIMITS`.

6. Draw labelled axis around the plot window. This is useful in any plot, but contrary to `LIMITS`, this command is not compulsory. It can be issued at any moment (after `LIMITS` of course).

7. Write the caption of the X axis, in particular the type and units of the user coordinate.

8. Same as above for the Y axis. User coordinates can be anything as you can see...

9. Now connect the data points by straight lines to get a simple curve. If your data is not sorted, it will be quite a mess... Note that command `BOX, LABEL` and `CONNECT` could appear in any order, but after the command `LIMITS`. At this stage, your plot looks like the figure 1.

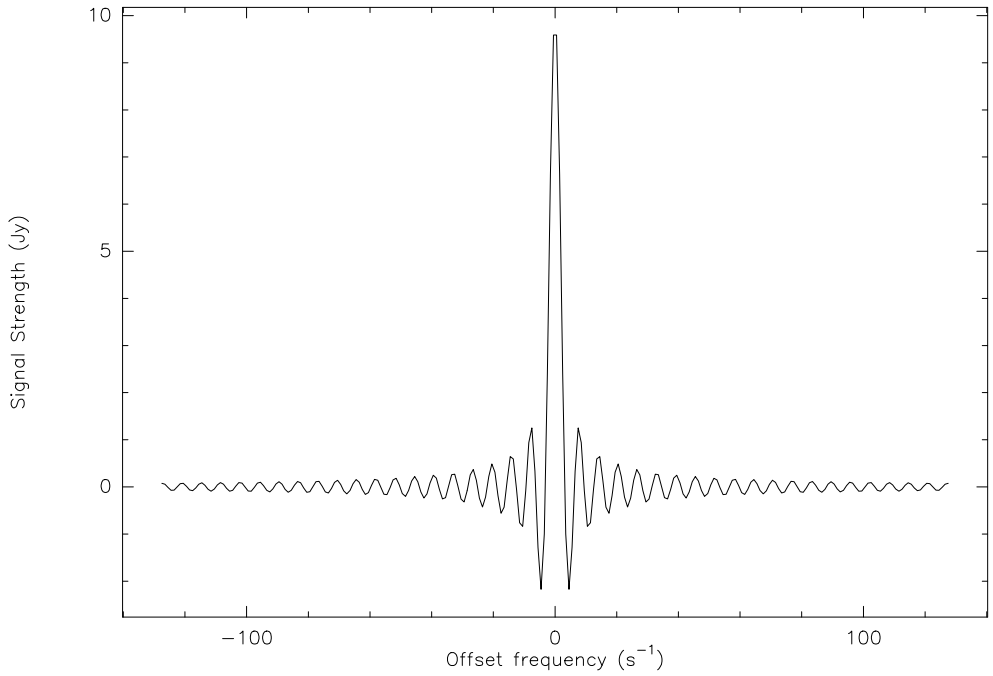


Figure 1: The X-Window graphic window just before clearing the plot in the demonstration procedure.

10. This command not only clears the graphic screen, but also destroys the current drawing. A new empty window is re-created afterwards.

11. Define the values of the X and Y coordinates at the corners of the plot window. Here, manual setting is used for X axis, and automatic setting for Y axis.

12. Define the type of marker you want. A marker is a regular polygon defined by its number of summits (0 to infinite), the type of polygon (0 to 4) and diameter in physical units (which on a paper output will be centimeters). Try the different values for the type to see what it means.

13. Now, plot a marker as defined above at each data point. Note that you do not need to read again your data, neither to define again the user coordinates, the last values have been retained.

14. and connect the data points by a smooth curve.

15. Read data into the Z buffer from column 3. You need not redefine the data file, neither the line range which are the same as in command number 2. The Z buffer is similar to the X and Y arrays into GREG but used in different ways.

16. Use the values in the Z buffer to draw symmetric error bars along the Y axis at each data point. The Z values will define the length of each side of the bar in Y user coordinates.

17. Same effect as above, but since the plot has been cleared...

18. idem...

19. idem...

20. Specify the text centering mode

21. write some legend to the figure

22. This plot seems good, make a hardcopy to save it. With the option /PRINT the command sends the hardcopy to the default system printer. This command has many other possibilities, such as creating PostScript files. Your plot should look like figure 2.

You have now mastered most of the 1 dimensional capabilities. At this point, you may want to add some title or any other comment on your plot. Then you will need to get a hardcopy of your drawing and to send it to a plotter.

2.4 Annotations or Using the Cursor

Most additional annotations can be done using the cursor, which is called by command `DRAW`. In command `DRAW`, the user can specify coordinates in three available systems :

- The USER coordinate system, as specified above, which can be defined as the default system by command `SET COORDINATE USER`
- The BOX coordinate system. In this system, coordinates are offsets in physical units from one of the 9 most remarkable points in the box (the corners, the center and the middle of sides) numbered according to a standard numeric keypad notation as on VT100 terminals. This system can be specified using command `SET COORDINATE BOX N`, where N can take values 1-9 to specify the corner. The default value N=0 may also be used, it behaves differently when the command `DRAW` is used with the cursor or explicitly. When using the cursor in `DRAW`, the nearest remarkable point will automatically be used as the reference point. If you use the explicit form of command `DRAW`, 0 behaves as 1.

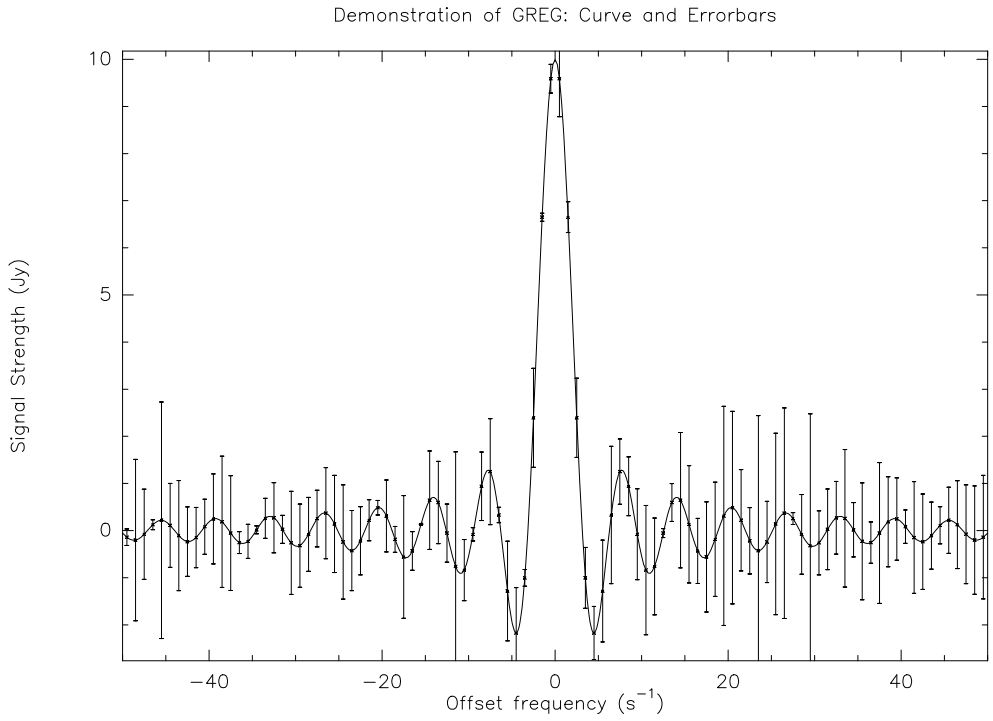


Figure 2: The printed output of the simple demonstration procedure.

- The `CHARACTER` coordinate system, which is essentially the same as the `BOX` system except that offsets are specified in units of character size. This system can be specified with the command `SET CHARACTER N`, where N has the same meaning and default value as in BOX. The character size is specified by the command `SET CHARACTER Size`.

By typing DRAW, the cursor appears on the screen. By hitting the appropriate key on your keyboard, you can obtain different actions :

- `R for RELOCATE` defines the current cursor position as the new pen position. Nothing visible happens because this is a pen up movement.
- `L for LINE` draws a line from the current pen position to the cursor position (pen down movement).
- `M for MARKER` draws a graphic marker of the current type and size centered at the cursor position.
- `A for ARROW` draws an arrow from the last pen position to the cursor position.
- `T for TEXT` prompts you for a string to be written at the cursor position (with the current centering option). Enter your text, then type `RETURN`, and the text will appear on the graphic screen.
- `C for ‘‘Centered TEXT’’` allows to override the current centering option. It prompts you for a string, then for the centering option you want to use.

- `E for EXIT` allows you to escape from this forever looping command.
- `D for DELETE` destroys the vectors drawn in the last operation. This is equivalent to `CLEAR SEGMENT`, except that only the segments created by the current `DRAW` command can be deleted in this way. Note that the plot is not refreshed. To refresh the plot, hit E to `EXIT` from the `DRAW` loop and use the command `ZOOM REFRESH`.

After each of the precedent action but `EXIT`, the cursor position becomes the current pen position. Anything else usually gives you the cursor coordinates. However some letters may be used to add new possibilities in command `DRAW`. Never press `RETURN` or `^Z` while the cursor is on, as this causes sometimes dramatic effects...

Note that by default, clipping within the box is turned off when you use command `DRAW`. Clipping can be enforced for the actions `LINE, ARROW` or `MARKER` by using the `/CLIP` option when you type the command. The action `TEXT` is never clipped.

When there is no cursor available (no graphic device active, or no cursor on the graphic device), to use command `DRAW` you must type explicitly the complete command as follows :

- `DRAW RELOCATE Xc Yc [/BOX N] [/CHARACTER N] [/USER] [/CLIP]` to relocate the pen at position (Xc,Yc). The coordinates is the coordinate system specified in the option, or the default coordinate system as defined by command `SET COORDINATE`.
- `DRAW LINE Xc Yc` to draw a line
- `DRAW ARROW Xc Yc` to draw an arrow
- `DRAW MARKER Xc Yc` to draw a marker
- `DRAW TEXT Xc Yc ''Text to be written'' I` to write the string "Text to be written" at (Xc,Yc) where I is the centering option used (this explicit form also corresponds to the code C used with the cursor).

This explicit form can also be used on interactive devices. The cursor will not be called in such case. There is no explicit form for D and E. In interactive mode, the explicit command corresponding to the cursor action is written to the Log File and to the internal stack. Accordingly, the stack can be replayed to produce the same results without any interaction with the cursor. The choice of the coordinate system is beyond the scope of this cookbook; for a single plot it should not matter.

2.5 Getting Hardcopies

2.5.1 The easy way

Now that you have obtained a wonderful plot on the screen, you may want to draw it on a paper sheet. As shown in the procedure, command `HARDCOPY /PRINT` prints out such a hardcopy on the default printer of your installation. That is the easy way, but it should have been configured properly by your system manager (or your local **GILDAS** expert) to work properly.

2.5.2 Printable (PostScript or others) Files

Instead of getting an immediate paper copy, you may prefer to create a file in some graphic format, such as PostScript, HPGL or others, for later printing or insertion in other documents.

To get a PostScript file from your GREG plot, use the following command

```
HARDCOPY plot.ps/DEVICE PS FAST
```

which create a `plot.ps` file containing a PostScript translation of the plot. The `/DEVICE PS` option indicates that the format of the file is PostScript, and the `FAST` argument indicates that line thickness and dash pattern should be generated by PostScript rather than by GREG (this produces smaller files, but at the expense of small clipping errors in case of very wide lines). Two other variants of the `PS` device exist: `GREY` for greyscale plots, and `COLOR` for color devices. Device EPS is similar to device PS, but the `BoundingBox` (in PostScript sense) is computed from the the plot boundaries rather than from the Plot Page size.

A `/DEVICE HPGL` option would have created an output file using the HP-GL command language. So far, PS and HPGL are the only supported output formats. Others (such as PCL for example) may come later.

2.5.3 Metacode File

Rather than preparing an output file in PostScript or HPGL, you can also produce it in GREG format directly. This is done using the `METACODE EXPORT` command. The file produced can be later reinserted in a GREG plot for further processing using the `METACODE IMPORT` command. These commands are described in more details in the section "Plot Structure".

2.5.4 Raster Devices

For raster devices (not supporting vectors), a somewhat different method is used to get a printout. First, a vector file (default extension .vec) is created, and it is then processed by another utility to produce a drawing. Several different utilities are provided to do so. Their use and availability will depend on your own site specificities.

- `PLXY` is used to provide a bit-file for `LXY11 Dec` printers (also called `Printronix 300`). This bit-file extension is `.PLT` and the name is the same as the input metacode file.
- `VTXY` is used to plot on Versatec.
- LA100 is used to create bit-file for an `LA100` Decwriter (extension `.LA100`).
- And others for other supports...

2.6 Internal Zooming

GREG has the possibility of zooming a plot being created. Use command `ZOOM` to do it. `ZOOM X1 X2 Y1 Y2` will compute scale factors to match the designed area (in Physical Coordinates) to the screen, preserving the aspect ratio. `ZOOM OFF` restores the full screen, `ZOOM REFRESH` redraws the plot with the current zooming factor. Without arguments `ZOOM` calls the cursor, and several keys can be used to control the zooming factor :

- "0" turns off zooming and displays the full plot page. The previous zooming factor is not destroyed, so that typing a space (see below) will restore a Viewing Window of same size as the last one centered on the cursor position. The cursor position is not modified by the command itself.

- " " (space) executes the standing zooming operations. With "0", it is the only effective command. The zoomed area is centered around the cursor position and can be delimited using command B.
- "Z" increases the zooming factor by 1.414 and draws the corresponding box around the zoomed area. The zooming is deferred until " " has been struck, allowing zooming factors to be changed by any power of square root of 2. The box drawn around the zoomed area is not a part of the current plot, and will not be visible in a Hardcopy for example.
- "-" decreases the zooming factor by 1.414, and draws the corresponding box if visible.
- "B" draws a box delimiting the area to be zoomed.
- "A" to erase the alphanumeric screen
- "E" to exit...

Any other gives you the cursor position. Zooming can be used for example to enlarge part of a complex drawing to make precise annotations. Note that the zooming has no effect on the hardcopy.

On X-Window systems, the zoomed area normally appears in another window. The mouse can be used instead of the keyboard for some actions:

- left button: as spacebar, execute the zoom
- middle button: increase zooming factor by 1.414
- right button: exit

3 GreG Manual

3.1 Basic Concepts

GREG uses a graphic library with a virtual memory storage for all normal plot actions. Accordingly, the "plot" is a notion entirely independent of any graphic device, and it can be generated without any. The only thing necessary to define a plot is the *Plot Page* size in a conventional unit called the Physical Unit. Plot coordinates on the Plot Page are called *Physical Coordinates*, or *World Coordinates*. By convention, the Physical Unit will be called a centimeter ; this is meaningful because when you produce a drawing from a metacode file using a specific driver such as `PLXY`, a Physical Unit will match a centimeter if you use the `/EXACT` option.

3.1.1 Coordinate Systems

GREG is often used (but far from being limited to) for plotting two dimensional graphs showing the dependence of one variable on another. A typical graph has data points, represented by special markers such as diamonds or stars, and possibly with error bars, or perhaps plotted on the same scale a theoretical model drawn as a smooth curve. The graph must be labelled with two axes to indicate the coordinates. The other major GREG application, namely contouring, also requires such a labelling of the plotting area.

The meaning of the coordinates is entirely defined by the user. For example in an astronomical map it may be Right Ascension Offset in arcsec along the X-axis and Declination Offset in arcsec along the Y-axis; a correlation study between visual extinction and molecular content will have the visual extinction Av as abscissa (no units) and ^{13}`CO` column density as ordinate (molecules per square centimeter).

Throughout this document, these coordinates will be referred as the *User Coordinates*. GREG maps a selected region of the User Coordinate Space onto a specified rectangle, called the *Box*, of the *Plot Page*.

All data plotting is done in User Coordinates and clipped in the Box, except for the perspective algorithm which uses a specific sequence. Other reference systems are available for annotations (see command `DRAW`).

3.1.2 The Plot Page

GREG is a completely device independent graphic system. This means that a sequence of plot actions will give exactly the same drawing on any device, except possibly for a global scale factor (contrary to many systems where the plot is distorted by some X/Y aspect ratio). It is then possible to define a unique Physical Coordinate unit. By convention in GREG this *Physical Unit* corresponds to 1 true centimeter on a paper output, if you use the `/EXACT` option in the metacode device driver. The Plot Page is defined in terms of such units.

A default Plot Page is defined at GREG initialization. It is an A4 format page (30 by 21 cm) with the `LANDSCAPE` orientation, i.e. with the largest dimension along the X coordinate. Plot pages of other dimensions can be defined using command

`SET PLOT_PAGE SizeX SizeY`

Another frequently used Plot Page corresponds to the A4 format with the `PORTRAIT` orientation (long dimension corresponding to Y) which can be accessed by command `SET PLOT_PAGE PORTRAIT`.

3.1.3 The Viewing Window

Only a part of the Plot Page need be displayed on the graphic device (if any). This part is called the *Viewing Window*, (not to be confused with the Box). This window can be modified at any time using the command `ZOOM`. When you define a new plot page, the window is automatically reset to the full plot page. Changing device does not modify the Viewing Window.

This window has no effect at all on the metacode file produced by command `HARDCOPY`, which always contain the full plot page.

3.1.4 The Box

The Box is defined by the position of its corner in Physical Coordinates in the Plot Page by command `SET BOX_LOCATION Xmin Xmax Ymin Ymax`
The default Box for the default Plot Page can be accessed by typing `SET BOX LANDSCAPE` or `SET BOX PORTRAIT` as required. This default box is however usually inadequate for maps, where the User Coordinates in X and Y may be related. The box must of course stay within the limits of the PLOT_PAGE, so that attempts to define a PORTRAIT page in a LANDSCAPE page (or vice versa) will fail: an apropriate SET PLOT_PAGE should have been issued before the SET BOX command.

3.1.5 The User Coordinates

There is a single command to define the correspondence between the User Coordinates and the Physical Coordinates. `LIMITS Xleft Xright Ylow Yup`
by which you specify the User Coordinates values at the left and right ends of the X-axis and low and up ends of the Y-axis. Note that Xleft may be greater than Xright. GREG stores all User Coordinates as Real*8 numbers to allow high precision labelling.

If you have no specific idea about the range of values spanned by your data, just type `LIMITS` GREG then automatically computes the extrema of the input data (read by COLUMN see section 3.2) and adds some reasonable margin to set the limits. You can mix automatic and fixed limits using the "wild" value "`*`" `LIMITS * Xright * Yup`
will computes automatic limits for the left end of the X axis and low end of Y axis.

The previous examples set *Linear Conversion* formula between the User Coordinates and the Physical Coordinates. You can obtain a *Logarithmic Conversion* formula for the abscissa or the ordinate using the options `/XLOG` or `/YLOG` respectively. Note that, contrary to most systems, GREG includes a *true* logarithmic conversion : you do *NOT* have to provide the logarithm of your data. Also, error bars will be correctly plotted for the logarithmic conversion : all the necessary computations are done into GREG .

3.2 The Data Structure

GREG has space reserved into internal buffers for the user's data. Four buffers are available, those with conventional names X Y Z and the Regular Grid array. Buffers X and Y are one dimensional arrays used to store the X and Y data for graphs Y=f(X) (or pairs (X,Y) in some applications). Z is also a one dimensional array and is used for storing additional values such as error bars corresponding to the X (or Y) data. The Regular Grid array is a two dimensional array used to store regularly spaced data (maps) for two-dimensional applications like contouring. Additional buffers are used for specific applications, such as the Polygon buffer.

3.2.1 One-Dimensional Arrays X Y Z

A single command, `COLUMN` is used to specify the input file, select part of this input file, and load data in the X Y Z buffers.

Formatted Files : The input file must be organised in a Table-like way, with formatted numbers arranged in column and lines. GREG uses list-directed format to read this file, so that the numbers need only be separated by spaces, tabs or commas. However, a single complete logical line of the table must be contained in a logical record of the input file. Any column, and any range of lines, can then be accessed typing `COLUMN X Nx Y Ny Z Nz [/FILE Infile] [/LINES Lmin Lmax]`
where Nx is the column number from which the X buffer is to be read (resp. Ny and Nz), Infile is the input file name, and Lmin Lmax define the range of lines to select. By default, the last connected file is used. Changing the input file resets Lmin and Lmax to select the complete file. The order of the X Y Z keywords is not compulsory, and some may be missing ; however each keyword must be immediately followed by its associate column number. There is an implementation dependent limit (usually 50000) on the number of lines that can be read by one COLUMN command in a formatted file. To go over that limit, you can convert the formatted file to a table (usually a good idea), or work by pieces using /LINES.

Table Format : Tables are ensembles of columns strictly equivalent to the formatted files. The only difference is that they are unformatted, and hence access time is typically 50 times faster... The number of lines is fixed, but the number of columns may be extended indefinitely. In fact, a table may be consider as a 2-D image (and vice-versa if you want) but does not require "axis" information... Tables can be accessed in command `COLUMN` using option `/TABLE` instead of `/FILE`. Using tables is recommended whenever a large number of rows or columns. Two programs can be used to convert from tables to formatted files (`GILDAS_RUN:LIST.EXE`) and vice versa (`GILDAS_RUN:TABLE.EXE`).

3.2.2 Two-Dimensional Regular Grid Array

For mapping purpose, one need to store RG=f(I,J) data into the Regular Grid array and to define a linear correspondence between the User Coordinate Space and the indices I and J, X=x(I) and Y=y(I). All this is done using command `RGDATA` to read a purposely formatted file. Contrary to the X Y Z buffers which are Real*8, the Regular Grid RG array is declared Real*4 as there is usually no meaning in defining contours with very high precision.

The Regular Grid array is loaded using command `GREG2\RGDATA Name [/VARIABLE]`
where Name is a variable or the input file name if the `/VARIABLE` option is not present.

Variables and Images: The SIC image format is the equivalent for maps of the table format for columns. Images are regularly sampled 2-d, 3-d or 4-d data which require conversion formula for the coordinates along each axis. Data values are real (single precision) or double precision. Access time to SIC images is typically 20 times faster than the `RGDATA` format. GREG can read images using the SIC command `DEFINE IMAGE` (see the SIC manual for details). Images are then available as multi-dimensional variables, whose names can be specified as argument to a `RGDATA/VARIABLE` command. Any information about projection, coordinate system, etc... associated with the image is given to GREG to define astronomically correct plots. The *GRAPHIC* program, a superset of GREG, also incorporates an `IMAGE` command for similar purpose. GREG can write Images, by

saving the Regular Grid array as an image (see `WRITE IMAGE`). Header information (conversion formulae, projection information...) is written according to the current parameters defined by command `SET`.

RGDATA File Format : A somewhat obsolete way of initializing the RGDATA array is rge so-called "RGDATA file format". Suitably formatted files can be read by the `RGDATA` command when no `/VARIABLE` option is specified. A header is read first to find the array dimensions, and then the array, using a user-specified format. The default format is `Z8.8` and can be changed using the `/FORMAT Expression` option. . `Expression` must be a valid FORTRAN format. It is possible to select only a subset of the input array, using the option `/SUBSET IX1 IY1 IX2 IY2`, where IX1 and IY1 are the pixel values of the bottom left corner, IX2 IY2 those of the top right corner of the area to be selected.

The input file for the RG buffer must be a fixed length formatted sequential file with 80-Bytes record length. The first four records are used to describe the correspondence between indices and User Coordinates and must give the following values

- `Record 1 NX XREF XVAL XINC`
  describing the X axis Coordinates, corresponding to indice I, where
  - NX is the number of (I) pixels
  - XREF is the X-axis reference pixel. XREF is a real, that is one can place the reference pixel on non-integer values.
  - XVAL is the User Coordinate (abscissa) at the reference pixel
  - XINC is the User Coordinate increment per pixel along the X-axis, which can be negative.
- `Record 2 ‘‘Any comment you want for the X axis’`
  is a comment line for bookkeeping. It may be empty but must be present. This comment will be written by GREG when it finds it (as an alphanumeric comment, not on the plot). It may help you remember the X coordinate type for example, or simply the file content.
- `Record 3 NY YREF YVAL YINC`
  similar to record 1, but for the Y axis Coordinate (indice J).
- `Record 4 ‘‘Any comment you want for the Y axis’’`
  similar to record 2.

All the following records contain the RG array, written in the standard Fortran ordering (I varies first) in format 20A4. The variables XREF, XVAL, XINC, YREF, YVAL and YINC are declared Real*8 to provide accurate conversion formulae. The conversion formulae are thus

```
X(I) = XINC*(I-XREF)+XVAL
Y(J) = YINC*(J-YREF)+YVAL
```

respectively for X and Y coordinates.

3.2.3 Using Variables

Instead of reading data into the X, Y, Z or Regular Grid buffers, it is possible to use directly SIC variables in some GREG commands. Currently, the following commands support SIC variables as extra arguments :

```
GREG1\CONNECT [Xv Yv]
GREG1\CURVE [Xv Yv] [/VARIABLE Z [Zv]]
GREG1\HISTOGRAM [Xv Yv]
GREG1\ERRORBAR Type [Xv Yv Zv [Orv]]
GREG1\POINTS [Xv Yv] [/SIZE maxsize [Zv]]
GREG1\VALUES [Xv Yv Zv]
```

where, if not specified, the Xv Yv Zv variables default to the X Y Z buffers, which are known as SIC variables of the same names.

SIC variables are defined using command `SIC\DEFINE`, and can be external tables or images. See SIC documentation, or use `HELP DEFINE` within GREG for more details.

The option `/VARIABLE` of command `RGDATA` indicates that the argument is the name of a known SIC variable, instead of a file name. This can be used to contour directly 2-D SIC variables. Moreover, the Regular Grid is known as a SIC variable named RG, hence it is possible to assign values to RG within GREG . This does not modify the pixel to user coordinates conversion formula.

3.3 The Pen Attributes

GREG can draw different style of lines : solid lines or dashed ones, thin or thick ones, dim or bright ones, and possibly coloured ones on devices supporting this possibility. All these capabilities are controlled by means of virtual pen attributes.

3.3.1 Pen definition

A virtual pen is defined by its conventional number (0 to 15), and its attributes. Currently, the attributes can be

- COLOUR, an integer code for the colour. The integer can take values from 0 to 15 with undefined conventions, because the colour table is dynamically selectable on some devices. (e.g. ARGS). On a non-color device with default terminal settings, it corresponds to an intensity level. 0 is the brightest available intensity. Values 1 to 15 correspond to increasing intensities, scaled to cover the full range of available intensities on the current device. As most devices have three intensity levels, 1-5 will give the dimmest intensity, 6-10 the intermediate one and 11-15 the brightest (i.e. the same as 0).
- DASHED pattern, an integer from 1 to 7 with the following significance
  1. Solid line
  2. Short dashed line
  3. Dotted line
  4. Short dash - Dot line pattern
  5. Long dashed line

6. Long dash - Dot
7. Short dash - Long dash

The first four attributes corresponds to the standard GKS (Graphic Kernel System) convention, and the hardware generation of the output device may be used. It is not used for the other ones.

- WEIGHT, an integer from 1 to 5 giving the thickening factor of the line. Hardware generation may be used.

A pen is loaded and defined by command `PENCIL Ipen /DASHED Idash /WEIGHT Iweig /COLOUR IColo /DEFAULT`
All subsequent plots will be done with this virtual pen, until a new command `PENCIL` is issued. If the attributes are not given, the previous ones (resulting from the last definition) are used. If a device has not the required capability, the code is ignored. The `/DEFAULT` option can be used to reset the default settings of the attributes which are not specified. If no pen number is specified, the `/DEFAULT` option reset all default attributes to every pen.

3.3.2 Pen Usage and Default Settings

Pen number 0 is preset with no thickening, colour 0, solid line. Pen number 1,2,3 are preset with no thickening, colour 4,8,12 respectively (in order to match the three intensity levels available on most devices) and solid line. Pen number 15 is preset with no thickening, colour 0 dashed pattern number 2. All other pens have the same default attributes as Pen 0.

In general, a plot command uses the current pen with all its attributes. Exceptions are

- The dashed pattern is ignored by the character plotting routine (commands `LABEL` and `DRAW TEXT`)
- The dashed pattern is ignored by the marker plotting routine (commands `POINTS, DRAW MARKER` and `DRAW ARROW`)
- The dashed pattern is ignored by the axis plotting routine. (commands `BOX` and `AXIS`)
- Contour plots use Pen number 0 for positive contours and pen number 15 for negative ones (command `RGMAP`), unless specified in option. This is described in more detail later.

3.4 Characters and Markers

For labelling and annotations of the plots, GREG includes a complex character set with special symbols, and the possibility of plotting any regular polygon. The characters and markers are always drawn without the dashed pattern, as mentioned above.

3.4.1 The Character Set

GREG includes two basic character sets generated by software. The `SIMPLEX` set is the default for interactive devices. The `DUPLEX` set is nicer, but slower and requires a higher resolution device ; typically it will be reserved for quality publication plots. Except for the aspect of the characters, there is no difference between the `SIMPLEX` and `DUPLEX` fonts, that is the sizes and proportional spacings are identical. The default font may be overridden by `SET FONT SIMPLEX or DUPLEX`. In each quality, complete roman, script and greek alphabets are available. Special characters are used

to access specific symbols not available on a keyboard, including mathematical and astronomical symbols. The table of correspondence is shown in Section 7. As a rule, astronomical symbols are obtained in the greek character set, and mathematical symbols in the script set, the roman set having of course an exact correspondence with the keyboard, except for the double quote (key not available because of SIC character handling) which is obtained using the counter-quote, degree symbol which is obtained using the circumflex symbol, and the back-slash which is not available.

3.4.2 Handling Text Strings

A text string (plotted by command `LABEL` or `DRAW TEXT`) can include the escape character "\" which is used to generate superscripts and subscripts and to monitor the font used. This escape character may be used in 2 ways

```
\\X - set mode X until other mode change sequence
\X  - set mode X for next character only
```

where X can be any of the following values and causes the following actions :

```
N - Switch to current default character set
1 - Switch to Simplex character set
2 - Switch to Duplex character set
R - Roman font
G - Greek font
S - Script font
I - Toggle italics
U - Increase superscript/subscript level (move Up)
D - Decrease superscript/subscript level (move Down)
B - Backspace over previous character
```

Superscript and subscripts are handled using a "level" philosophy. \U increases the level by 1, \D decreases it by 1 and the size of the characters is (0.7)**ABS(level) times the current defined size. The italic mode is toggled by the \I escape code. The character size is defined using command `SET CHARACTER`.

3.4.3 Centering Facility

Labels may be automatically positioned with respect to a given position. This is done using the Centering code, which can be specified in the `/CENTERING` option of command `LABEL`, as the 5-th argument of command `DRAW TEXT`, or defaulted to a value set by command `SET CENTERING` N. This code N is an integer in the range [0-9] with the following meaning :

- 1 to 9 : The character string is put in position 1 to 9 with respect to the current pen position (`LABEL`) or coordinates specified (`DRAW TEXT`). The position code corresponds to a standard numeric keypad as on most terminals, 1 being lower left, 2 lower middle, etc...
- 0 : For command `LABEL`, it corresponds to code 6, i.e. the label is just written on the right of the current position. For command `DRAW TEXT`, the centering is computed according to the location of the current position with respect to the Box. This location gives a code in range 1-9 with the same conventions as above. Hence a string written at the left of the box will be automatically left adjusted (code 4) while a string written inside the box will be centered and so on.

3.4.4 Graphic Markers

In addition to the character set which includes symbols, GREG can plot any regular polygon under 4 different styles of any size. The current type of graphic marker is set by command `SET MARKER Nsides Istyle Size`
where Nsides is the number of sides (or of summits) of the regular polygon, Size is the diameter of the marker in physical units, and Istyle defines one of the four possible styles according to

- 0 - Regular empty polygon
- 1 - Vertex connection only. The sides of the polygon are not drawn, but the radii connecting the polygon center to the summits are plotted.
- 2 - Fancy starred marker. The star with Nsides summits is drawn. The inner radius of the star is half the outer radius.
- 3 - Filled regular polygon. The filling may be a rather slow process on some devices. Also the filling may fail for very high resolution supports (e.g. a pen plotter with a very thin pencil). If this happens, please notify the authors of GREG .

The number of sides is not limited, but the larger this number, the slower the plot will be...

3.5 GREG1 : One Dimensional Problems

By "one dimensional data" we mean any distribution of (X,Y) data points. This obviously includes functions Y=f(X) and X=f(Y), but also more general cases. Plotting such kind of data is the simplest thing GREG can do. This can be done basically in four modes :

1. The broken line mode using command `CONNECT`, in which data points are simply connected by straight lines. Note that data must be ordered.
2. The curve mode using command `CURVE`, in which the data is interpolated to produce a smooth aspect. Again, the data must be adequately sorted.
3. The histogram mode using command `HISTOGRAM`. As above, data must be ordered. Note that this capability is restricted to functions Y=f(X).
4. The marker mode using command `POINTS`, in which a graphic marker is plotted at each data point. The size of the markers may depend on values in the Z buffer. Contrary to the other commands, the data need not be ordered at all.

In addition to these four commands, the command `ERRORBAR` which uses the Z buffer to define errors may also be relevant to one-dimensional data. A facility to sort data by ascending order is given by means of command `SORT`.

All these commands belong to the so-called "GREG1" language (in the SIC meaning) ; this language also includes all the utility functions of GREG such as pen definitions, annotations, coordinate conversions, etc...

3.6 GREG2 : Two Dimensional Problems

We call "two dimensional data" any data represented by a function f(X,Y). In practice, this representation may be regularly or randomly sampled. The first case corresponds to the Regular Grid array for which RG=f(I,J) and linear conversion formulae exist to convert between I and X and J and Y respectively. The second corresponds to triplets (X,Y,Z) stored in the corresponding buffers. Basic handling of 2-D data includes contouring, perspective view, bitmap processing, and extraction of one dimensional data.

Only regularly sampled 2-D data (i.e. a Regular Grid) can be conveniently handled. The limits of a Regular Grid can be defined as the plot limits using command `LIMITS /RGDATA`. In this case, GREG computes the user coordinates corresponding to pixels 0.5 and NX+0.5 in X (same in Y) and defines these values as the user coordinate limits. This means that the Box will exactly cover the *Image* corresponding to the given map.

For randomly sampled data, GREG provides a way of interpolating them on a Regular Grid by command `RANDOM_MAP`. All other commands are provided to work exclusively on the Regular Grid array. This includes :

- A general contouring facility using command `RGMAP`
- A simple perspective view using command `PERSPECTIVE`
- A bitmap display capability for X-Window terminals and PostScript output, command `PLOT`
- A resampling facility either to produce finer contours, or to produce maps with the same sampling, and hence comparable pixel by pixel.
- Limited map analysis facilities : pixel value interrogation with command `DRAW VALUE`, statistics using command `MEAN`, masking part of a map using command `MASK`, computations of global and local extrema using command `EXTREMA`, strip extraction using command `STRIP`. For more general image processing facilities, the user is referred to the *GILDAS* documentation.

All these commands belong to the "GREG2" language.

3.7 Astronomical Mapping

"No matter how tricky you are, you cannot pave a sphere with square tiles."
(Attributed to A. Einstein)

About 101% of the difficulties encountered in astronomical mapping comes from this very profound evidence. The remaining few percents (within the errors) come from the multiplicity of coordinate systems used by the astronomers. For small field mapping, the sphere can reasonably be approximated by its tangent plane at the field center, but for fields larger than a few degrees (depending on the required positional accuracy), curvature effects become important.

As spherical plotters are not easily commercially available (and their output hardly accepted by journal editors), the big problem is to represent part of a sphere on a plane sheet. GREG offers several facilities to deal with this problem, by means of commands `PROJECTION`, `CONVERT` and `GRID` in the `GREG2` language.

The current philosophy to handle this problem is to make all plotting *in relative coordinates on the projection plane*. No drawing is done in absolute coordinates on the sphere. This was

decided because the plot page is plane indeed. Another apparently restrictive convention in GREG projections is that all angles are internally in the natural angular unit Radian. Accordingly, when you give a map to be contoured, the map coordinates should be offsets in radians from the projection center. For user convenience, it is possible to specify limits in Degrees, Minutes or Seconds using the command `SET ANGLE_UNIT`, but this command has no effect on internal conversion formulae. Again, the rationale behind this convention is that we are in fact working in the projection plane, where angles have no meaning but only their projections remain.

However, it is *always possible to bypass* these *apparent* restrictions provided your understand what a conversion formula and a projection are. As an example is always much better than lengthy discussion, assume you want to overlay a contour map to the Equatorial and Galactic grids relevant to the mapped area. Unfortunately, the map coordinates are in Degrees from a point situated at (0.5,0.5) ("degrees" in projection) from the projection center (note that this sentence is complete nonsense, because you cannot have "degrees" in the projection plane...)

```
SET ANGLE_UNIT/DEFAULT                          ! (1)
LIMITS 5 -5 -5 5                                ! (2)
RGDATA MYMAP                                    ! (3)
LEVELS -1 1 TO 5                                ! (3)
RGMAP/BLANKING -2 .1                            ! (3)
!
SET SYSTEM EQUATORIAL                           ! (4)
PROJECTION 6:25:30 35:40.5 0.0/TYPE GNOMONIC    ! (5)
SET ANGLE_UNIT DEGREES                          ! (6)
LIMITS 4.5 -5.5 -5.5 4.5                        ! (7)
SHOW LIMITS                                     ! (7)
PEN 1                                           !
GRID 2 2                                        ! (8)
PEN 2                                           !
GRID 2 2/ALTERNATE                              ! (9)
```

1. Make sure to work as if you had no problem at all
2. Define the map limits. As you are not worrying about the angular units, the internal limits will be just what you type.
3. Read your map and draw your contours. This is the usual process for any map.
4. Here start the specific astronomical problem. You know that your coordinate system is Equatorial. Specify it.
5. Define the projection in this system. Note that Right Ascension is in Hours, and Declination in Degrees as usual for Equatorial coordinates. The projection type depends on your problem of course.
6. Specify that your will *now be giving limits in Degrees*
7. Give the limits of the map with respect to the projection center. The system automatically converts the values typed in to internal limits in radians, as you can check by the `SHOW` command. Note how you handle the shift between the (0,0) of your map and the projection center which is always the (0,0) of the projection plane (compare with command (2))

8. Everything is now correct to plot the grid of meridians and parallels over your map.

9. You may even plot a *Galactic* grid just by specifying the `/ALTERNATE` option in the `GRID` command.

As shown in this example, the *only* effect of the `SET ANGLE_UNIT` command is to force automatic conversion of the typed limits to radians. The same result would have been obtained by typing
`LIMITS 4.5 -5.5 -5.5 4.5 DEGREE`
instead of commands (6) and (7).

You can work in three different systems :

- `UNKNOWN`, for which GREG makes no assumption at all about the meaning of the unprojected coordinates. In particular, there is no alternate system in this case.

- `EQUATORIAL` with a custom equinox (GREG assumes to be at equinox 2000.0 by default). The alternate system is `GALACTIC` of course.

- `GALACTIC`, with `EQUATORIAL 2000.0` system as alternate.

When you measure positions with the cursor in the last two systems, both galactic and equatorial coordinates are given. For user convenience, sexagesimal notations in Hours Minutes Seconds for Right Ascension and Degrees, Minutes Seconds for Declination are used, while decimal notations with angle in degrees are used for L and B (as well as if the system is `UNKNOWN`).

Approximate absolute labelling in Hours and Degrees (sexagesimal notation) can be obtained for the Box by specifying the option `/ABSOLUTE` to command `BOX` if the system is `EQUATORIAL`. If the system is `GALACTIC` or `UNKNOWN`, this option produces absolute labelling in Degrees. Note that it is only meaningful for small fields of view. Without this option, `BOX` produces relative labelling in current angle units.

In addition, command `CONVERT` can convert absolute positions or projected coordinates from a different projection (in any angular units), to projected coordinates (in radians) in the current projection. This command may be used to plot star positions on a map, and so on.

3.8 The Blanking Capability

Experimental data are seldom completely sampled. For example, a spectrometer may have a bad channel, an image bad pixels and so on. To handle this problem, GREG includes the notion of *Blanking Value*. Most GREG data functions handle this blanking value which is defined using command `SET BLANKING Bval Eval`
where Bval is the blanking value and Eval the tolerance for blanked data, necessary because of limited accuracy. Once a blanking value has been defined, all functions liable to handle it effectively use it. The default value can be overridden using the appropriate option `/BLANKING`. However some functions which should do it still do not handle blanked values ; this currently includes `PERSPECTIVE`.

To turn off the blanking value checking, you must specify a negative value for Eval, or simply use the command `SET BLANKING/DEFAULT`.

The blanking value can be used in two different ways :

1. Avoiding bad points in a curve. In this case it is assumed that points with the Y value blanked are meaningless. Note that this feature allows you to plot a complete set of curves in a single operation : you just need to specify a blanked point to separate each curve.

2. Avoiding bad pixels in an image. In this case, pixels with the blanked value are not considered (for example in command `MEAN`)

One command considers both aspects at the same time : this is command `RGMAP/KEEP Blanking_bis`, for which the default blanking is used to check bad pixels and the Blanking_bis value to force pen up between contours (or parts of a single contour).

4 Advanced Users Guide

Most of the features described in this section (with the exception of the PLOT and RGMAP /GREY commands), are available through commands of the **GTVL** language, which is the command language supporting the facilities offered by the graphic library on which GREG is build. This library may also be accessed directly through other programs.

4.1 Greyscale and Color plots

GREG now has the ability to display color or greyscale images, overlaid with contours if needed. GREG also has area filling capabilities. These possibilities are best exploited on X-Window terminals and PostScript printers. They are usually not available on any other devices.

4.1.1 Bitmap display of images

The PLOT creates a bitmap display of a 2-D images, very much like the command RGMAP draws contour maps. As all other commands in the GREG software, the PLOT command essentially works in user coordinates. The PLOT command is essentially used in the following way:

```
    Greg> SET BOX LOCATION Gx1 Gx2 Gy1 Gy2  ! Define box position
    Greg> RGDATA Varname /VARIABLE          ! Get characteristics from image.
    Greg> LIMITS /RGDATA                    ! Get limits
    Greg> PLOT Varname                      ! Plot the array in the box
! And then other commands
    Greg> BOX
    Greg> RGMAP                             ! Draw contour levels (...)
```

which shows the similarity between the PLOT and RGMAP commands.

The PLOT command has several options, among which the most important is the /SCALING Type Low_cut High_cut option. Type indicates which type of transfer function is desired between the image and the bitmap, and can be either LINEAR or LOGARITHMIC. Low_cut and High_cut are respectively the smallest and largest values plotted. Values below (above) are truncated to Low_cut (resp. High_cut.

Blanking values are recognized by the PLOT command. The values used for blanking are derived from the variable characteristics, or if not set, by the current GREG blanking, or from the /BLANKING option.

The PLOT command also has less frequently used options. See the internal help for details. The sample procedure below produces figure 3:

```
SIC\DEFINE IMAGE A GAG_DEMO:SMALL READ
GREG1\LIMITS /RGDATA A
GREG1\SET BOX_LOCATION MATCH
GREG2\PLOT
GREG1\BOX /ABSOLUTE
GREG1\LABEL "Right Ascension" /X
GREG1\SET ORIENTATION 90
GREG1\DRAW TEXT 1.000 .0000E+00 "Declination" 5 /CHARACTER 6
GREG1\SET ORIENTATION 0
GREG1\DRAW TEXT .0000E+00 1.000 "Example of PLOT command" 2 /BOX 8
GTVL\HARDCOPY FIG3.PS /DEVICE PS GREY
```

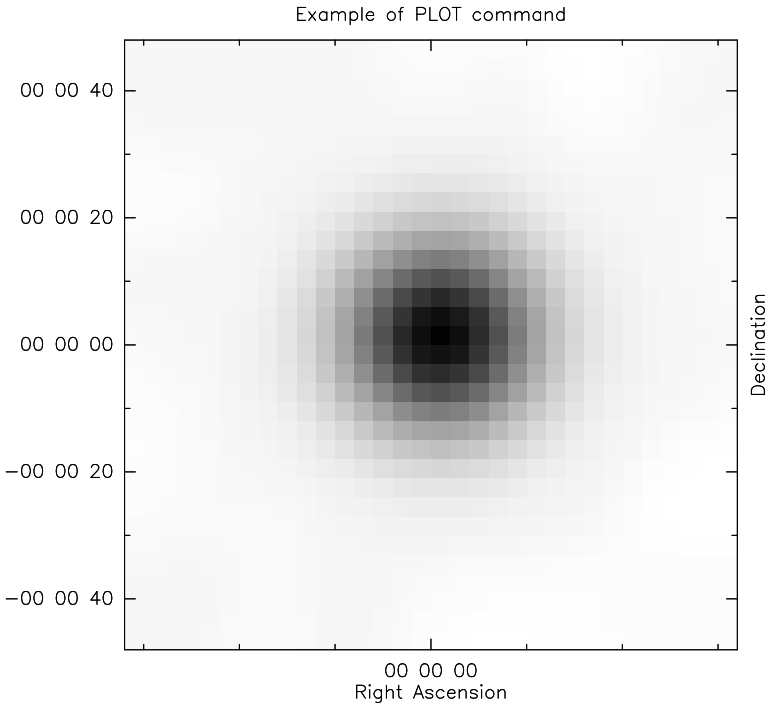


Figure 3: An example of bitmap display in GreG.

4.1.2 Filled Areas

Connected to the bitmap capability, GREG can also produce filled curves, histograms or pie charts. The option `/FILL` of commands `CONNECT` `HISTOGRAM` and `ELLIPSE` are used for hat.

- `CONNECT /FILL Colour`
  closes the polygon and fills it with the current or specified Colour. This is incompatible with blanking values.

- `HISTOGRAM /FILL Colour`
  fills the histogram with the current or specified colour. It is intended to be used in conjunction with the `/BASE` option.

- `ELLIPSE /FILL Colour`
  fills the ellipse with the current or specified Colour. If the `/ARC` option is also present, the corresponding "part of the pie" is filled rather than the subtended arc.

So far, no filling pattern is available.

Contours can also be filled automatically, using command `RGMAP /GREY`. The `RGMAP /GREY` command does not use the current pen, but scans pencil colours from 8 to 24, changing the pencil colour by 1 for each new contour. Colours can later be edited using the look-up table facilities provided by GREG (see below).

Finally, the polygon defined by command `POLYGON` can be filled using the `POLYGON/FILL Colour` command, where `Colour` is a pen color (0 through 23).

4.1.3 Bitmap Color Editing

GREG offers the possibility of editing the color look-up table (LUT) for bitmaps. The colors are represented by three SIC variables:

- `HUE`
  The `HUE` array, with values between 0 and 360, represent the color on a standard color cycle (from Red to Yellow, Green, Blue, Violet and Red again).
- `SATURATION` The `SATURATION` array, with values between 0 and 1, indicates the fraction of the original (saturated) color mixed with white. 0 is pure white, 1 a purely saturated color.
- `VALUE` The `VALUE` array, with values between 0 and 1, indicates the intensity. 0 is black, 1 is maximum lightness.

These variable can be modified by any standard SIC expression. The new values get transferred to the display by typing the command `LUT`. This command also accepts other arguments:

- `COLOR` Load a default color table
- `WHITE` Load a black and white color table (White background, black sources)
- `BLACK` Load a black and white color table (Black background, white sources).
- `LUT` Load the color table defined by the arrays. Same as without any argument.
- `EDIT` Calls an interactive look-up table editor (on X-Window systems onlyt) *not yet implemented.*
- `Any other` Red Green Blue values are read from the formatted file specified as argument. The RGB representation is converted to HSV before being used.

The color associated with the blanking value can be modified using the `B_HUE, B_SATURATION` and `B_VALUE` scalar variables.

4.1.4 Pen Colors

GREG uses 24 colors for the pencils. Colors 0-7 are fixed colors, with the following values:

```
0 Black or White  (depending on window background color)
1 Red
2 Green
3 Blue
4 Cyan
5 Yellow
6 Magenta
7 White or Black  (the window background color)
```

Colors 8-23 can be modified by the user through the `P_HUE, P_SATURATION, P_VALUE` arrays and `LUT /PEN` command, in the same way as the bitmap colors. The default values for these arrays correspond to grey intensities from white to black.

4.1.5 Devices and Hardcopies

The color facilities are available only under X-Window systems. Moreover, not all X-Window like devices recognized by GREG effectively use the color for bitmaps. Only the `DEVICE IMAGE` does. This restriction exists because the color map allocate by GREG is a private color map. As a consequence, no more than a single GREG with `DEVICE IMAGE` can operate at any one time on an X-Window terminal. The pencil colors (pencils from 8 to 23) can always be edited. The number of bitmap colors is usually 128, but can be less if many color applications already use most of the available colors of the X-Window terminal.

For hardcopies, color is supported only the PostScript format. Two options exists for the type of PostSsript created: `GREY` or `COLOR`. The `GREY` version, used by `HARDCOPY /DEVICE PS GREY`, has a fixed transfer function of greyscales. The transfer function is non-linear, and reasonably suited for most astronomical images. The `LUT` command has absolutely no influence on this type of HARDCOPY. The `COLOR` version, used by `HARDCOPY /DEVICE PS COLOR`, uses the current `LUT` to produce the PostScript output. On Greyscale printers, the colors are converted to grey intensities using standard formulas (what you would see by replacing a color display by a monochrome one). Colors are used on color printers.

4.2 Plot Architecture and Multi-Window Capabilities

4.2.1 Directories

GREG incorporates a fairly sophisticated plot architecture, which allows the user to organize its plot in logical elements. The organisation is like a directory tree, with graphic segments attached to a "directory". Directories as a whole (and all their subdirectories) can be manipulated as single entities. While this organisation is mostly transparent for simple plots, it can help organize more complex drawings, specially when the user uses the capability to save subtrees and reincorporate them later in a plot.

One or more graphic segments are created for each GREG command. The graphic segment is the smallest entity recognized in the plot. The directory architecture is under user-control, although some applications layered on GREG may automatically create their own plot organisation. Directories can be created using command `CREATE DIRECTORY`. The top directory is named `'<'`, and cannot be accessed by the user (you cannot type `CD <`). Directories attached to the top directory are named "main directories". To create a main directory, use the following syntax:

```
CREATE DIRECTORY <MAIN
```

where `MAIN` is the name of the directory to be created. The command

```
CREATE DIRECTORY SUB
```

creates a subdirectory from the current working directory, for example `<MAIN<SUB`.

The user can move across the directory structure using command `CHANGE DIRECTORY` (abbreviation `CD`), print his current working directory using command `DISPLAY DIRECTORY` (abbreviation `PWD`). Newly created graphic segments are attached to the current working directory. A whole directory can be erased using command `CLEAR DIRECTORY`, saved on a metacode file for later use by command `EXPORT`.

Directories and segments have attributes (pen colour and thickness, transfer function for images, visibility and depth) which can be edited using command `CHANGE`. Directories and segment can be made invisible by the `CHANGE VISIBILITY` command; this is a reversible action until the `COMPRESS` command has been used to effectively destroy all invisible segments and directories.

Each directory may have its own coordinate system attached. When created, subdirectories inherit the coordinate system from their parent directory. The coordinate system is automatically modified by the `SET BOX` and `LIMITS` commands typed within the directory. This feature allows to maintain several coordinate systems in a plot. However, the user must then realize that user coordinates may change when changing from one directory to another, as for example:

```
LIMIT 0 1 0 1
CREATE DIRECTORY NEW
CHANGE DIRECTORY NEW
LIMIT 0 2 0 2
DRAW RELOCATE 0.5 0.5 /USER
CHANGE DIRECTORY ..
DRAW      ! User coordinates are now (0.25, 0.25)
```

4.2.2 Windows

Each directory may have one or several X-Window windows attached to it to display its content. Each window has its own magnification factor. Windows are created by command `CREATE WINDOW`, which create a new window for the current directory. They can be deleted by command `CLEAR WINDOW`.

The combination of multi-window capabilities with directory structure allows the user to save a plot in one window, and create a new version of it in another window for comparison. Each window has its own color table, although because of terminal limitations, only one color table is active at a time.

4.2.3 The `CLEAR` command

Because of the multi-window and directory capabilities, the `CLEAR` command has many possible arguments.

- `CLEAR ALPHA` erases the alphanumeric screen alone, without affecting the plot. If possible, rather than erasing the alpha screen, the graphic screen (current window) is raised up.
- `CLEAR DIRECTORY [DirName]` makes the named directory (or by default the current directory) invisible. All the attached structure becomes invisible.
- `CLEAR GRAPHIC` lowers the graphic windows, popping up the alpha screen.
- `CLEAR PLOT` is equivalent to either `CLEAR TREE` or `CLEAR WHOLE`, depending on user preference as expressed in command `CHANGE CLEAR`.
- `CLEAR SEGMENT` destroys the last graphic segment, i.e. the part of the plot corresponding to the last graphic command. Can be used repetitively.
- `CLEAR SEGMENT SegName` makes the named segment invisible. This is equivalent to `CHANGE VISIBILITY NameSeg OFF`.
- `CLEAR TREE` deletes the current directory, that is all subdirectories descending from the current main directory. Other parallel trees (if any) are not destroyed.
- `CLEAR WHOLE` deletes the whole plot, all main directories and their subdirectories. A new (empty) main directory is automatically recreated with one associated window.

- `CLEAR WINDOW` delete the current graphic window. Beware that this may leave the plot with no associated window.

4.2.4 Plotting Depth

Another feature which is essential with the bitmap and area filling capabilities is the *depth* of the graphic segment. Because bitmaps or filled areas are opaque, it is important to know in which order they should be displayed. GREG uses the *depth* attribute of the graphic segment to do so. *Depths* range between 1 and 40. Depth 1 is the top layer: graphic segments at depth 1 are in front of any graphic segment at other depths. Depths 40 to 2 are plotted in this order. This means that segment at depth 40 are behind any other segment, segments at depth 39 are behind segments at depth 38, etc... Whenever segments have the same depth, they are drawn in their chronological (creation time) order.

To save unecessary refresh of the drawing, the depth attribute is not used when a segment is created: the segment appears on top of the existing ones at this time. The depth attributes becomes effective after a `ZOOM` action, a redraw (e.g. window resized), or for hardcopies. GREG incorporates a default handling of depths when segment are created in the following way:

- Normal (vector) segments are created with depth = 1
- Bitmaps are created with depth = 2
- Filled areas are created with depth = 1

This allow bitmap images to be plotted in the background, with all standard graphic overlaid on top of them without user intervention.

This behaviour is often sufficient. When not, the user can modify the depth of any graphic segment using the command `CHANGE DEPTH`. See the internal help for details.

5 GREG1 Language Internal Help

We give here a *fac simile* of the internal HELP file for GREG1 (one dimensional plots). In case of trouble, the user should refer directly to the internal help which is the most up-to-date.

5.1 GREG1\

```
                        GREG1\ Language Summary

AXIS      : Draws an axis according to its name
BOX       : Makes a box labelled according to LIMITS and TICKSPACE
COLUMN    : Reads the data file
CONNECT   : Connects (X,Y) pairs with line segments
CORNERS   : Display corners of the plotting surface.
CURVE     : Connects (X,Y) pairs with a spline interpolation
DRAW      : Calls the interactive cursor or execute detailed command
ERRORBAR  : Draws error bars on (X,Y) pairs
HISTOGRAM : Connects (X,Y) pairs as an histogram
LABEL     : Writes a string... according to options given
LIMITS    : Sets the limits of the plot (no args for auto)
LOOK      : Calls the cursor and executes a command when pressing key
PENCIL    : Selects and defines the pen attributes
POINTS    : Draws markers at the (X,Y) pairs
RULE      : Makes a grid by joining axis tickmarks
SET       : Modifies some basic parameters
SHOW      : Shows basic parameters
TICKSPACE : Sets tick intervals for BOX or AXIS
VALUES    : Write the Y or Z values at the (X,Y) positions
```

5.2 AXIS

```
    [GREG1\]AXIS  NAME  [A1  A2]  [/TICK Orien Small Big] [/LOCATION X Y
Len] [/LABEL Code  [ONLY]]  [/[NO]LOG]  [/ABSOLUTE]  [/UNIT  Valid_Unit]
[/[NO]BRIEF]

Makes  an  axis labelled from A1 to A2 at location X, Y, length Len. The
current ORIENTATION determines the angle of the axis.

The axis  scale  is  LINEAR  or  LOGARITHMIC  according  to  the  option
/[NO]LOG.

/TICK:  the  tick  orientation "Orien" may be IN or OUT or NONE with re-
spect to the BOX. Tick spacing can be defined by Small and Big (see HELP
TICKSPACE  for more information on the tick spacing on linear and logar-
ihmic axes). The orientation NONE cancels both ticks and labels.

/LABEL: labels for other "Orien" are drawn according to the code N[one],
P[arallel]  or O[rthogonal] (to the axis). If option /LABEL has the sec-
```

ond argument ONLY, only the labels of the axis are written, not the axis nor the ticks. This feature allows use of different pens for the labels and the axis.

AXIS provides default values for all these parameters according to the axis NAME (XLow, XUp, YLeft, YRight) and the current values used by BOX.

AXIS creates a graphic segment named "AXIS".

5.2.1 AXIS /ABSOLUTE

The option /ABSOLUTE is used to write (RA,DEC) labels for EQUATORIAL system or (L,B) coordinates for GALACTIC system when a projection is active, i.e., both a PROJECTION and a SYSTEM are defined. RA (or L) is used for X-like axis, and DEC (or B) for Y-like axis. Note that this should be used only for small fields (size less than 0.2 Radians), and must be used only with the axes at the default position (i.e. no /LOCATION option). When SYSTEM is defined but the projection is NONE or has never been defined, the /ABSOLUTE option supports large fields (since PROJECTION NONE makes a non-conformal mapping anyway). The SET SEXAGESIMAL command (see help) permits some mastering on how UNKNOWN or GALACTIC ABSOLUTE labels are written.

See HELP TICKSPACE for more information on how to master the Tick spacing with the /ABSOLUTE or the /UNIT options.

5.2.2 AXIS /BRIEF

The options /BRIEF and /NOBRIEF can be used to override the default tick labeling as ruled by the command G\SET AXIS. If /BRIEF is used, the tick labels are abbreviated, if possible. If /NOBRIEF is present, the tick labels are kept entire. The 2 options are exclusive. See HELP G\SET AXIS for details and examples.

5.2.3 AXIS /LOCATION

```
[GREG1\]AXIS NAME /LOCATION X Y Len
```

By default, each axis (XLow, XUp, YLeft, YRight) is drawn by connecting the appropriate corners of the current box location. For example, XLow draws an axis from [BOX_XMIN,BOX_YMIN] to [BOX_XMAX,BOX_YMIN]. This can be overriden with the option /LOCATION by giving custom starting point and axis length (in paper coordinates).

5.2.4 AXIS /UNIT

The option /UNIT is used to convert the axis coordinates to the desired unit, M for arc minutes, S for arc seconds, R for Radians. This option is valid only if a PROJECTION and a SYSTEM (EQUATORIAL or GALACTIC) are both defined. See HELP TICKSPACE for more information on how to master the Tick spacing with the /ABSOLUTE or the /UNIT options.

5.3 BOX

[GREG1\]BOX [Arg1 [Arg2 [Arg3]]] [/ABSOLUTE] [/UNIT valid_unit] [/LABEL Pen] [/FILL Color] [/[NO]BRIEF [X|Y]]

BOX puts axes around the plot region, labelling the lower and left ones. Arguments can be used to customize the ticks and labels:
- Arg1, Arg2: modify the labelling of the lower and left axes respectively. They may take the values P for Parallel labels (default for X axis), O for Orthogonal labels (default for Y axis) or N for No labels (preserving the ticks).
- Arg3: indicates that the ticks are to be IN or OUT of the box, or not drawn at all (NONE). Disabling ticks also disable labels.

The option /LABEL is used to specify a different pen to use for axis labelling. Creates a supplementary graphic segment "LABEL".

The option "/FILL Color" will fill the inside of the box with the specified color (see HELP PEN /COL for possibilities). Creates a supplementary graphic segment "BACK".

BOX N N N makes a rectangle with the current pen, even if the pen is dashed.

5.3.1 BOX /ABSOLUTE

The option /ABSOLUTE is used to write (RA,DEC) labels for EQUATORIAL system or (L,B) coordinates for GALACTIC system when a projection is active, i.e., both a PROJECTION and a SYSTEM are defined. RA (or L) is used for X-like axis, and DEC (or B) for Y-like axis. Note that this should be used only for small fields (size less than 0.2 Radians), and must be used only with the axes at the default position (i.e. no /LOCATION option). When SYSTEM is defined but the projection is NONE or has never been defined, the /ABSOLUTE option supports large fields (since PROJECTION NONE makes a non-conformal mapping anyway). The SET SEXAGESIMAL command (see help) permits some mastering on how UNKNOWN or GALACTIC ABSOLUTE labels are written.

See HELP TICKSPACE for more information on how to master the Tick spacing with the /ABSOLUTE or the /UNIT options.

5.3.2 BOX /BRIEF

The options /BRIEF and /NOBRIEF can be used to override the default tick labeling as ruled by the command G\SET AXIS. If /BRIEF is used, the tick labels are abbreviated, if possible. If /NOBRIEF is present, the tick labels are kept entire.

If the keyword X or Y is used as argument of the options, it indicates to apply the corresponding mode only to the designated axis.

The options /BRIEF and /NOBRIEF are compatible as long as the same axis is not designated twice. See HELP G\SET AXIS for details and examples.

5.3.3 BOX /UNIT

The option /UNIT is used to convert the axis coordinates to the desired unit, M for arc minutes, S for arc seconds, R for Radians. This option is valid only if a PROJECTION and a SYSTEM (EQUATORIAL or GALACTIC) are both defined. See HELP TICKSPACE for more information on how to master the Tick spacing with the /ABSOLUTE or the /UNIT options.

5.4 COLUMN

[GREG1\]COLUMN [X Nx] [Y Ny] [Z Nz] [/FILE Name] [/LINES L1 [L2]] [/COMMENT "Separator"]
[GREG1\]COLUMN [X Nx] [Y Ny] [Z Nz] [/TABLE Name] [/LINES L1 [L2]] [/CLOSE]

This command will read X data from column Nx of the current file, Y data from column Ny and Z data from column Nz of the current (or specified) input file or binary table. Any combination of any of three X,Y,Z items is valid in any order, provided the column number immediately follows the column descriptor. The X and Y arrays contain respectively the X and Y coordinates of points to be plotted. The Z array is an additional buffer which is used for ERRORBARS, for RANDOM maps and so on.

5.4.1 COLUMN /COMMENT

[GREG1\]COLUMN /COMMENT "Separator"

Specify which character is used to indicate the beginning of a comment line in the input file. "Separator" is a single character; typical values are "!", ";", "#", although any single character can be specified. The default is set by command SET COMMENT (default "!").

5.4.2 COLUMN /CLOSE

[GREG1\]COLUMN /CLOSE

Free memory allocated for the table previously opened with command COLUMN /TABLE, if any.

Formatted files opened with COLUMN /FILE are implicitly closed right after read: this option is useless in this case.

5.4.3 COLUMN /FILE

[GREG1\]COLUMN /FILE File_Name

Indicates in which formatted (list-directed free format) file the data are to be read. If not given, the last input file is used.

Use wisely this command on extremely large formatted file because the memory allocated by the COLUMN command is never released before program exit.

5.4.4 COLUMN /LINES

[GREG1\]COLUMN /LINES L1 [L2]

Limit the range of lines read in the input file or table. L1 and L2 refer to absolute line numbers. Since comment lines are ignored, number of read lines is at most L2-L1+1, and can be 0 if all lines were comments.

This option is useful to avoid non-data lines, or to read by pieces a formatted file which is too long for the column buffers. L1 and L2 are reinitialized for each new input file or table. L2 defaults to end of file if not specified.

5.4.5 COLUMN /TABLE

[GREG1\]COLUMN /TABLE Table_Name

Indicates that the columns are to be read in a "Table" at the GILDAS format. If not given, the last input table is used. "Table" format is typically 100 times more efficient used than the formatted file format.

5.5 CONNECT

[GREG1\]CONNECT [Array_X Array_Y] [/BLANKING Bval Eval] [/FILL [Color]]

CONNECT draws line segments connecting the coordinates read by COLUMN X and Y, or stored in the variables Array_X Array_Y. The current pencil with its dashed pattern is used.

CONNECT uses the current blanking values, which can be overridden by the

/BLANKING option. Hence, it does not connect with data points so that abs(Y(i)-Bval) <= Eval. Eval negative means no blanking value, and Bval and Eval values default to those specified in SET BLANKING.

5.5.1 CONNECT /FILL

```
[GREG1\]CONNECT [Array_X Array_Y] /FILL [Color]
```

The /FILL option indicates to fill the connected line. Blanking is irrelevant. The connected line is closed by linking together the first and last point. It is then filled with the color of the current pen, or with the specified color if any (see HELP PEN /COL for possibilities).

5.6 CORNERS

```
[GREG1\]CORNERS
```

Displays angles in corners indicating the limits of the plotting surface.

5.7 CURVE

[GREG1\]CURVE [Array_X Array_Y] [/ACCURACY A] [/VARIABLE V [Array_V]] [/PERIODIC] [/BLANKING Bval Eval]

Builds the spline interpolation of the (X,Y) pairs read by COLUMN, or stored in the variables Array_X Array_Y, using the selected algorithm and options. The current pen with its dashed pattern is used. Presently the only algorithm available is CUBIC_SPLINE. By default, the command assumes that a curve Y=f(X) is to be plotted ; this can be changed using options to specify the kind of curve to be plotted.

5.7.1 CURVE /ACCURACY

```
[GREG1\]CURVE /ACCURACY A
```

Controls the accuracy of the spline interpolation. The argument is the desired accuracy (in paper units, i.e. centimeters) and should be set to the plotter resolution. The default value is defined using the SET ACCURACY command.

5.7.2 CURVE /BLANKING

```
[GREG1\]CURVE /BLANKING Bval Eval
```

Does not uses data points such that abs(Y(i)-Bval) < Eval. These points act as separators. Eval negative means no blanking value. Bval and Eval values default to those specified in SET BLANKING.

5.7.3 CURVE /PERIODIC

```
[GREG1\]CURVE /PERIODIC
```

Specifies that the curve is periodic (and currently closed also). If /VARIABLE X, it expects that y(1)=y(NXY) ; if /VARIABLE Y, that x(1)=x(NXY) ; and in the case of a parametric curve, that x(1)=x(NXY) and y(1)=y(NXY).

5.7.4 CURVE /VARIABLE

```
[GREG1\]CURVE /VARIABLE V [Array_V]
```

Selects the the interpolation variable V, which may be

- X To plot a function Y=F(X) (Default)
- Y To plot a function X=F(Y)
- Z [Array_V] To plot a curve with an explicit parametrization using the Z array, or the array Array_V if this second argument is present.
- POLYGONAL_LENGTH To plot a curve using the polygonal length of the curve as parametrization. It is fast and of general use.
- CURVILINEAR_LENGTH Refined and slow version of the parametrization in POLYGONAL_LENGTH.
- NUMBERING The parameter is the numbering of points. It is only appropriate if the numbering reflects a reasonable parametrization of the curve.

5.8 DRAW

```
[GREG1\]DRAW [Action] [Xc Yc] [/CLIP] [/BOX N] [/CHARACTER N] [/USER
[Unit]]
```

This is a powerful command which allows you to make drawings without data either by specifying coordinates (Xc,Yc) and action desired (Action), or by interactive use of a cursor.

Interactive mode with explicit action

If Action is present but Xc and Yc are omitted, the cursor is invoked to select the desired position. The complementary information, if relevant (e.g. text to be drawn), is prompted in the terminal. The command terminates after the action.

Interactive mode without action

If the Action is also omitted, the cursor is invoked and the action is defined by using the proper key stroke at the desired location:

- R for RELOCATE,
- L for LINE,

- M for MARKER,
- A for ARROW,
- T for TEXT,
- C works like T, but prompts for the centering parameter in addition to the text,
- V for VALUE (map value and cursor coordinates in the current angular unit when a projection is defined),
- 0 1 2 3 work like V except they temporarily (i.e., as long one does not exit from cursor mode) change the current angular unit in which the coordinates are returned,
- D can be used to DELETE the last operation, and has no action on the operations which were plotted previously to the current DRAW command,
- E exits from the cursor mode,
- ^C will exit AND generate an error, which can be trapped (useful to regain control inside of forever SIC loops calling the interactive cursor repeatedly),
- any other key work like V.

The cursor mode loops indefinitely as long as it is not exited.

For graphical displays, you may use the mouse buttons for the commands RELOCATE (left mouse button), LINE (middle mouse button), and EXIT (right mouse button).

The complete command (i.e. with action and coordinates) is written to the LOG_FILE so that you can replay it easily. The option allows you to supersede the default value of the coordinate system defined by SET COORDINATE or to keep clipping.

Command line mode:

When using the explicit form, Xc and Yc may be equal to * to reuse the current pen position.

Any "realistic" combination of literal values, 0-d and 1-dimensional variables is accepted for that command. For example,

```
DRAW MARKER A B /USER MINUTES
```

will plot markers at each location given by the two arrays A and B (provided they are of the same size). A and B must be CHARACTER arrays in the case where the "/USER ABSOLUTE" option is used.

5.8.1 DRAW ARROW

```
[GREG1\]DRAW ARROW Xc Yc
```

Draw an arrow from current location to given location. The arrow size is governed by EXPAND and MARKER size. Cursor form A.

See also command G\ARROW.

5.8.2 DRAW LINE

[GREG1\]DRAW LINE Xc Yc

Move pen down to given location (Xc,Yc). The line will be clipped in the box only if the /CLIP option is present. Cursor form L.

5.8.3 DRAW MARKER

[GREG1\]DRAW MARKER Xc Yc

Draw a graphic marker at given location (Xc,Yc). Current marker style and size is used. Cursor form M.

5.8.4 DRAW RELOCATE

[GREG1\]DRAW RELOCATE Xc Yc

Move pen up to given location (Xc,Yc). Cursor form R.

5.8.5 DRAW TEXT

[GREG1\]DRAW TEXT Xc Yc "Text" [N [Orien]] [/CLIP [SOFT|HARD]]

Draw a text at location (Xc,Yc) according to the centering parameter N, or to the current centering parameter if N is not specified. Cursor form T, or C to be prompted for the centering. The orientation angle of the text (in degrees, counterclockwise) can be specified after the centering parameter; otherwise the current orientation defined by SET ORIENTATION is used.

The text can be clipped at the box boundaries with the option /CLIP. 2 modes are available:

- SOFT truncates the text symbols exactly at the box boundary, which means some part of the text will disappear.
- HARD clips everything or nothing. If the reference point (Xc,Yc) is in the box, all the text is drawn (even if some parts are partly out of the box). If the reference point is out of the box, the text is not drawn at all (even if some parts are partly in the box).

If the clipping mode is omitted, the default is SOFT.

5.8.6 DRAW VALUE

[GREG1\]DRAW VALUE Xc Yc

Inquires the map value at the location (Xc,Yc). A regular grid array must be present to use this, (Xc,Yc) must be within the Regular Grid array limits; otherwise the command is ignored. Cursor form V.

5.8.7 DRAW /BOX

```
[GREG1\]DRAW [Action Xc Yc] /BOX N
```

Specifies that coordinates Xc Yc are physical units relative to point number N of the current BOX. The 9 most remarkable points of the box (corners, middle of the sides, and box center) are numbered according to a VT100 numeric keypad notation (see HELP GREG1\LABEL /CENTERING).

5.8.8 DRAW /CHARACTER

```
[GREG1\]DRAW [Action Xc Yc] /CHARACTER N
```

Specifies that coordinates Xc Yc are units of character size, and relative to point number N of the current BOX. The 9 most remarkable points of the box (corners, middle of the sides, and box center) are numbered according to a VT100 numeric keypad notation (see HELP GREG1\LABEL /CENTERING).

5.8.9 DRAW /CLIP

```
[GREG1\]DRAW [Action Xc Yc] /CLIP
```

Keeps clipping in the box for all drawing actions (except for labels which are never clipped).

5.8.10 DRAW /USER

```
[GREG1\]DRAW [Action Xc Yc] /USER [Unit]
```

Specifies that coordinates are user coordinates.

The Unit argument in the /USER option, if present, can be any of SECONDS, MINUTES, DEGREES, RADIANS (in which case the Xc and Yc coordinates are taken to be in the corresponding unit) or ABSOLUTE (in which case Xc and Yc are taken as absolute coordinates, usually exprimed in sexagesimal format). The presence of the code suboption is valid only if a PROJECTION and a SYSTEM (EQUATORIAL or GALACTIC) are both defined.

5.9 ERRORBAR

```
[GREG1\]ERRORBAR Argument [Array_X Array_Y Array_Z [Orientation]]
```

This command draws error bars on all (X,Y) points (read by COLUMN X and Y, or specified in Array_X Array_Y) of length read by COLUMN Z or specified by Array_Z. Argument may be +X X -X +Y Y or -Y. Symmetric errorbars are drawn if you do not specify the sign, while only the errorbar of the given sign is drawn if you do so. This allows independent errorbars in opposite directions. The size of the line at the end of the er-

rorbar is the Marker size and can therefore be adjusted with SET MARKER.

Errorbars with arbitrary orientation can be obtained by specifying code +0, 0 or -0. The orientation (in degrees) is then either read from a fourth array if one is specified on the command line, or otherwise taken from the current marker orientation (as specified in SET ORIENTATION).

5.10 HISTOGRAM

[GREG1\]HISTOGRAM [Array_X Array_Y] [/BASE [Ybase]] [/BLANKING Bval Eval] [/FILL [Colour]] [/HATCH [Ipen] [Angle] [Separ] [Phase]] [/Y]

Connect the coordinates read by COLUMN X and Y, or stored in the variables Array_X Array_Y as a histogram.

The /BASE option specifies a "true" histogram, connected to a base level. A scalar value means a flat base level, while a 1D variable (same size as X and Y arrays) means a custom base for each bin. Default is 0 base level.

The /BLANKING option will supersede the current blanking values (as defined by SET BLANKING command) so that data points with abs(Y(i)-Bval) < Eval are not plotted. Eval negative means no blanking value. Blanking always applies on bin counts, i.e. Array_Y values, or Array_X values if /Y is present.

By default, binning is done along X axis (assuming increasing Array_X values), and Array_Y provides the bin counts. This can be reverted thanks to option /Y. In this case, binning is one along Y axis (assuming increasing Array_Y values), and Array_X provides the bin counts. This creates a 90 degrees rotated histogram.

5.10.1 HISTOGRAM /FILL

[GREG1\]HISTOGRAM [Array_X Array_Y] /FILL [Colour] [/BASE Ybase]

The /FILL option indicates to fill the histogram with the current pen colour or with the specified colour (see HELP PEN /COL for possibilities). Blanking is handled as for other histograms. Usually needs to be done in conjunction with the /BASE option to properly fill the histogram. Icol is the number (0-23) of the color used to fill. The colors of the last 16 pens (8-23) can be changed by the user (See HELP LUT /PEN).

5.10.2 HISTOGRAM /HATCH

[GREG1\]HISTOGRAM [Array_X Array_Y] /HATCH [Ipen] [Angle] [Separ] [Phase] [/FILL Icolor] [/BASE Ybase]

Fill the histogram with parallel lines. The pen (default current), the line orientation in degrees (default 45), separation in physical units (default 0.25 cm), and phase between 0. and 1. (default 0.) can be customized. The phase indicate to displace the hatch lines by this fraction of the separation from a fixed reference.

The histogram is filled down to the base Ybase (default 0.). The option /FILL can be combined with /HATCH. The histogram contour is not drawn, if desired this must be done with other call(s) to the command.

5.11 LABEL

[GREG1\]LABEL "Character String" [Orientation] [/APPEND] [/CENTERING N] [/X [Offset]] [/Y [Offset]]

Writes the string Character String (included between double quotes) at current pen position or location specified by option, and with current or requested centering. The label is written according to the current or specified Orientation and EXPAND factors. Within a string, the character "\" is an escape character and causes the following action :

```
\\X - set mode X
 \X - set mode X for next char
 \N - Default character set
 \1 - Simplex character set
 \2 - Duplex character set
 \R - Roman font
 \G - Greek font
 \S - Script font
 \I - toggle italics
 \U - superscript
 \D - subscript
 \B - backspace over previous char
```

5.11.1 LABEL /APPEND

[GREG1\]LABEL /APPEND

Append the label at current pen location. This corresponds to /CENTERING 6.

5.11.2 LABEL /CENTERING

[GREG1\]LABEL /CENTERING N

The label is oriented with respect to the current location according to the argument N which can be 1 - 9 for :

	right	center	left	justified
label above	7	8	9	

```
              centered    4         5         6
              below       1         2         3
These conventions follow the standard numeric keypads notation.
```

5.11.3 LABEL /X

```
    [GREG1\]LABEL /X [Offset]
```

Put the label centered below the X axis made by BOX. Offset is an optional argument to indicate the separation between the label and the axis (in character size, default set by SET LABEL).

5.11.4 LABEL /Y

```
    [GREG1\]LABEL /Y [Offset]
```

Put the label centered left of the Y axis made by BOX. Offset is an optional argument to indicate the separation between the label and the axis (in character size, default set by SET LABEL).

5.12 LIMITS

```
    [GREG1\]LIMITS [X1 X2 Y1 Y2 [Unit]] [/XLOG] [/YLOG] [/RGDATA]
[/BLANKING Bval Eval] [/REVERSE [X] [Y]] [/VARIABLES Array_X Array_Y]
[/MARGIN [...]]
```

Sets the coordinates of the plot region. The limits are the user coordinates of the BOX corners, and in conjunction with the BOX_LOCATION, specifies the conversion formula between USER and PLOT coordinates.

The limits can be computed from different data:
- if LIMITS has no arguments, it will compute automatic limits using data from the most recent COLUMN X and Y, if any,
- if the option /RGDATA is present, the current Regular Grid map is used, if any,
- if the option /VARIABLES Array_X Array_Y is present, the named SIC variables are used.

Options /RGDATA and /VARIABLES are exclusive.

Some special characters are allowed instead of numerical values for the limits :

```
      *   Compute automatic limit for this argument
      <   Compute automatic limit for this argument, and take
          the minimum of this value and the precedent limit.
      >   Same as above, but take the maximum.
      =   Keep the precedent value for this limit.
```

An additional argument can be used when a projection and a system are

defined. It may take values
- RADIAN : The values are assumed to be normal projected coordinates from the projection center.
- SECOND, MINUTE or DEGREE : The values are converted from the specified angular unit to radians. They still represent offsets from the projection center.
- ABSOLUTE : The values are assumed to be absolute coordinates on the sphere. APPROXIMATE corresponding projected coordinates are computed from these values (the projected coordinates are necessarily approximate since in general e.g. the upper left and lower left corner of the box correspond to different absolute Right ascension for Equatorial system).

The default value is the current angle unit as defined by SET ANGLE.

5.12.1 LIMITS /BLANKING

[GREG1\]LIMITS [Args . . .] /BLANKING Bval Eval

Does not use data points such that abs(Y(i)-Bval) < Eval. These points act as separators. Eval negative means no blanking value. Bval and Eval values default to those specified in SET BLANKING.

Note that blanking applies to the intensities (Y) array only, but that the blanked values in the Y array are used as a mask to compute the X limits.

This option can not be used with /RGDATA.

5.12.2 LIMITS /MARGIN

[GREG1\]LIMITS [Args . . .] /MARGIN [% ...]

Add or modify the default margins applied to the limits. Without this option, LIMITS adds margins or not depending on the context:

LIMITS
    with no argument (i.e. guess limits from X and Y buffers) a 5% margin is implicitly added on all sides

LIMITS /VARIABLE Array_X Array_Y
    adds an implicit 5% margin on all sides

LIMITS /RGDATA
    adds no margin

LIMITS X1 X2 Y1 Y2
    with explicit values, no margins are added

If the option /MARGIN is present, margins are added in all cases. The margin sizes can be customized as follows:

/MARGIN
    with no values, add a 5% margin on all limits

/MARGIN Val
with a single value, add a "Val" (%) margin on all limits
/MARGIN ValX ValY
with 2 value, add a ValX (%) margin on the X limits, and a ValY (%) margin on the Y limits
/MARGIN ValXL ValXR ValYL ValYU
with 4 values, add a ValXL (%) margin on the left X limit. Same for right X limit, lower Y limit, and upper Y limit

The margin values are percent of the axis range. They can be negative, which means the axis range will be truncated.

Note that the * = < > arguments to the command apply AFTER margins are added.

5.12.3 LIMITS /REVERSE

[GREG1\]LIMITS [Args . . .] /REVERSE [X] [Y]

Exchange the left and right limits for X axis, and/or top and bottom limits for Y axis.

5.12.4 LIMITS /RGDATA

[GREG1\]LIMITS [Args . . .] /RGDATA

Specifies that the current Regular Grid array should be used to compute the (non-specified) limits, instead of the current column arrays. Logarithmic conversion formulae are not allowed in this case. The /BLANKING and /VARIABLES options are incompatible with /RGDATA.

5.12.5 LIMITS /XLOG

[GREG1\]LIMITS [Args . . .] /XLOG

Specifies that the X conversion formula should be logarithmic. Cannot be used with the /RGDATA option.

See also HELP SET AXIS EXPO to enforce exponential labeling.

5.12.6 LIMITS /YLOG

[GREG1\]LIMITS [Args . . .] /YLOG

Specifies that the Y conversion formula should be logarithmic. Cannot be used with the /RGDATA option.

See also HELP SET AXIS EXPO to enforce exponential labeling.

5.13 LOOK

```
[GREG1\]LOOK "Command"
```

Calls the cursor, and executes the specified command each time it is pressed. The command can be a procedure (e.g. @my_look) and can test the pressed character which is added at the end as first argument. Usual exit keys ("E", right-clic, ...) or "*" can be used to exit. For example, a calling session may look like:

```
GREG-PROMPT> LOOK "SAY You pressed "
You pressed Q
GREG-PROMPT>
```

if "Q" and then "E" have been pressed.

5.14 PENCIL

```
[GREG1\]PENCIL [N|*] [/COLOUR C] [/DASHED D] [/WEIGHT W] [/DEFAULT]
```

PENCIL selects the current pen or changes the pen attributes.

Command argument:

- with a pen number, select this pen as the current one and optionally changes its attributes if options are present.
- with a * wildcard, modify the named attributes of all pens without changing the current pen number.
- without argument, only modify the current pen attributes.

Attributes are defined in terms of colour, dashed pattern and weight (thickness). Up to 16 pens can be defined (0-15). Most plotting commands use the current pen. The major exception is RGMAP (iso-contouring) which uses the pen 0 (solid and foreground color by default) and 15 (dotted and blue by default). Some commands also ignore the dashed patterns, in particular all labels and the BOX command.

- The dashed pattern D must be in range 1 to 8, 1 means solid lines.
- The weight factor W must be a weight number or value. See subtopic /WEIGHT for details.
- The colour index C is a color number or name. See subtopic /COLOUR for details.

PENCIL N /DEFAULT reset default attributes of pen number N. PENCIL /DEFAULT reset default attributes for all Pens, as defined at program initialization.

5.14.1 PENCIL /COLOUR

```
PENCIL [N] /COLOUR Arg
```

Modify the current pen color, or the color of the N-th pen.

The argument can be a color name (subset of the X11 colors catalog), e.g. RED, LIGHT_SEA_GREEN, MEDIUM_BLUE... The complete list is available by typing "PENCIL /COLOUR ?". The colors can also be displayed thanks to the demonstration procedure "@ gag_demo:demo-pencolors.greg". The list is also available in the character array GTV%COLORS for use in procedures.

There are 3 special color names:
- BACKGROUND resolves as WHITE on white devices and BLACK on black devices,
- FOREGROUND resolves as BLACK on white devices and WHITE on black devices,
- NEGATIVE inverts the pixel colors below the graphical segment begin drawn. This ensures that the segment is always visible, whatever the context. NEGATIVE is supported only for X and PNG devices. Other devices use the FOREGROUND color as a fallback.

The argument can also be an integer value (explicit, or a variable name, or the result of a math expression) from -1 to 23 with the following signification:
- -1 NEGATIVE
- 0 FOREGROUND
- 1 RED
- 2 GREEN
- 3 BLUE
- 4 CYAN
- 5 YELLOW
- 6 MAGENTA
- 7 BACKGROUND
- 8 to 23: those 16 colors can be customized by the user (see HELP LUT /PEN for details). They can be used as any other color, but they also correspond as the "fill pens" used by the command RGMAP /GREY. Those colors are dynamic, i.e., by default, changing them will also modify the segments previously drawn with them (see HELP CHANGE LUT).

5.14.2 PENCIL /WEIGHT

```
PENCIL [N] /WEIGHT Arg
```

Modify the current pen weight, or the weight of the N-th pen.

The argument can be the pen weight (controling the line width) in millimiter using the following syntax:

```
PEN /WEIGHT 1.23mm
```

For reference, the weight has to be compared with the current PLOT_PAGE (default 30cm x 21cm).

The argument can also be an integer index from 1 to 5. They translate as follows:

```
PEN /WEIGHT 1 => 0.15mm
PEN /WEIGHT 2 => 0.30mm
PEN /WEIGHT 3 => 0.45mm
PEN /WEIGHT 4 => 0.75mm
PEN /WEIGHT 5 => 1.20mm
```

For bitmaps devices (X, PNG), weights lower or equal than 0.15 mm always translate as 1 pixel width lines. On the other hand, for vectorial devices (PS, EPS, SVG), all widths are preserved and those lower than 0.15 mm give different rendering depending on the viewing/printing application.

5.15 POINTS

[GREG1\]POINTS [Xarray Yarray] [/BLANKING Bval [Eval]] [/SIZE Zvalue [Zarray [Exponent]]] [/MARKER SidesArray StyleArray]

Makes points of the current style (MARKER), size (MARKER and EXPAND), and orientation (ORIENTATION) at the X and Y coordinates read by COLUMN, or in the variables Xarray and Yarray.

With the option /SIZE, followed by a real value Zvalue, POINTS will draw markers of sizes governed by the values of the Z array (or of the Zarray if specified). Points with Z value equal to Zvalue will have a marker of size the current marker size. All other markers will have an AREA proportional to the Z value at each point (i.e. marker radius at X(i) Y(i) proportional to the square root of Z(i); this power law exponent can be changed by specifying an additional argument to option /SIZE). If Zvalue is equal to zero, the program uses the maximum absolute value of the Z array instead.

The /BLANKING option can be used to override the current blanking behaviour, as defined by SET BLANKING command. If Eval (defined by /BLANKING or SET BLANKING) is null or positive, blanking is enabled. If /SIZE is used, blanking applies to the Z (or Zarray) values, e.g. in a context of a (coordinate,coordinate,intensity) map. If /SIZE is not used, blanking applies to the Y (or Yarray) values, e.g. in a context of a (abscissa,intensity) profile.

The /MARKER option can be used to specify a different marker sidedness and style for each data point.

5.16 RULE

```
[GREG1\]RULE [X] [Y] [/MAJOR] [/MINOR]
```

Without an argument, or with both X and Y arguments, RULE makes a grid within the BOX using the current pen. Major or minor ticks or both are selected according to the options. With the argument X or Y, the grid is restricted to X or Y ticks respectively. The /MAJOR and /MINOR options can be combined in the same command.

5.16.1 RULE /MAJOR

```
[GREG1\]RULE [X] [Y] /MAJOR
```

Makes a grid at major ticks (This is the default if no option is given).

5.16.2 RULE /MINOR

```
[GREG1\]RULE [X] [Y] /MINOR
```

Makes a grid at minor ticks.

5.17 SET

```
[GREG1\]SET Argument [Value [...]] [/DEFAULT]
```

Specify or reset some default value for a parameter used by GreG. These values may sometimes be overridden for a single command by the appropriate option (e.g. /BLANKING and SET BLANKING). SET Argument /DEFAULT reset the default values for the given key.

SET /DEFAULT reset all default values of SET including the FONT and the PLOT_PAGE ; thus the plot cleared. Use PENCIL /DEFAULT to reset the PENCIL definitions, and TICKSPACE 0 0 0 0 to reset tick spacing parameters.

You can use GREG1\SHOW to see the current value of one or all items.

5.17.1 SET ANGLE_UNIT

```
[GREG1\]SET ANGLE_UNIT D
```

Sets the angle unit for the projection limits. This will become effective only when a projection is effective, and only affects the way limits are given and labels written (not internally stored). D may have the values SECOND, MINUTE, DEGREE, RADIAN.

5.17.2 SET ACCURACY

```
[GREG1\]SET ACCURACY D
```

Sets the default accuracy (in paper units, i.e. centimeters) used by the command GREG1\CURVE. It should be set to the plotter resolution, and must be in range 0.0001 to 1. Default value is 0.01.

5.17.3 SET AXIS

[GREG1\]SET AXIS EXPO|NOEXPO [X|Y|Z]
[GREG1\]SET AXIS BRIEF|NOBRIEF [XDECIMAL|YDECIMAL|XSEXAGESIMAL|YSEXAGESIMAL]

SET AXIS EXPO enforces the use of exponential notation for tick labels.

By default (NOEXPO mode), Greg labels the ticks with plain integers (if abs(value)>=1) or decimal floats (if abs(value)<1) as long as the label is 6 characters or less. For larger labels, Greg switches to the exponential notation.

This default mode can lead to inhomogeneous labels, some as plain integers, others in exponential format. The mode EXPO enforces the use the latter format for all labels.

The labelling rule can be customized for X, Y, or Z (intensities i.e. wedge labelling). With no argument, the command applies to those three.

The plain integer/decimal versus exponential formats apply to decimal and logarithmic axes. Sexagesimal axes have their own labelling rules.

SET AXIS BRIEF|NOBRIEF [XDECIMAL|YDECIMAL|XSEXAGESIMAL|YSEXAGESIMAL]

The BRIEF keyword indicates to the commands G\AXIS and G\BOX to abbreviate the major tick labels, if possible. Abbreviating means dropping off leading digits which are common to all tick labels of one axis, in order to make the relevant information (the variable digits) easier to read. This is particularly suited to axes showing a small range of values around a large one. This can also help saving place depending on the axis and its tick labels orientation. Note that the first tick label is kept entire while the other are abbreviated, and sign is preserved. The NOBRIEF keyword indicate not to attempt the abbreviation.

A complementary argument can indicate which kind of axes should be affected. X and Y refer respectively to horizontal and vertical axes. The suffix DECIMAL refers to standard linear numbering, while SEXAGESIMAL refers to sexagesimal notations of any kind. Logarithmic axes are not affected. By default the command modifies the behavior of both axes in both supported modes.

Defaults are:

```
  XDECIMAL      NOBRIEF
  YDECIMAL      NOBRIEF
  XSEXAGESIMAL  BRIEF
  YSEXAGESIMAL  NOBRIEF
```

Here are several examples for axes with 3 major ticks:

* NOBRIEF mode:

```
       123456       123457       123458
    -123456.7   -123456.75    -123456.8
         1000         2000         3000
           -1            0            1
    12h34m56s    12h34m57s    12h34m58s
    12h34m00s    12h36m00s    12h38m00s
```

* Same in BRIEF mode:

```
       123546            7            8
    -123546.7         -.75         -.8
         1000         2000         3000
           -1            0            1
    12h34m56s          57s          58s
    12h34m00s       36m00s       38m00s
```

5.17.4 SET BLANKING

```
[GREG1\]SET BLANKING Bval Eval
```

Define a blanking value Bval with tolerance Eval. Default is no blanking (i.e. Eval negative). The blanking is used by most curve plotting commands such as CURVE, CONNECT, POINTS to ignore data points which verify ABS(Y-Bval) less or equal to Eval. The blanking value is also used for contours (RGMAP), to avoid plotting contours in pixels whose value verify the same relation as above. And finally, some commands require a blanking value to attribute when they are unable to define a real value ; this include RANDOM and MASK.

5.17.5 SET BOX_LOCATION

```
[GREG1\]SET BOX_LOCATION Argument_List
```

Define the position of the box. The argument list specifies various options for the box position :

- PORTRAIT Define a default Portrait oriented box
- LANDSCAPE Define a default Landscape oriented box
- SQUARE Define a square box
- MATCH [Gx1 Gy1 [Ratio]] Define a box which matches the ratio of the physical units. By default, the bottom left corner is placed at the default position for the current plot page, but can be moved by specifying arguments Gx1 and Gy1. The box size is adjusted such that the box occupies as much space as possible within the default box

position for the current plot page type. Ratio is an additional arguments which indicates a scaling factor for the Y axis.

WARNING : The box is computed from the current limits, and will not change if you compute new limits.

- Gx1 Gx2 Gy1 Gy2 Defines the positions of all box corners in physical units.

The default is LANDSCAPE, PORTRAIT or the default VIEWPORT according to the current PLOT_PAGE type.

5.17.6 SET CENTERING

[GREG1\]SET CENTERING N

Sets the centering option. Default is 0, which means automatic centering according to the position relative to the box.

5.17.7 SET CHARACTER

[GREG1\]SET CHARACTER S

Sets the character size to S physical units. Default is 0.6 .

5.17.8 SET COMMENT

[GREG1\]SET COMMENT "Separator"

Specify which character is used to indicate the beginning of a comment line in formatted input files for command COLUMN. "Separator" is a single character; typical values are "!", ";", "#", although any single character can be specified. The default is "!".

5.17.9 SET COORDINATES

[GREG1\]SET COORDINATES [System [N]]

Sets the coordinate system for DRAW. The system may be BOX, CHARACTER or USER. If BOX or CHARACTER, N can be used to specify the point of the box to which the units refer. Nine points are available, following a standard VT100 keypad disposition (see HELP GREG1\LABEL /CENTERING). N may be 0. In this case, the nearest point will be used when making annotations with the cursor, and point 1 will be used in explicit form. The default is BOX 0.

5.17.10 SET DECIMAL

[GREG1\]SET DECIMAL [X] [Y]

Specify that labelling of X or Y axis is with a decimal field (default). Used to revert from sexagesimal labelling (See HELP SET SEXAGESIMAL).

5.17.11 SET EXPAND

```
[GREG1\]SET EXPAND E
```

Expands all characters or markers by a factor E. Default is 1.

5.17.12 SET FONT

```
[GREG1\]SET FONT F
```

Defines the character font used. F may be SIMPLEX (default) or DUPLEX, which is nicer but substantially slower, and should be reserved to publication quality plots. Default is SIMPLEX.

5.17.13 SET LABEL

```
[GREG1\]SET LABEL X|Y [Offset]
```

Defines the distance between the label (legend drawn by command G\LABEL) and the corresponding axis. The default is 2 character sizes in X, and 6 in Y. This sometimes require adjustment for publication quality plots.

See also command LABEL /X [Offset] and /Y [Offset].

5.17.14 SET MARKER

```
[GREG1\]SET MARKER Nsides Mstyle Size Orien
```

Sets the marker type to a polygon of Nsides, of style Mstyle (0-4) and size Size (physical units).

Nsides:
- 0,1 Dots
- 2 Bar
- 3 Triangle
- ...

Mstyle:
- 0 Convex polygon
- 1 Vertex connected
- 2 Starred polygon
- 3 Filled convex polygon (only for Nsides>=3)
- 4 Filled starred polygon (only for Nsides>=3)

The default is Nsides=0 Mstyle=0 Size=0 and Orientation 0 (Points, optimized algorithm). The Orientation is used to plot the marker (e.g. Horizontal bar for MARKER 2 0 * 0.0, and vertical bar for same marker MARKER 2 0 * 90.0).

A * instead of a numerical value indicate to keep the last value.

5.17.15 SET ORIENTATION

[GREG1\]SET ORIENTATION T [M]

Set orientation of text to T degrees and that of markers to M degrees (M = T if not specified). The text orientation also controls the orientation of axes. Default is 0.0 (horizontal).

Text orientation can also be controlled by command DRAW TEXT, and Marker orientation by command SET MARKER.

5.17.16 SET PLOT_PAGE

[GREG1\]SET PLOT_PAGE X Y

Sets the physical size of plot page. One can use "PORTRAIT" and "LANDSCAPE" for A4 format with adequate orientation, and square will give a 30 by 30 cm plot page. Default is LANDSCAPE (A4 30 by 21 cm).

5.17.17 SET SEXAGESIMAL

[GREG1\]SET SEXAGESIMAL [X [Nx]] [Y [[Ny]]

Set X axis labelling in sexagesimal notation with Nx decimals (resp. Y). The default (Nx=1, Ny=0 and no sexagesimal notation) is nearly always perfect for everybody.

So, this command is used for two restricted purposes:
- to enable sexagesimal notation of axis when a projection is in use, the system is GALACTIC and the /ABSOLUTE option is required (for EQUATORIAL systems, the sexagesimal notation is always used in this case, but the default for GALACTIC system is a decimal representation of degrees).
- to specify the number of decimals when using ABSOLUTE labelling (see BOX /ABSOLUTE or AXIS /ABSOLUTE).

Note that, when a realistic tick spacing is required by the user or (the default) GreG computes this spacing automatically, labelled tickmarks will fall on rounded values, so no decimals will appear (unless the field of view is smaller than a few arc seconds).

5.17.18 SET SYSTEM

[GREG1\]SET SYSTEM Name [Equinox]

Specify the coordinate system used in case of projection. The name can be UNKNOWN, GALACTIC or EQUATORIAL (default equinox is 2000.0 if not provided). The SYSTEM affects the projection definitions (in particular

the GRID command) and coordinates sent back by the cursor (different formats are used for each system).

5.17.19 SET TICKSIZE

```
[GREG1\]SET TICKSIZE Major [Minor]
```

Sets the major tick size to Major (in physical units). The default value is 0.3. Minor tick size can also be set. If absent, Minor is half the Major tick size value.

5.17.20 SET VIEWPORT

```
[GREG1\]SET VIEWPORT Px1 Px2 Py1 Py2
```

Defines the position of the box in terms of fractions of the plot page size in X and Y. Default is 0.150 0.925 0.125 0.925 .

5.18 SHOW

```
[GREG1\]SHOW Item
```

- SHOW <SET_key> lists the current value of the associated parameter(s).
- SHOW ALL lists the values of all the SET parameters.
- SHOW PEN lists the current pen definitions (use the PENCIL command itself for informations on the active pen alone).
- SHOW PROJECTION lists the current projection used.
- SHOW [WHERE|LIMITS] [DEGREE|MINUTE|SECOND|RADIAN|ABSOLUTE] shows the current pen location and plot region limits in Plot coordinates (i.e. centimeters) and user coordinates.
  User coordinates are native user values if no projection is currently defined, or current angle unit (i.e. according to SET ANGLE) if a projection is defined.
  In the latter case, the second argument overrides the angular unit in which the user values are displayed.
- SHOW without arguments is a synonym of SHOW WHERE.

5.19 TICKSPACE

```
[GREG1\]TICKSPACE SmallX BigX SmallY BigY
```

Sets tick intervals (in User coordinates) for BOX or default intervals for AXIS. SmallX refers to the interval between small tick marks on the X axis, BigX refers to the interval between large ticks, etc. If Big is 0, the axis routine will supply its own Big intervals according to the label limits and use your Small value if non zero. To restore fully automatic ticking, set Small and Big equal to 0. To suppress small ticks, specify equal values for Small and Big.

The Small and Big values are meaningless for LOGarithmic axes, which uses their own conventions. If two major ticks are separated:
- by one decade, the minor ticks are at all unitary values of the decade,
- by two decades, the minor ticks are at values 2, 5, 10, 20, and 50,
- by three or more decades, the minor ticks are at (some of) the intermediate decades.

When using the /ABSOLUTE or /UNIT option for axis-drawing commands, one has to keep in mind that Small and Big (if not 0) should be expressed:
- in seconds of arc for declination or galactic (sexagesimal notation) axis, /ABSOLUTE option (one can usually multiply by 3600 the desired tick spacing)
- in seconds of time for right ascension axis, /ABSOLUTE option (multiply by 12)
- in seconds, minutes or degrees when option /UNIT [SECOND|MINUTE|DEGREE] is used.

Thus in the case of a user-defined tick spacing, TICKSPACE must be redefined before using another option.

5.20 VALUES

[GREG1\]VALUES [Array_X Array_Y [Array_Z]] [/BLANKING Bval [Eval]]

With no argument, VALUES writes (in the shortest possible format) the values of the Z array at the (X,Y) positions in the box. Three X Y Z arrays can be specified explicitly instead, e.g. in a context of a (coordinate,coordinate,intensity) map.

With two X Y arguments, VALUES writes the values of the Y array at the (X,Y) positions, e.g. in a context of a (abscissa,intensity) profile.

The current character size, expansion factor and fonts are used. Only points inside the current box are written, but the labels may still span over the box itself.

Blanking (if any) applies to the plotted values (Y or Z if 2 or 3 arguments resp.). Global blanking values (SET BLANKING) can be overriden with the option /BLANKING.

6 GREG2 Language Internal Help

6.1 Language

GREG2\ Language Summary

```
ARROW       : Draw a list of arrows in User coordinates.
CONVERT     : Converts data in the X,Y buffer in the current projection.
ELLIPSE     : Draws an ellipse in User coordinate.
EXTREMA     : Shows minimum and maximum of the Regular Grid array.
GRID        : Plots a Grid in (A,D) with steps As and Ds (in degrees).
LEVELS      : Sets the contour levels.
MASK        : Masks part of a regular grid map.
MEAN        : Computes statistics on map values.
PERSPECTIVE : Makes a 3-D perspective of the Regular Grid array.
PLOT        : Plots a SIC image variable to the window.
POLYGON     : Defines a polygon for use by MASK and MEAN.
PROJECTION  : Defines a spherical projection.
RANDOM_MAP  : Creates a Regular Grid array from randomly sampled data.
RESAMPLE    : Resamples the Regular Grid array on a different Grid.
RGDATA      : Reads/creates a 2-D map and put it in the Regular Grid array.
RGMAP       : Draws contour lines for the Regular Grid array.
STRIP       : Extracts a strip from the Regular Grid array.
WEDGE       : Draws wedges.
WRITE       : Saves an internal buffer on a file.
```

6.1.1 Language NEWS

See HELP GREG1\ News for information

6.2 ARROW

[GREG2\]ARROW Xref Yref Length Angle [Reference]

This command draws one or more arrows at given position, and of given length, and angle:

- Xref and Yref define a reference point (in user coordinates) for the arrow. The Reference value (5th argument) indicates where this point lies on the arrow (0 for the start of the arrow, 0.5 for the middle of the arrow, 1 for the tip of the arrow). Any intermediate value is valid; default is 0.5.
- Length defines the arrow length, in paper units (cm).
- Angle defines the arrow orientation angle. It is ALWAYS in DEGREES, TRIGONOMETRIC ORIENTATION.

Additionally, the arrow head size can be customized with SET EXPAND.

All the 5 arguments can be scalar explicit values or scalar variable names: this will draw a single arrow. But the 4 first arguments can also

be array variables: this will draw as many arrows as the arrays provide values (their size have to be consistant). Mixing scalar and array variable is possible, e.g.

```
GREG> ARROW Xarray Yarray 1 AngleArray
```

will draw a set of arrows at different positions and orientation angles, but all of same length.

In order to draw arrows defined by a starting point and ending point coordinates, use commands G\DRAW RELO and G\DRAW ARROW.

6.3 CONVERT

[GREG2\]CONVERT A0 D0 [Angle] [/TYPE Ptype] [/UNIT Unit] [/SYSTEM EQU|GAL [Equinox]] [/VARIABLE Var_X Var_Y]

The command converts coordinates in a given projection and coordinate system to GREG current ones:

* Input:
  - Coordinates are found in Var_X and Var_Y if the option /VARIABLE is present, else buffers X and Y are used. Var_X and Var_Y must be DOUBLE precision, writeable, 1-dimensional arrays. If input projection type is NONE, values are absolute spherical coordinates. Else they are offsets from the projection center.
  - The unit of coordinates can be set with the option /UNIT with the argument SECOND, MINUTE, DEGREE, or RADIAN. Default is current Greg angle unit (see HELP G\SET ANGLE_UNIT).
  - Input coordinate system is set with the option /SYSTEM EQU|GAL [Equinox]. Default equinox is 2000 if system is Equatorial.
  - Input projection is defined by CONVERT A0 D0 [Angle] [/TYPE Ptype]. A0 and D0 are the coordinates of the projection center (reference of the offset coordinates). They are relevant except for the NONE projection. Format is degrees in sexagesimal strings (A0 is hour angle if input system is EQUATORIAL). Angle, if relevant, must be set in degrees. Supported types can be found with CONVERT /TYPE ?. Default is NONE.

* Output:
  - Converted coordinates are saved in the input variables (overwritten). If the current Greg projection is NONE, values are absolute spherical coordinates. Else they are offsets from the current Greg projection center.
  - The unit of output coordinates is always natural units (i.e. the equivalent of Radians after reprojection).
  - Output coordinate system is the current Greg one (see SHOW SYSTEM and HELP SET SYSTEM).
  - Output projection (center and type) is the current Greg one (see HELP PROJECTION).

```
There is no provision for "hidden" parts which are  treated  exactly  as
visible ones.
```

6.3.1 CONVERT EXAMPLES

```
* Converting relative coordinates to absolute:

Say  one  wants  to  convert the RADIO-projected coordinates (+100,+200)
arcseconds from Eq.2000  center  (01:23:45.67,76:54:32.10)  to  absolute
Eq.2000 coordinates:

  ! Define input offsets
  define double myx myy
  let myx +100
  let myy +200
  ! Define output system of coordinates
  set system eq 2000
  ! Define output projection. NONE means CONVERT output will be absolute
  ! spherical coordinates
  projection /type none
  ! Convert offsets given their input description
  convert 01:23:45.67 76:54:32.10 /type radio /syste eq 2000 /var myx myy /u
  ! Variables are now absolute spherical coordinates (radian unit)
  exa myx myy
  ! Convert from radians to RA-DEC sexagesimal strings
  define char*23 chra chdec
  let chra  myx /sexa h r
  let chdec myy /sexa d r
  exa chra chdec

* Converting offsets from one projection to another:

Say one wants to convert the RADIO-projected offsets (+100,+200) arcsec-
onds away from Eq.2000 center (01:23:45.67,76:54:32.10) to GNOMONIC-pro-
jected offsets (same projection center):

  ! Define input offsets
  define double myx myy
  let myx +100
  let myy +200
  ! Define output system of coordinates
  set system eq 2000
  ! Define output projection
  projection 01:23:45.67 76:54:32.10 /type gnomonic
  ! Convert offsets given their input description
  convert 01:23:45.67 76:54:32.10 /type radio /syste eq 2000 /var myx myy /u
```

```
! Variables are now offsets in the new projection (radians)
exa myx myy
```

6.4 ELLIPSE

[GREG2\]ELLIPSE Major [Minor [Position_Angle]] [/BOX X Y] [/USER X Y [code]] [/ARC Theta_min Theta_max] [/FILL [Colour]] [/HATCH [Ipen] [Angle] [Separ] [Phase]]

This command draws at current pen position (or at position (X,Y) if option /BOX or /USER is present) an ellipse of given semi-major axis, semi-minor axis, (default Minor = Major) and Position_Angle (default 0 degrees). This command is useful for plotting beam sizes, uncertainty ellipses, pie charts, etc.

Major, Minor are in User Coordinates. X and Y are in User Coordinates (option /USER) or in Physical Units (centimeters from the bottom left box corner, option /BOX). Major, Minor, X and Y, can be 1-D arrays of any size, provided the sizes are the same.

The Position_Angle is ALWAYS in DEGREES, TRIGONOMETRIC ORIENTATION, starting 0 from X>0 half-axis. Trigonometric means it increases from X>0 half-axis to Y>0 half-axis. As such, orientation can go clockwise or counter-clockwise depending if the axes are reverted or not, like e.g. for astronomical plots (X increase to the left). The Position_Angle can be indifferently an array, a number, or omitted.

The code suboption in the /USER option, if present, can be any of 'SECONDS', 'MINUTES', 'DEGREES', 'RADIANS' (in which case the X and Y coordinates are taken to be in the corresponding unit) or 'ABSOLUTE' (in which case X and Y are taken as absolute coordinates, usually exprimed in sexagesimal format). The presence of the code suboption is valid only if a PROJECTION and a SYSTEM (EQUATORIAL or GALACTIC) are both defined.

A portion of the ellipse can be drawn by specifying the boundary angles in option /ARC (in degrees, trigonometric sense from the position angle). Not compatible with the array mode.

/FILL [Colour] will fill the ellipse(s), with the current pen colour or with the specified colour (see HELP PEN /COL for possibilities). If /ARC is also present, the filled area is the corresponding pie part, not the subtended arc.

/HATCH will fill the ellipse(s) with parallel lines. The pen (default current), line orientation in degrees (default 45), the separation in physical units (default 0.25 cm) and phase between 0 and 1 (default 0) can be customized. In this case the contour(s) are not drawn. If /ARC is also present, the filled area is the corresponding pie part, not the

subtended arc.

6.5 EXTREMA

[GREG2\]EXTREMA [/BLANKING Bval Eval] [/PLOT] [/COMPUTE] [/LOCAL PLOT|TERMINAL|FileName]

Computes and shows the minimum and maximum values of the Regular Grid array: shows XMIN,XMAX,YMIN,YMAX,ZMIN,ZMAX. A useful command for deciding where to set contour levels, or what size to give to the BOX if you want an exact aspect ratio between two coordinates. The current blanking value is used, but can be overridden using option /BLANKING.

Option /LOCAL specifies that instead of computing global extrema LOCAL extrema values should be computed and:

- PLOT: written at appropriate places on the plot. This is a very good way to avoid ambiguities in contour map. A shortest format is used for writing the values, and the character size controls the label size. /PLOT is an alias for /LOCAL PLOT.
- TERMINAL: written to the terminal,
- FileName: written to the given file name.

These arguments can be combined. If output is TERMINAL and/or file, X and Y values are offsets in radians.

If option /COMPUTE is not present, the global extrema are only computed if not already known (from a previous call to EXTREMA, or from an image header). /COMPUTE forces computation from the data array. It should be used if for any reason the known extrema are incorrect (invalid image header, killed bad pixel, change of blanking value...).

6.6 GRID

[GREG2\]GRID [Astep [Dstep]] [/ALTERNATE] [/LABEL]

Plots a grid of meridian and parallels according to the current projection and system. Astep is the grid step for meridian in degrees (Default 15), Dstep for Parallels (Default Astep). If one step is 0, this part of the grid is not plotted. If the /ALTERNATE option is present, the grid will be a grid in the alternate coordinate system (Equatorial or Galactic). This does not currently work for projection type AITOFF and RADIO.

If /LABEL is present, the meridians and parallels will be labeled with their absolute coordinates.

6.7 LEVELS

[GREG2\]LEVELS [Args ...]

LEVELS without arguments will display the contour levels used by command

RGMAP. The level values can also be found in the array GREG%LEVELS[GREG%NLEVEL] (not defined if no levels), where GREG%NLEVEL is the number of levels (0 if no levels).

```
[GREG2\]LEVELS NONE
```

reset the level list (and thus GREG%NLEVEL becomes 0).

```
[GREG2\]LEVELS C1 C2 TO C3 BY C4 ...
```

Sets the contour levels to be C1, C2, C2+C4, C2+2*C4, ..C3, and so on, using the same list format as SIC\ command FOR. The contour levels are used to make contour plots of the Regular Grid array using command RGMAP. Up to 40 contours can be given at a time. Note that it is more efficient to use a single RGMAP command with many levels than many RGMAP commands with a single level each.

```
[GREG2\]LEVELS EXPO Step [Linear Scale]
```

Sets the contour levels in a semi-exponential scale. Linear is the number of linear levels: levels from -Linear*Step to -Step by Step and Step to Linear*Step by Step are regularly spaced. Above Linear*Step, the next contour level is Scale times larger than the previous one. The defaults are Step=1, Linear=3 and Scale=sqrt(2).

6.8 MASK

```
[GREG2\]MASK [IN|OUT] [/BLANKING Bval]
```

masks all pixels of the Regular Grid array lying inside (if argument is IN) or outside (if argument is OUT or by DEFAULT) the current polygon (see command POLYGON) by attributing them a blanking value. This value is defined by command SET BLANKING, or specified using the option /BLANKING Bval.

6.9 MEAN

```
[GREG2\]MEAN [/CLIP Nsigma]
```

computes crude statistics on the part of the Regular Grid array lying inside the current polygon. Blanking values as defined in SET BLANKING are ignored. The results are displayed (some of them according to the current ANGLE_UNIT), and stored in the variables:
- POLY%NPIX (number of non-blanked pixels in the polygon),
- POLY%MIN
- POLY%MAX
- POLY%AREA (area of the non-blanked pixels),

- POLY%SUM (integrated intensity),
- POLY%RMS.

If option /CLIP is present, iterative kappa sigma rejection is used to reject outlier pixels.

6.10 PERSPECTIVE

[GREG2\]PERSPECTIVE [Altitude Azimuth] [/FACTOR Fv Ov] [/LOWER] [/LINES] [/STEP Nsx Nsy] [/AXES Xmin Xmax Ymin Ymax] [/CENTER] [/VERTICAL Vmin Vmax]

Makes a parallel projective view of the Regular Grid array, with hidden lines removed. If /LINES option is present, lines along a single axis are plotted. Altitude and Azimuth are the values of the corresponding viewing angles in Degrees. Default values are 30 and 45 at the beginning, and then the last values given. The upper part is drawn, unless the /LOWER option is present.

Automatic scaling to match approximately the current box is used, but it is only a rough guess and may fail if extrema of the Regular Grid occurs near the edges. Fine tuning of the plot scale can be obtained using the /FACTOR option. It controls scaling of the Regular Grid values by the factor Fv (default 1) and an offset Ov which is in physical units along the Y direction of the plot.

The Regular Grid array is plotted according to the orientation implied by command LIMITS, but the whole array is plotted. The /STEP option may be used to indicate to take only 1 pixel over Nsx ones for the X axis (resp. Nsy and Y). The /AXES option plots (X,Y) axes. The /VERTICAL option controls the max, min of plotted perspective and plots a Z axis. The /CENTER option centers the perspective. BLANKED PIXELS are forced to the minimum value of the map, or the Vmin value when the /VERTICAL option is in use.

6.11 PLOT

[GREG2\]PLOT [Varname] [/SCALING Type Low_cut High_cut] [/BLANKING Bval Eval] [/POSITION Posx1 Posx2 Posy1 Posy2] [/BOUNDARIES Userx1 Userx2 Usery1 Usery2] [/VISIBLE]

PLOT will put a pixel image (pixels contained in the variable Varname) inside the current BOX. Varname is a 2-D SIC variable name that defaults to the RG variable if omitted. Subsets like A[4] where A is a 3-D sic variable are not yet allowed. How to create and handle images in programs calling the GREG2\ language (including GREG) is described in the subtopic IMAGE_HOWTO.

This command is normally used in the following sequence:

```
Greg> SET BOX LOCATION Gx1 Gx2 Gy1 Gy2  ! Define box position
Greg> RGDATA Varname /VARIABLE          ! Put image in the RG variable,
                                        ! read associated header variables
Greg> LIMITS /RGDATA                    ! Computes associated limits
Greg> PLOT                              ! Plot the array in the box
Greg> BOX                               ! Draws the box
```

6.11.1 PLOT IMAGE_HOWTO

There exist a number of ways to get pixels into GREG2\:

- Read the X, Y, Z values of a Z=f(X,Y) "image", use RGDATA (if X and Y define a regularly sampled grid) or RANDOM (if X and Y are "random points") to make a Regular Grid Map (see HELP GREG1\COLUMN, GREG2\RGDATA and GREG2\RANDOM)
- Read a RGDATA-format file with the RGDATA command (see topic RGDATA)
- Define a 2-D SIC variable and fill it with values, or connect a SIC variable with an existing GILDAS DATA FORMAT (GDF) image (see HELP SIC\DEFINE), or use the SIC\ACCEPT command to read formatted/unformatted streams of values and put them in a SIC 2-D variable (see HELP SIC\ACCEPT). Then give this 2-D variable to the internal image buffer by the RGDATA Varname /VARIABLE command.
- The command GREG3\IMAGE connects directly an existing 2, 3 or 4-D GILDAS DATA FORMAT image in the GREG image buffer. See HELP GREG3\IMAGE for details.

FITS files can also be loaded in Greg:

- Use the VECTOR\FITS command to convert a FITS image to a GDF (Gildas Data Format) image that will be directly readable afterwards.
- "on-the-fly" automatic conversion from FITS to GDF format for GREG3\IMAGE command.
- avoid disk-to-disk conversion by loading the FITS directly in memory with the command SIC\DEFINE IMAGE.

See each command HELP for details.

6.11.2 PLOT /BLANKING

```
[GREG2\]PLOT /BLANKING Bval Eval
```

Blanking value (Bval) and tolerance (Eval). Default values are those defined by SET BLANKING command.

6.11.3 PLOT /BOUNDARIES

```
[GREG2\]PLOT /BOUNDARIES Userx1 Userx2 Usery1 Usery2
```

User coordinates corresponding to the image boundary. The default is

those of the plotted image (when the image has any), or the current user limits if not.

6.11.4 PLOT /POSITION

[GREG2\]PLOT /POSITION Posx1 Posx2 Posy1 Posy2

Box location in physical units (default is the current GreG box location).

6.11.5 PLOT /SCALING

[GREG2\]PLOT /SCALING Type [Low_cut High_cut]

Defines the type of transfer function to be used. Type can be LINear, natural LOGarithmic, or EQUalization. The Low_cut and High_cut are the lowest and highest represented values respectively. The default "cuts" are the image extrema. The current cuts are stored in the variable array CURIMA%SCALE. The current scaling (as an integer code) is stored in the variable CURIMA%SCALING.

The LOG transfer function computes the logarithm of the pixel values. There can be negative pixel values as long as the low and high cuts remain positive. If one or two cuts are negative or null, they will be implicitly replaced with a better suited positive value (lowest positive or highest positive value depending on the cut).

The EQUalization scaling tries its best to put the same number of pixels in each slot of the color table, thus increasing immensely the visibility of low-contrast images. This scaling mode has problem (and warns user) when a large number of pixels have exactly the same value (i.e., no contrast at all). Beware that most "real" images are obtained with receivers working with a small number (11 to 16) of bits, thus restricting the range of available Real numbers in the data.

The SIC variables CURIMA%EQUAL%NLEV, CURIMA%EQUAL%LEV and CURIMA%EQUAL%HIST contain the number of different levels computed in EQUALIZATION mode, the values of these levels, and the number of pixels in each level, respectively. Useful to know which contour levels to draw, and necessary for the WEDGE command.

6.11.6 PLOT /VISIBLE

[GREG2\]PLOT /VISIBLE

Specify that the image is to be always drawn, even when totally masked by an overlapping image. This allows special features like movies when the plot content is drawn or redrawn, although the "movie" speed depends on the computer power.

6.11.7 PLOT RGB

PLOT [3D_Var] [/SCALING LIN|LOG|EQU [Rlcut Rhcut Glcut Ghcut Blcut Bhcut]]
PLOT [3D_Var] [/SCALING LUPTON [Beta]]

THIS FEATURE IS CURRENTLY EXPERIMENTAL. Calling sequence, option names, and behavior are subject to changes in the future.

If the RG buffer (or the named variable, if any) is a 3D cube with 3 planes, the command will plot it as a RGB image (R for 1st plane, G for 2nd plane, B for 3rd plane).

The extrema are always (re)evaluated for each plane individually. That is, global cube extrema and RG%MIN and RG%MAX (if available) are ignored.

The default is to display the whole extrema ranges with linear scaling. This can be overridden with the option /SCALING, giving a custom scaling and cuts for each plane. Lupton scaling (combining each planes in a non-independent way) is available; Beta factor defaults to 3 but can be customized.

6.12 POLYGON

[GREG2\]POLYGON [(File)Name] [/VARIABLE]
[GREG2\]POLYGON [/PLOT] [/FILL [Colour]] [/HATCH [Ipen] [Angle] [Separ] [Phase]]
[GREG2\]POLYGON [(File)Name] /RESET

The first syntax defines the polygon either from:

CURSOR

If no argument and no option, the interactive cursor is invoked to define the polygon summits. Type any key to go to next summit, C to correct the last one, D to delete it, and type E to end the polygon definition. The last polygon side will then appear. The polygon definition may be aborted by typing Q. For graphical displays, you may use the mouse buttons for the commands. The left mouse button draws a vertex, the middle mouse button deletes the last vertex, and the right mouse button ends the polygon definition. After the use of the cursor, the polygon plot is stored in the GTV metacode in a segment named POLYGON. You can delete it with the command CLEAR SEGMENT.

FILE

If a file name is given as argument, the cursor is not called. The summit coordinates are read from the named ASCII file (X in column 1, Y in column 2).

VARIABLE

If a SIC variable name is given with the /VARIABLE option, the sum-

```
    mit coordinates are read either from a variable array of the form:
         VAR[NXY,2]  Real or Double
    or a structure of the form (i.e. same as output):
         VAR%NXY         Integer or Long
         VAR%X[VAR%NXY]  Real or Double
         VAR%Y[VAR%NXY]  Real or Double
Whereever they come from (cursor, file, or variable), the polygon values
are stored internally; they can be printed with the command
GREG2\WRITE POLYGON, and they correspond to the variables POLY%NXY (num-
ber of vertices), POLY%X and POLY%Y (the corresponding coordinates). The
currently defined POLYGON is used by the commands MEAN and MASK.

The polygon loaded by the command can be directly or later plotted with
the following options:
/FILL [Colour]
    the polygon is color-filled with the current pen colour or with the
    specified colour (see HELP PEN /COL for possibilities),
/HATCH [Ipen] [Angle] [Separ] [Phase]
    the polygon is filled with parallel hatch lines with the specified
    pen (default current), with the given angle in degrees (default 45),
    separation in physical units (default 0.25 cm), and phase from 0 to
    1 to displace the lines by this fraction of the separation from a
    fixed reference (default 0).
/PLOT
    the polygon contours are drawn with the current pen,
For a color-filled and/or hatched and/or contoured polygon, these three
options can be combined; they will be executed in the above order.

Finally, the third syntax with the /RESET option allows to undefine the
POLY% variable and free the internal buffers.
```

6.13 PROJECTION

```
    [GREG2\]PROJECTION [A0 D0 [Angle]] [/TYPE Ptype]

Define a projection of the (celestial) sphere from point of (A0,D0),
(which are Longitude and Latitude respectively) of the specified type.
Angle is the angle between the Y axis and the North pole. The previous
values are kept if no argument is specified. All angles are in degrees,
except if the SYSTEM is EQUATORIAL in which case A0 is the right ascen-
sion and must be specified in hours. Formats like -dd:mm:ss.s or
hh:mm.mmm in sexagesimal notation up to the point field are allowed. Af-
ter the point, decimal values are assumed.

When a projection is active, the User coordinates are assumed to be pro-
jected coordinates of the sphere, and hence in the case of small field
of view where distortion are negligible, correspond to angular offsets
MEASURED IN RADIANS. The field of view of the projection is defined by
```

command LIMITS.

The TYPE can be

NONE — Disables the projection system. User coordinates then loose their interpretation in terms of projected coordinates. The ANGLE_UNIT is then totally ignored.

CARTESIAN — Cartesian projection with linear coordinates in both directions, with a possible projection angle.

GNOMONIC — Radial projection on the tangent plane. Being R and P the (angular) polar coordinates from the projection point (tangent point), the projected coordinates are given by X = Tan(R).Sin(P) and Y = Tan(R).Cos(P) .

ORTHOGRAPHIC — View from infinity. X = Sin(R).Sin(P) and Y = Sin(R).Cos(P)

AZIMUTHAL — Spherical offsets from the projection center. X = R.Sin(P) and Y = R.Cos(P).

STEREOGRAPHIC — Uses Tan(R/2) instead of Tan(R), and is thus less distorted than the Gnomonic projection. This is an inversion from the opposite pole.

LAMBERT — Equal area projection. Projected distance is 2*Sin(R)/Sqrt(2*(1+Cos(R)).

AITOFF — Equal area projection. Angle and D0 are ignored.

RADIO — The standard radio astronomy single dish mapping "projection", in which X = (A-A0).COS(D) and Y = D-D0. The Angle is obviously ignored.

SFL — Sanson-Flamsteed projection, similar to the RADIO projection with one exception: X = (A-A0).COS(D-D0) and Y =D-D0. Beware that an Euler rotation of the celestial sphere is necessary as an additional step, i.e. (A0,D0) and (A,D) here are not the absolute celestial coordinates (see Calabretta & Greisen 2002).

MOLLWEIDE — Equal area projection. Angle and D0 are ignored. The projection trades accuracy of angle and shape for accuracy of proportions in area, and as such is used where that property is needed, such as maps depicting global distributions.

NCP North Celestial Pole. Projection to a plane perpendicular to the pole. Used by the WSRT.

6.14 RANDOM_MAP

[GREG2\]RANDOM_MAP [Arg1 [Arg2]] [/NEIGHBOURS Nb] [/TRIANGLES] [/EXTRAPOLATE] [/BLANKING Bval] [/VARIABLES Vx Vy Vz] [/SKIP [TRIANGULATION] [INTERPOLATION]]

This command is a general purpose interpolation task which uses data from the X, Y and Z arrays (or those specified in option /VARIABLES) to fill in a Regular Grid array representing the same surface Z=f(X,Y) by an interpolation process. X, Y and Z are arrays defined by the COLUMN command (see HELP COLUMN). It triangulates the data for interpolation. If a triangulation already exists, and only the Z array has been changed, RANDOM_MAP does not make a new triangulation.

Often, the user-provided Z=f(X,Y) surface is REGULARLY SAMPLED, even if NOT COMPLETELY SAMPLED. In this case, it is recommended to use directly the RGDATA command to create a Regular-grid map, since RANDOM is known to perform awkwardly with regularly sampled data.

The interpolated grid can be defined by the arguments. If Arg1 is "RGMAP", the interpolated grid will be exactly coincident with the current Regular Grid array, else Arg1 and Arg2 are used to indicate the number of pixels in X and Y directions and Arg2 = Arg1 if not specified. If no argument is specified, the previous grid (if any) is reused (see also subtopic /SKIP).

Note that several hypothesis are made about the geometry of triangles in the plot page space (hence the geometry may be changed by changing the LIMIT or the BOX_LOCATION). You should thus use limits which gives a reasonable representation of what are the neighbours of a given data point. Moreover, this is an interpolation process. Hence if the basic sampling theory is not respected by your choice of input data points and output grid, spurious oscillations may occur in the resulting grid.

6.14.1 RANDOM_MAP /BLANKING

[GREG2\]RANDOM_MAP /BLANKING Bval

Specify the value Bval to be attributed for pixels lying outside the convex hull of triangles. The default value is that defined in the SET BLANKING command. This switch is mandatory if no default blanking value is preset and no extrapolation required.

6.14.2 RANDOM_MAP /EXTRAPOLATE

[GREG2\]RANDOM_MAP /EXTRAPOLATE

Control whether extrapolation outside the convex hull of the triangles is to be done or not. The default is not, i.e. the command fills with the blanking value the exterior of the convex hull. Beware that extrapolation is always hazardous.

6.14.3 RANDOM_MAP /NEIGHBOURS

[GREG2\]RANDOM_MAP /NEIGHBOURS Nb

The argument Nb changes the number of points influencing the interpolated values. Default is 4 and values up to 8 may be used in some cases. Caution, it slows down the program, and may enhance oscillations in some cases.

6.14.4 RANDOM_MAP /SKIP

[GREG2\]RANDOM_MAP /SKIP [TRIANGULATION] [INTERPOLATION]

The option /SKIP will avoid recomputing the triangulation and/or interpolation, in order to save time e.g. on large maps. Those optimizations are under the responsibility of the user, who should know if the context (e.g. variables) has changed or not. The command can not guess it by itself.

- /SKIP TRIANGULATION can be used if the triangulation has already been done. The triangulation depends on the x and y values, which can come from the X and Y buffers or /VARIABLES Vx Vy, but also on the current plot limits.
- /SKIP INTERPOLATION can be used if gridding (interpolating) has already been done. It depends on the z values, which can come from the Z buffer or /VARIABLES Vz. It also depends on the triangulation.

Note that the command may not honor the skip request if it detects that the context has changed. This is true e.g. at first call of the command.

6.14.5 RANDOM_MAP /TRIANGLES

[GREG2\]RANDOM_MAP /TRIANGLES

Plot the triangles selected by the program for interpolation. A single graphic segment will contain all triangles.

6.14.6 RANDOM_MAP /VARIABLES

[GREG2\]RANDOM_MAP /VARIABLES Vx Vy Vz

Use variables Vx Vy Vz instead of the default X,Y,Z buffer to compute the map.

6.15 RESAMPLE

[GREG2\]RESAMPLE Nx Ny [/X Xref Xval Xinc] [/Y Yref Yval Yinc] [/BLANKING Bval]

This command resamples (by bilinear interpolation) the current regular grid array on a different grid. The number of pixels of the new grid must be specified. Unless the user specifies an explicit conversion formula in the /X and /Y options, the program adjusts it to match the current Regular Grid array. A blanking value MUST BE specified (either by default in SET BLANKING or using the option /BLANKING) because no extrapolation is performed. For the same reason, any output pixel's value that would be interpolated from at least one input blanked pixel, is itself blanked.

6.16 RGDATA

[GREG2\]RGDATA [Name|Array_X Array_Y Array_Z] [/SUBSET NXmin NYmin NXmax NYmax] [/VARIABLE] [/FORMAT Fmt [code]] [/INCREMENT IncX IncY] [/BLANKING Bval]

This command optionally creates, then loads a two-dimensional map into the Regular Grid array (to be contoured by RGMAP, plotted by PLOT...). This is THE basic command needed for subsequent 2-dimensional treatment. "Regular Grid" means that data is internally stored as a two-dimensional array, thus lies on a Regularly sampled Grid. The user-provided "pixel values" may come from various "descriptions" of such regularly sampled (but possibly uncompletely sampled) data:

1) Three 1-dimensional arrays, say, X Y and Z, that contain Z=f(X,Y) at regular intervals in X and Y.
2) A preexisting internal 2-D array (possibly a section of a 3D or 4D array).
3) An external, specially formatted, file.

For data NOT REGULARLY ("randomly") sampled, use the GREG2\RANDOM_MAP command instead. The Regular Grid buffer can be saved in a file with the command GREG2\WRITE.

Once defined, the Regular Grid description and data are available under the SIC variables:

- RG: the data array e.g. RG[1,1]
- RG%NX: dimension along X
- RG%XREF, RG%XVAL, RG%XINC: X axis conversion
- RG%NY: dimension along Y
- RG%YREF, RG%YVAL, RG%YINC: Y axis conversion

- RG%MIN, RG%XMIN, RG%YMIN: minimum value and position
- RG%MAX, RG%XMAX, RG%YMAX: maximum value and position

The following command syntax is used to deduce which "description" is provided:

- With 0 or 3 arguments, RGDATA will try to assemble Z=f(X,Y) either from the X,Y and Z arrays (as defined by command COLUMN) or from "Array_X Array_Y Array_Z", that should be 1D SIC variables previously created. The option /INCREMENT is used to force the X and Y sampling interval to (IncX,IncY) in case of roundoff errors. Defining twice the same pixel is an error. If a blanking value is currently defined, non-sampled pixels will be attributed this value, which is overriden by the Bval value of the /BLANKING option. Note that, if a blanking value is currently defined, pixels for which X or Y are in the blanking range are themselves blanked.

- With ONE argument (Name) following the command, Name is taken as the name of an existing SIC 2D variable if option /VARIABLE is present. Otherwise, Name is a specially formatted file (see HELP RGDATA FILE_FORMAT) from which the Regular Grid array must be read in.

A rectangular subset of the array defined by the pixel coordinates of the Bottom Left Corner and Top Right Corner can be selected thanks to the /SUBSET option.

6.16.1 RGDATA FILE_FORMAT

The format for the input file consits of a four line header as such:
1st line : NX XREF XVAL XINC
2nd line : (any comment for first axis, could be blank)
3rd line : NY YREF YVAL YINC
4th line : (any comment for 2nd axis, could be blank)
followed by the data (NX times NY pixel values) in a format which can be specified with the /FORMAT option when the default 10z8 is not used.
NX is the number of pixels in the 1st dimension of the map (on the "X axis"), XREF the index of the pixel for which the actual X abscissa value is XVAL, the increment between two pixels being XINC, and the same for the y axis. Thus, the abcissa X of the pixel 'I' is just X=(I-XREF)*XINC+XVAL
This format is very simple-minded (so that any inexperienced programmer can use it in less than 5 minutes), but highly non efficient in I/O processing. A more elaborate data format ("IMAGES"), specially suited for astronomical applications and large maps is available through GREG3\ language (command GREG3\IMAGE), or directly using SIC variables (command SIC\DEFINE) and the /VARIABLE option of this command. One should read once its data in RGDATA format in GreG, then convert it for future use

in IMAGE format with the command GREG2\WRITE IMAGE filename.

See also the IMAGE_HOWTO subtopic of the GREG2\PLOT command.

6.16.2 RGDATA /FORMAT

The /FORMAT option governs how the data part (pixel values) of the RGDATA file must be read by GreG. Fmt is a valid fortran format (default is 10z8, the minimal way to encode real*4 data). code may be BY, R4, R8, I4 or I2, depending if the data written in the file are BYtes, Real4, Real8, Integer4 or Integer2. (The values in the GreG map will always be Reals*4 after the read is done).

6.17 RGMAP

[GREG2\]RGMAP [Quiet|Fast|chunksize] [/PERCENT P1] [/ABSOLUTE A1] [/BLANKING Bval Eval] [/GREY COLOUR N] [/KEEP File_Name [Blank]] [/PENS [Pos Neg]] [/ONLY POSITIVE|NEGATIVE]

Draws (or fills) isocontours of the Regular Grid array. The RG is an internal 2D "map" created/loaded by various commands (RGDATA, RANDOM_MAP, RESAMPLE, IMAGE), or loaded by a calling program. The levels are those specified by command LEVELS, but may be affected by a scaling factor by option /PERCENT or /ABSOLUTE.

This command is normally used in the following sequence:

```
Greg> SET BOX LOCATION Gx1 Gx2 Gy1 Gy2  ! Define box position
Greg> RGDATA (options...)               ! Put image in the RG variable,
                                        ! read associated header variables
Greg> LIMITS /RGDATA                    ! Computes associated limits
Greg> PLOT                              ! Plot the array in the box
Greg> BOX                               ! Draws the box
Greg> LEVELS 0.1 to 0.9 by 0.1          ! define contour levels
Greg> RGMAP /PERCENT 1                  ! Draw contour levels  (in this
                                        ! case, as percentage of peak)
```

The "Quiet" mode does contouring silently. For "Fast" and "chunksize" modifiers, see subtopic MEMORY_OPTIONS.

6.17.1 RGMAP MEMORY_OPTIONS

The program normally allocates less that 1/5 of the total number of pixels in the map to store the contour segments, and warns the user when that limit is reached. Besides, contouring may be slow on large maps. The modifier "Fast" cuts the map in smaller "chunks" and performs contouring on those submaps, without the 1/5 above limitation.

The Contour-filling mode (/GREY) can consume (temporary) a large amount of memory, so is always performed on subsets of the image ("chunks") when the image size is greater than a system-dependent limit (256*256 on UNIX systems). When the contours are too involved, an internal limit can nevertheless be reached. One can then retry the contour-filling by specifying a smaller "Chunksize" (in pixels). For example, to force contour-filling on subsets of 64 "lines" of a 512x512 pixel image, type RGMAP 64*512 /GREY

6.17.2 RGMAP /ABSOLUTE

[GREG2\]RGMAP /ABSOLUTE A1

Contour levels are multiples of A1, e.g. for LEVELS 1 2 3, the contour used will be A1 2*A1 3*A1.

6.17.3 RGMAP /BLANKING

[GREG2\]RGMAP /BLANKING Bval Eval

Override the current blanking value as defined by command SET BLANKING. Contours are not drawn in pixels touching pixels with value V so that ABS(V-Bval) <= Eval. This is extremely useful for regular grids only partially filled as often occur in astronomy.

6.17.4 RGMAP /GREY

[GREG2\]RGMAP /GREY [start [step] [background]]

On graphic displays with area filling capabilities, fills contours with up to 16 different color pens (but the number of contours is not limited to 16). These pen colors may be changed in the same manner as for the pixels colors (see HELP LUT /PEN). "start" (default 0) and "step" (default 1) may be used to change the exploration of the 16-pen palette. "background" is the number of a color used to fill the map before contour-filling, thus providing a user-defined background for the contour-filled map.

In case of Filling problems, see the subtopic MEMORY_OPTIONS of this HELP.

6.17.5 RGMAP /KEEP

[GREG2\]RGMAP /KEEP File_Name [Blank]

Will keep a formatted copy of the coordinates of the contour points in the specified file. This file can later be used as an input file for COLUMN. X coordinates are in column 1 and Y coordinates in column 2. The Blank value is written as a separator value for later CONNECT /BLANKING

Blank. Blank defaults to the SET BLANKING value if it exists, else Blank is mandatory.

6.17.6 RGMAP /ONLY

```
[GREG2\]RGMAP /GREY /ONLY POSITIVE|NEGATIVE
```

Apply the filling capabilities provided by the /GREY option only to positive or negative contours for better clarity.

6.17.7 RGMAP /PENS

```
[GREG2\]RGMAP /PENS [Pos Neg]
```

Selects the pens for positive and negative contours. Three modes of operation are possible :

- Without option /PENS, positive contour levels use pen 0 and negative contour levels use pen 15. Positive means that the value given in command LEVELS is positive, not the final contour level value which is affected by a possibly negative factor.
- With option /PENS, all contours use the current pen.
- With /PENS Pos Neg, positive contours use pen number Pos and negative contours use pen number Neg.

6.17.8 RGMAP /PERCENT

```
[GREG2\]RGMAP /PERCENT P1
```

Computes M=MAX(ABS(min),ABS(max)) of the data to be contoured. Contour levels selected with LEVELS are multiples of P1 percent of M. E.g. if P1 = 10 and LEVELS 1 2 5 9, the contour levels are 10, 20, 50 and 90% of the peak value.

From the above rule you can deduce the absolute level values with the following commands:

```
DEFINE REAL ABSLEVELS /LIKE GREG%LEVELS
LET ABSLEVELS MAX(ABS(RGMIN),ABS(RGMAX))*P1*GREG%LEVELS/100
EXA ABSLEVELS
```

6.18 STRIP

```
[GREG2\]STRIP [X1 Y1 X2 Y2]
```

Will extract from the current Regular Grid array a strip going through points (X1,Y1) and (X2,Y2) in User coordinates. If no arguments are present, it will call the cursor to set the two points. Although the end points need not be on the map boundaries, STRIP will always produce a full strip across the map.

For strip parallel to the X or Y map axis, the nearest pixel is used to fill the values. For any other strip orientation, if the tangent of the angle is less than (NY-1)/(NX-1) (i.e. if you scan the X map axis faster than the Y map axis), the number of resulting points on the strip profile will be NX and the user coordinates along the strip will be the map X coordinate. For each pixel, interpolation along the Y axis is done using the three nearby Y pixels. A similar situation with X replacing Y occurs if the angle is larger.

The map user coordinates are put into the X buffer, and map values into the Y buffer. The strip can then be plotted using CONNECT, but remember to set decent limits before.

6.19 WEDGE

[GREG2\]WEDGE [Top|Bottom|Left|Right [Size]] [/SCALING Lin|Log|Equ Min Max] [/LEVEL [Label]]

Will plot a WEDGE along the current BOX. WEDGES are used after a PLOT command to show the relationship between pixel hues and image values.

The default position is Right, i.e., on the right side of the box, but the other location and size modifiers are self-explanatory. The SCALING defaults to the current scaling of the last image PLOTted, but can be changed (as in command PLOT) with the /SCALING option.

The /LEVEL option will draw levels (as defined by the LEVEL command) at their appropriate location on the wedge. The modifier Label will label the wedge axis with the level values. This is the default (i.e., some levels should be defined) for the EQUALIZATION Mode, for which the relationship between pixel hues and image values is strongly non-linear.

6.20 WRITE

[GREG2\]WRITE Item File_Name
[GREG2\]WRITE COLUMN File_Name [OLD|NEW [Format]] /TABLE [X Nx] [Y Ny] [Z Nz]

This command is used to save some GreG internal buffers on an output file for later processing. The item specifies what is to be saved, and the format of saving, and can be :

POLYGON
Save the current polygon in a formatted way on two columns easily readable by command COLUMN or POLYGON later. The default extension is .POL

RGDATA
Save the current Regular Grid array on a RGDATA-like output file (to preserve the result of a masking, or of a random mapping interpolation). See also HELP RGDATA FILE_FORMAT. The default extension is .DAT

IMAGE
Same as above but use the more efficient and complete IMAGE data format of GILDAS. The default extension is .GDF

COLUMN (no option)
Save the current X Y Z buffers on a formatted output file (after a SORT or a STRIP for example). The default extension is .DAT

COLUMN /TABLE
Save the X Y Z buffers but on column Nx, Ny, Nz of the specified output table (Gildas Data Format). A new table is created if argument NEW is specified, otherwise the table must already exists (default OLD). The format of NEW tables can be specified as a 4th argument in REAL (default), DOUBLE or INTEGER. The OLD tables may be expanded if any of Nx, Ny or Nz exceed the table column number ; exact match on the number of lines is required. The tables can be read by command COLUMN /TABLE.

7 GREG3 Language Internal Help

The commands of this language are obsolescent. They will either disappear or be remplaced sooner or later.

7.1 Language

GREG3\ Language Summary

```
IMAGE [Filename] : Reads the GDF map Filename. Default extension is .GDF
KILL             : Kills pixels.
SPECTRUM         : Extracts or compute a mean spectrum from an image.
```

7.2 IMAGE

[GREG3\]IMAGE [Filename] [/PLANE I1 I2] [/SUBSET Imin Imax Jmin Jmax] [/WRITE] [/CLOSE]

Read the GDF map Filename. The default image extension is .gdf. This command defines the image found in given file as the new current image. Projection, system and extremas are also defined if needed. Unless options are present, the first plane of the image becomes the new Regular Grid (RG) array in GreG.

Associated "G_*" variables are defined after the first call to the IMAGE, SPECTRUM or KILL commands of GREG3\ language. Be careful that the "G_*" variables might not reflect the RG current contents if it is later modified by a GREG2\ command (e.g. RESAMPLE).

The /PLANE I1 I2 option allows to define part of a more than 2-Dimensional image as the regular grid array. A file name should not be specified if you want to select a new plane in the current image.

The /SUBSET Imin Imax Jmin Jmax option allows to load only a subset of the input image or image plane. Again, a file name should be specified only to change the input image. You can combine /PLANE and /SUBSET options.

At open time, the /WRITE option allows you to map the image writeable (instead of Readonly by default), a prerequisite to use some functions (e.g. KILL which kills pixels).

The /CLOSE option allows you to close the currently opened file, and to free associated memory, if any.

Without option nor argument, the header of the image currently in memory is listed, if any.

7.3 KILL

```
[GREG3\]KILL
```

KILL calls the interactive cursor to interact with the current IMAGE buffer. The buffer must have been loaded in write mode (IMAGE /WRITE). Recognised keys are:
- V to give the value of the pixel,
- K to give the current blanking value to the pixel,
- I to interpolate the value from the neighbour pixels,
- E to exit from interactive cursor mode.

Any other key is ignored.

7.4 SPECTRUM

```
[GREG3\]SPECTRUM I [J [K]]
    or
[GREG3\]SPECTRUM OutSpec InCube [Mask] [/CORNER Imin Imax Jmin Jmax]
[/PLANE First Last] /MEAN or /SUM
```

SPECTRUM I [J [K]]
Extract a spectrum from an image according to the following numbering:
Spectrum (l) = Image (l,i,j,k)
for a 4-dimensional image. The spectrum is loaded into the X,Y buffers of GreG. It can be processed later by the standard commands LIMITS, CONNECT, CURVE and so on.

The alternate syntax, used if any option is present, computes in the output variable OutSpec a mean or integrated spectrum over the specified region of the input Image variable InCube, using the current Greg polygon and the specified Mask if any.

7.4.1 SPECTRUM /CORNER

```
[GREG3\]SPECTRUM OutSpec InCube [Mask] /CORNER Imin Imax Jmin Jmax
[/PLANE First Last] /MEAN] or /SUM
```

Restricts the computation to the specified 2-D region of the data cube. One of the mutually exclusive options /MEAN or /SUM must be present.

7.4.2 SPECTRUM /MEAN

```
[GREG3\]SPECTRUM OutSpec InCube [Mask] /MEAN
[/CORNER Imin Imax Jmin Jmax] [/PLANE First Last]
```

Indicates that we are computing a Mean spectrum, not extracting

a spectrum from the default Greg data cube. The spectrum is
the average spectrum accounting for all valid values.

7.4.3 SPECTRUM /PLANE

[GREG3\]SPECTRUM OutSpec InCube [Mask] /PLANE First Last
[/CORNER Imin Imax Jmin Jmax] /MEAN or /SUM

Restricts the spectrum to the specified channels of the data cube.
One of the mutually exclusive options /MEAN or /SUM must be present.

7.4.4 SPECTRUM /SUM

[GREG3\]SPECTRUM OutSpec InCube [Mask] /SUM
[/CORNER Imin Imax Jmin Jmax] [/PLANE First Last]

Indicates that we are computing an integrated spectrum, not extracting
a spectrum from the default Greg data cube. Blanked pixels
are treated as zeros. The result corresponds to the integral
of the signal over the valid area (sum of values times the
pixel size in user units).

/SUM is typically used to compute integrated flux from Jy/Beam
units.

8 GTVL Language Internal Help

8.1 Language

```
                        GTVL\ Language Summary

CHANGE      : Change some attributes of the plot.
CLEAR Arg   : Clear (some parts of) the plot or windows.
COMPRESS    : Remove invisible parts of the plot.
CREATE Arg  : Create directory, windows or LUTs.
DESTROY Arg : Destroys (some parts of) the plot or windows.
DEVICE      : Open the graphic device.
DISPLAY     : List some parameters of the plot.
GTV SEARCH  : Search for a GTV directory.
HARDCOPY    : Get a printed copy of the plot.
LENS        : Call the lens on the active window.
LUT [arg]   : Change the color Look-Up-Table.
METACODE    : Save or load part of the plot to/from metacode file.
REFRESH     : redraw all or some windows
REPLICATE   : Copy a directory to another place.
ZOOM        : Zoom on the plot (possibly in another window).
```

8.2 CHANGE

```
   [GTVL\]CHANGE Item SegName Value [Val2 [Val3]]
   [GTVL\]CHANGE Behaviour Value

Changes some attribute of the Graphic Library. Two items concern the
current directory and active windows:
  - CHANGE DIRECTORY [DirName [WinNum]]
      changes the default directory to DirName (default is to change to
      the top directory), and optionally the active window number to
      WinNum (instead of 1) within this directory. The current working
      directory is stored as a character string in the SIC variable
      GTV%PWD.
  - CHANGE WINDOW WinNum|ZOOM
      changes the active window number to WinNum or to the ZOOM window.
      The active window is in particular the one in which the cursor ap-
      pears for commands which use it.

Some other items are image segment attributes:
  - CHANGE SCALING    SegName LIN|LOG [Lcut [Hcut]]
      will change the transfer function for the specified image segment.
  - CHANGE BLANKING   SegName BLACK|WHITE|Colour
      will change the colour of blanked pixels (if any) in the displayed
      image. Colour is a colour value as in PENCIL command (1-8).
  - CHANGE COLOUR     SegName Value
  - CHANGE DASH       SegName Value
  - CHANGE DEPTH      SegName Value. See subtopic for details.
```

- CHANGE VISIBILITY SegName ON|OFF
- CHANGE WEIGHT SegName Value

The last five items are general segment attributes. For these, if SegName is a segment, only that segment is modified, but if it is a directory, all segments attached to this directory are modified accordingly. See subtopic SEGMENT_NAMES for details on naming segments.

And finally, some general behaviours can be changed will the following keywords:

- CHANGE LUT STATIC|DYNAMIC
  toggles the Look-Up-Tables to STATIC or DYNAMIC mode. Default is DYNAMIC. See subtopic LUT for details.
- CHANGE PENCIL HARD|SOFT
  specifies whether the GTV library should use the (output dependent) hardware generator for dashes and thickness, or whether it should use its own (output independent) software emulation. Hardware generator may (or may not) produce nicer output, and may be faster...
- CHANGE POSITION
  changes the window position on the screen. See subtopic for details.

8.2.1 CHANGE DEPTH

The GTV segments have a depth attribute in order to create, control, or reorder different drawing layers. Depth value must lie in range 1-40.

By default, all vector-like segments are at depth 1. Images are always at the deepest available depth (2 at startup) so that e.g. the BOX is always drawn on top of a PLOT, independently of their creation order.

In practice, when the plotting window is refreshed, it draws first all the segments at deepest level, then all the segments at deepest level minus one, and so on up to level 1. For a given depth, segments are drawn in chronological order (i.e. in the order they were created).

8.2.2 CHANGE LUT

Specifies whether the color Look-Up-Tables (LUT and LUT /PEN) are static, i.e. associated with each graphic segment, or Dynamic, i.e. controlled by the terminal colors. This changes the behaviour of the LUT and LUT /PEN commands.

In STATIC mode, each graphic segment has its own LUT, so that this allows to display complex plots with many colors. The LUT and LUT /PEN which are stored with each segment must be set before the segment creation. It cannot be changed after. In this mode, the display may differ

from the hardcopy output, because not all interactive displays support many colors.

In DYNAMIC mode, one single LUT its associated to the plot. It can be changed dynamically afterwards using the LUT (and LUT /PEN) commands. It is appropriate for interactive visualisation. The hardcopy output will be identical to the display.

The default is DYNAMIC.

8.2.3 CHANGE POSITION

```
CHANGE POSITION Num
CHANGE POSITION Posx[Unitx] Posy[Unity]
```

The first syntax moves the current window to the specified position, where Num is in the range 1-9. The 9 most remarkable points of the screen (corners, middle of the sides, and center) are numbered according to a VT100 numeric keypad notation.

The second syntax moves the current window to the specified coordinates. The recognized units are 'p' for pixels, and '%' for percent of the screen size. Units default to 'p' if they are omitted.

8.2.4 CHANGE SEGMENT_NAMES

The 'SegName' used in all the CHANGE commands is formed by a name, given by the calling high-level program (usually a reminder of the command used), followed by an unique, incremental, number. To refer a particular segment, one uses the full name (as in CHANGE VISIBILITY CONTOUR:46 OFF). To refer to ALL the segments with the same name, omit the number (as in CHANGE VISIBILITY CONTOUR OFF). To refer to a range of segments, use a 'minus' sign in the range (as in CHANGE VISIBILITY CONTOUR:32-46 OFF). Segments names can be the segment name, as in CHANGE VISIBILITY *TOUR OFF).

8.3 CLEAR

```
[GTVL\]CLEAR [Arg [Value]]
```

CLEAR without argument performs a CLEAR ALL, i.e. it empties all the top directories and thus their associated windows.

Consult the following sections for the various CLEAR arguments.

8.3.1 CLEAR ALL

```
CLEAR ALL
```

Performs a CLEAR DIRECTORY on all the top directories, i.e. they are emptied and their attached windows are cleared.

8.3.2 CLEAR DIRECTORY

CLEAR DIRECTORY [DirName]

Empties the named directory (or by default the current directory), i.e. remove the segments and subdirectories it contains. As a consequence, under X, the windows attached to input directory are also cleared.

If the subdirectories had windows attached, they are destroyed in conjunction to them. If the current working directory has to be destroyed, i.e. it is a subdirectory of the directory to be cleaned, it is implicitely moved to the latter.

8.3.3 CLEAR SEGMENT

CLEAR SEGMENT [SegName]

Without argument, CLEAR SEGMENT destroys the last graphic segment of the current directory, i.e. in simplest case the part of the plot corresponding to the last graphic command. It can be used repetitively.

CLEAR SEGMENT SegName makes destroys the named segment.One can erase a range of graphic segments in a single command by typing a range of segment numbers, as in CLEAR SEGMENT 24-16. See command GTVL\CHANGE for details.

8.4 COMPRESS

[GTVL\]COMPRESS

Compress the internal metacode, by removing all the invisible segments and directories.

8.5 CREATE

[GTVL\]CREATE Argum Value [options]

Creates either a directory, a window, or a Look Up Table stored in the metacode.

8.5.1 CREATE DIRECTORY

CREATE DIRECTORY PathName [/PLOT_PAGE SizeX SizeY] [/GEOMETRY Args] [/POSITION Args]

Create a new directory. PathName syntax follows "Unix-like" pathnames, with the use of token '<' instead of '/'. Constructs like ..<Dir are valid.

To create a new directory tree (called e.g. NewTop), use the following syntax:

```
CREATE DIRECTORY <NewTop
```

The plot space size of a new directory tree can be customized with the option /PLOT_PAGE. This option can not be used to create subdirectories, since they inherit the plot space size of their parent directory.

Under X, a new window is implicitely attached to a new top directory being created. Its geometry and position can be customized through the options /GEOMETRY and /POSITION respectively. See HELP CREATE WINDOW for syntax and creation rules. These options are illegal when creating a subdirectory (for which no window is attached at creation time).

8.5.2 CREATE LUT

```
CREATE LUT
```

Store the current Look Up Table into the internal metacode. This makes sense if the LUT behavior is static (see HELP CHANGE LUT), so that the next graphic segments will use the last LUT stored in the metacode.

8.5.3 CREATE PENLUT

```
CREATE PENLUT
```

Store the current pencil colors into the internal metacode.

8.5.4 CREATE WINDOW

```
CREATE WINDOW [BLACK|WHITE] [NAME Name] [/GEOMETRY Sizex[Unitx] Sizey[Unity]] [/POSITION Posx[Unitx] Posy[Unity]]
```

Create a new window seeing the content of the current directory, with the corresponding attributes of background colour and Name. This command is only available under X.

The window geometry is set:

- if the option /GEOMETRY is present, to the values given to this option, recognized units being 'p' for pixels, '%' for percent of the screen size, and 'r' for a fraction (aspect ratio) of the other size (units default is 'p' if omitted),
- else, to the values read in the SIC logical named WINDOW_GEOMETRY, with the same syntax used for the option /GEOMETRY, if this SIC logical exists,

- else, to the internal default values.

The window position on the screen is then ruled:
- if the option /POSITION is present, by the values given to this option, recognized units being 'p' for pixels or '%' for percent of the screen size (units default is 'p' if omitted),
- else, by the choice of the window manager.

For example:
```
    GREG> CREATE WINDOW /GEOMETRY 400 2r
```
creates a window of size 400 x 800 pixels, and
```
    GREG> CREATE WINDOW /POSITION 100% 100p
```
creates a window aligned on the right and 100 pixels above the bottom of the screen.

8.6 DESTROY

```
[GTVL\]DESTROY ALL|DIRECTORY|WINDOW [Values]
```

Destroys (parts of) the plot tree and/or the windows seeing it.

8.6.1 DESTROY ALL

```
DESTROY ALL
```

Destroys all the plot, i.e. destroys all the top directories and their windows.

Since the user can not be in the root directory (<) and create segments in it, a new top directory and its first window are implicitely created after this. DESTROY ALL is thus the way to reset the tree and windows to their startup status.

8.6.2 DESTROY DIRECTORY

```
DESTROY DIRECTORY [DirName]
```

With a directory name as argument, completely suppress the input directory and its windows (if any). If the current working directory has to be destroyed, it is implicitely moved to the first parent directory which is not destroyed.

Without argument, completely suppress the last subdirectory of the current working directory.

8.6.3 DESTROY WINDOW

```
DESTROY WINDOW [DirName [WinNum|ZOOM]]
```

DESTROY WINDOW DirName destroys all the windows attached to the input directory. DirName defaults to the current directory.

If a window number is given, only the window identified by this number in Dirname is destroyed. The keyword "ZOOM" can be used as an alias for the zoom window in this directory, if any.

8.7 DEVICE

[GTVL\]DEVICE [Dev_Type [Mode]] [/OUTPUT Dev_Name]

Without argument, DEVICE displays the current working graphic device.

With a graphic device type as argument, directs the graphic output to it and sets default values for the plot region location and device physical limits. The basic unit is 1 cm for hardcopies. All plots to interactive devices are made with some pre-computed factor to match the screen size to the Plot Page size, defined by command SET PLOT_PAGE (default size is an A4 format page, 30 by 21).

Use DEVICE ? to get the list of recognized graphics devices or DEVICE type ? to get the list of modes on a given device.

/OUTPUT Dev_Name option allows you to direct the graphic output to something else than your own terminal (TT:). Note that some specific devices will not support this option: this is currently the case for X-Window devices.

8.8 DISPLAY

[GTVL\]DISPLAY Item [Arguments]

List the internal parameters of the named item:

DISPLAY DATA SegName
shows the data values in input segment. For debugging purpose.

DISPLAY DIRECTORY
shows the current directory and its active window, if any.

DISPLAY POINTER [SEGMENT|TREE]
shows the internal values of the pointers. For debugging purpose.

DISPLAY SEGMENT [SegName]
shows the attributes of input segment (either a leaf or a directory). Default is current directory.

DISPLAY TREE [DirName]
shows the directory tree in a recursive way. Default lists from current directory.

DISPLAY WINDOW
shows the active window and its attributes.

8.9 FLUSH

[GTVL\]FLUSH

Flush the internal stack. This could be useful when creating a complex plot (stored in the metacode) and when the graphic device is late (when reading the metacode). Then you may want to force the synchronization: FLUSH will return only when all the instructions in the stack are executed.

8.10 GTV

[GTVL\]GTV SEARCH DirName

If the GTV directory DirName exists, sets the variable GTV%EXIST to .TRUE., e.g.

```
GREG> GTV SEARCH <GREG
GREG> EXAMINE GTV%EXIST
GTV%EXIST       = T              ! Logical GLOBAL
```

8.11 HARDCOPY

[GTVL\]HARDCOPY [File] [/DEVICE Name [Attributes]] [/PRINT [Printer]] [/DIRECTORY DirName] [/GEOMETRY Sizex[Unitx] Sizey[Unity]] [/FITPAGE] [/EXACT] [/OVERWRITE]

Create a "hardcopy" of the current plot.

There are 3 possible outputs:
- a file: if a file name is provided, or if GTV%STDOUT is NO (default). In this latter case, the file name defaults to "gregplot.*".
- the terminal: if no file name is provided and GTV%STDOUT is YES.
- the printer: if /PRINT is used, see below.

Sending hardcopies to the terminal can be useful to avoid using temporary files on the disk. The calling process can read it instead directly from STDOUT. In case of PostScript or SVG hardcopies, their ASCII content is directly dumped in the terminal. In case of PNG, the binary data is encoded using the Base64 algorithm (portable ASCII sequence), and a header and a footer are added as description.

The default behaviour of the command is to scale the GreG PLOT_PAGE (centimeters) into the output physical page. This can be overriden with the two options:
- /EXACT: 1 cm on the GreG PLOT_PAGE will be 1 cm on the hardcopy physical page, for devices for which it makes sense,
- /FITPAGE: the plot will be automatically rotated and scaled to make the best use of the hardcopy physical page. The option /PRINT im-

plicitely enables this feature. See subtopic for details.
These two options are exclusive.

The /DEVICE option argument specifies which type of plotter will be used. See the subtopic /DEVICE for a list of the allowed devices. The other arguments passed to this option can modify the attributes of the hardcopy. If the option is not used, the harcopy device defaults to the content of the SIC logical GAG_HARDCOPY.

The /DIRECTORY option allows to specify which GTV directory should be sent to the hardcopy. Without this option, default is current directory.

The /PRINT option is used to force immediate printing and, optionally, to control which printer should be used. Printer is the printer name, which defaults to the content of the SIC logical GAG_PRINTER. The printing command is ruled by the SIC logical GAG_LPR. If no file name was specified for an immediate printing, the metacode file is deleted after print completion, otherwise it is kept.

8.11.1 HARDCOPY /DEVICE

[GTVL\]HARDCOPY [/DEVICE Name [Attributes]]

The /DEVICE option argument specifies which type of device will be used. The other arguments passed after the device name can modify the harcopy attributes. Several attributes can be combined. Allowed devices and attributes are:

PS (PostScript): the plot is automatically rotated and scaled on the hardcopy physical page.
GREY PostScript with fixed greyscale transfer function for bitmap.
COLOR PostScript with user controlled color transfer function. This is the default.
FAST PostScript with hardware pen thickness handling. Clipping of wide pens may be inaccurate. This is not the default.

EPS (Encapsulated PostScript): As PS, with the BoundingBox computed from the plot boundaries rather than from the Plot Page size. The plot is NOT rotated neither scaled to the hardcopy physical size by default. Use the option /FITPAGE to enable this feature.
GREY Same as PS.
COLOR Same as PS.
FAST Same as PS.

PDF (Portable Document Format): the plot is exported as PS and converted to PDF using "ps2pdf" if available on the system. The PS usual attributes can be used:

GREY Same as PS.
COLOR Same as PS.
FAST Same as PS.

EPDF (Encapsulated Portable Document Format): the plot is exported as EPS and converted to PDF using "epstopdf" if available on the system. The EPS usual attributes can be used:
GREY Same as EPS.
COLOR Same as EPS.
FAST Same as EPS.

PNG (Portable Network Graphics): create a bitmap representation of the GreG plot. The size of the PNG can be tuned with the option /GEOMETRY.
GREY Same as PS
COLOR Same as PS
WHITE PNG with white background and black foreground. This is the default.
BLACK PNG with black background and white foreground.
TRANSPARENT PNG with transparent background. This is not exclusive with WHITE and BLACK attributes, i.e. "TRANSPARENT BLACK" creates a PNG with transparent background and white foreground. Transparency is not activated by default.
NOBLANK Blanked pixels will not be drawn, i.e. they will use the background color (white, black, or transparent) or they will let you see previous drawings made behind.
CROPPED the GreG plot is expanded to fit exactly to the best PNG dimensions, and the other PNG dimension is shrinked to leave no margin.

SVG (Scalable Vector Graphics): create a vectorial representation of the GreG plot in the SVG format. The size of the SVG can be tuned with the option /GEOMETRY.
CROPPED the GreG plot is expanded to fit exactly to the best SVG dimensions, and the other SVG dimension is shrinked to leave no margin.

8.11.2 HARDCOPY /FITPAGE

HARDCOPY /FITPAGE

Automatically rotate and scale the desired part of the plot to match at best the hardcopy physical size. Alternatively, the variable GTV%FITPAGE can be set to YES to force this feature.

The desired part of the plot is the full Greg plot page for PS, or the cropped plot for EPS. The hardcopy physical page is controled by the sic logical GAG_PAPER_SIZE set at compilation time.

In the case of PS/EPS hardcopies, if the plot actually needs rotation, the line "%%Orientation: Landscape" or "%%Orientation: Portrait" is added in the PostScript header. This line is recognized by PostScript viewers (e.g. ghostview) so that they unrotate the file when displaying it. On the other hand, empirical tests show that Latex, MS/Open/LibreOffice, or eps2jpg ignore it. Hopefully, printers also ignore this line, giving this option its full sense.

8.11.3 HARDCOPY /GEOMETRY

```
HARDCOPY /GEOMETRY Sizex[Unitx] Sizey[Unity]
```

The /GEOMETRY option allows to customize the size of the hardcopy. This option is supported on the following devices:
- PNG: units allowed are 'p' (pixels) and 'r' (aspect ratio). If absent, units default to pixels.
- SVG

Typical use cases are:

```
  HARDCOPY /GEOMETRY 800 560    ! 800x560 pixels
  HARDCOPY /GEOMETRY 800p 560p  ! 800x560 pixels
  HARDCOPY /GEOMETRY 800 0.5r   ! Twice less pixels in Y than X: 800x400 pix
  HARDCOPY /GEOMETRY 3r 100     ! 3 times more pixels in X than Y: 300x100 p
  HARDCOPY /GEOMETRY 1r 2r      ! Invalid: both dimensions defined as
                                ! ratio of the other
```

Without this option, the hardcopy size can be ruled through the following SIC logicals, using the same syntax as above:
- PNG_GEOMETRY
- SVG_GEOMETRY

If neither the option is used nor the SIC logical is set, then the hardcopy size is defined with internal default values (800x560 pixels).

8.11.4 HARDCOPY /OVERWRITE

Existing hardcopy files are not overwritten, but the option /OVERWRITE can be used to force this. Alternatively, the variable GTV%NOFAIL can be set to YES to force overwriting.

8.12 LENS

```
[GTVL\]LENS
```

Under X, call the lens on the active window. The flow of commands is suspended until the lens is closed.

The usual way to call the lens is using the middle-click of the mouse on the plot. However, this command is useful to give a detailed look to an intermediate plot during a procedure, since it acts like a PAUSE.

When opened, the lens is controled by the following actions:
- Mouse wheel: reduce or enlarge the zooming factor,
- Left-click or CTRL+wheel: reduce the lens area,
- Right-click or CTRL+wheel: enlarge the lens area,
- Middle-click: close the lens

8.13 LUT

[GTVL\]LUT [Argum] [/PEN] [/REVERSE] [/BLANK Color]

Modify the bitmap or pen look up table. Option /PEN indicates to modify the value of the 16 user-controlled pen colors (colors 8 to 23) rather than the bitmap look-up table.

The default argument is LUT. Possibles arguments are:
- ?
  Type "LUT ?" to display the list of available LUTs, or execute the demonstration procedure @ gag_demo:demo-luts.greg for an overview. One can use alternatively the LUT editor (button "Edit Lut") to browse and edit the LUTs in an interactive widget.
- DEFAULT
  Load the default color table.
- COLOR
  Load a color table with a circular hue value, from red to red.
- BLUERED
  Load a color table from dark blue to light blue, white, light red, dark red, suited for blueshift to redshift display.
- BLACK
  Load a black and white color table (white background, black sources).
- WHITE, RED, GREEN, BLUE, MAGENTA, YELLOW, CYAN and NULL
  Load a color table with black background and sources in the corresponding color (NULL is fully black).
- LUT
  A custom color model can be defined in RGB or HSV arrays and applied. See subtopic LUT for details.
- Any other LUT Argum will read Red Green Blue values from the formatted file named "Argum". See subtopic FILE for details.

The LUT, whereever it comes from, can be reverted before use with the option /REVERSE.

8.13.1 LUT /PEN

Same behaviour as LUT, but will update the colors of the 16 pens (colors 8 to 23) used for contour-filling.

The associated HSV and RGB models can be found and customized in the sic arrays named LUT%PEN%HUE, LUT%PEN%SATURATION, LUT%PEN%VALUE, and LUT%PEN%RED, LUT%PEN%GREEN and LUT%PEN%BLUE, one or the other being used depending on the LUT%MODE value.

8.13.2 LUT /BLANK

The blanking color is used to paint blanked pixels in images. By default at startup this color is white. This can be customized with

LUT /BLANK Color

where the color is one of the supported pen colors (type LUT /BLANK ? for the complete list). The 2 most relevant values are BACKGROUND and FOREGROUND which translate as WHITE or BLACK depending on the device color.

For a custom blanking color, use command LUT LUT (see subtopic for details).

8.13.3 LUT LUT

If the argument is "LUT", load the color table defined by an HSV (HUE, SATURATION and VALUE) or RGB (RED, GREEN and BLUE) color model. There are six user-writeable SIC variables named:

- LUT%HUE,
- LUT%SATURATION,
- LUT%VALUE, and
- LUT%RED,
- LUT%GREEN
- LUT%BLUE

that contain the HSV and RGB model of the current LUT. These arrays values can be manipulated using standard SIC mathematic functions to create new Look-Up Tables (see below). Depending on the value on LUT%MODE, the model is reloaded from the HSV (LUT%MODE.eq.1) or from the RGB (LUT%MODE.eq.2) arrays.

A convenient value for the hue array is

```
LET LUT%HUE[I] = 256*(1-(I/LUT%SIZE))
LET LUT%SATURATION 1
LET LUT%VALUE 1
LUT LUT
```

which is a "classical" color table from blue to red as used in AIPS for example. Color contours can be obtained using variations around the following command:

```
        LET LUT%HUE[I] = 16*INT(256*(1-(I/LUT%SIZE))/16)
```
and so on with the most funny functions you may invent.

A similar behaviour is defined for the BLANKING color, with the six reals LUT%BLANK%HUE, LUT%BLANK%SATURATION, LUT%BLANK%VALUE, and LUT%BLANK%RED, LUT%BLANK%GREEN, LUT%BLANK%BLUE.

CAUTION: the hue is a real number between 0.0 and 360.0

8.13.4 LUT FILE

The command LUT can read the colormaps from a formatted file. A various number of these files is already available in the distribution. Type "LUT ?" to see these files.

The files are searched in the path(s) contained in the SIC logical LUT#DIR:. It can be a collection of paths customized by the user. By default LUTs are searched in the current directory and in GAG_LUT: (where the standard GTV LUTs are stored). The default extension is ".lut".

User can define and save its own LUT in such a file. The formatted file must be an ASCII file providing the three R, G and B intensities in three columns, and there must be as many lines as color levels needed. The intensities are three real numbers between 0.0 and 1.0.

The LUT loaded from such a file will then be resampled (using interpolation) to match the effective number of colors the device supports. For example, the file example.lut:
```
shell> cat example.lut
     .00000    .00000    .00000
     1.0000    .00000    .00000
```
will produce a black to red color map, with continuous color levels between.

8.13.5 LUT CET

GREG provides the collection of look-up-tables from colorcet.com under names cet-*.lut. These LUTs have uniform contrast which avoid missing significant features in the data and detecting false ones (see https://colorcet.com for details).

In practice the file name suffix encodes:
- cet-l*.lut: linear color maps,
- cet-d*.lut: diverging color maps (differentiate values that lie above, or below, a reference value),
- cet-r*.lut: rainbow color maps,
- cet-c*.lut: cyclic color maps (colors are matched at each end),

- cet-i*.lut: isoluminant color maps (equal perception lightness),
- cet-cb**.lut: color blind maps (the 'cb' characters are added in addition to the previous nomenclature).

Last, a trailing "s" stands for shifted colors.

These colour maps are released under the Creative Commons BY License.

8.14 METACODE

[GTVL\]METACODE EXPORT|IMPORT FileName [DirName] [/PATH PathName]

Allow to save or load whole or parts of the current plot to or from a metacode file.

8.14.1 METACODE EXPORT

[GTVL\]METACODE EXPORT FileName [DirName]

Export the current (or specified) directory tree to an external metacode file of name FileName. The default extension is .meta . The sub-plot can later be reincorporated using command METACODE IMPORT. This allows merging several plots together.

8.14.2 METACODE IMPORT

[GTVL\]METACODE IMPORT FileName [DirName] [/PATH PathName]

Insert an external metacode file at the specified PathName into the current plot. PathName defaults to the current directory.

8.15 REFRESH

[GTVL\]REFRESH [DirName [WinNum|ZOOM]]

By default, redraw all windows in all directories. If a directory name is provided, redraw the windows seeing this directory and its subdirectories. If a window number is also specified, redraw only this window. The keyword "ZOOM" can be used as an alias for the zoom window in this directory, if any.

The windows are drawn and redrawn as soon as new segments are added, or if the window manager requires it (e.g. window is resized). However, for efficiency purpose, segments are first drawn one onto the previous ones, in the chronological order. Depending on their depth (e.g. images which are by default at depth 2), this is not what happens in the subsequent redraws and in hardcopies. In this case, it makes sense to force the refresh of a window.

8.16 REPLICATE

```
[GTVL\]REPLICATE Dir1 Dir2
```

Copy Dir1 subtree to Dir2 subtree. Not very useful now, but will become interesting when shifting, stretching, rotations, and user coordinate changes will be allowed for all segments.

8.17 ZOOM

```
[GTVL\]ZOOM [X1 X2 Y1 Y2 | OFF]
```

The command ZOOM opens or closes a new window which displays a smaller region of the current plot. Each plot can have its own zooming window. It will be reused by subsequent calls to the command ZOOM.

Without arguments, ZOOM calls the cursor to define the viewing area. This area will be defined by its center (at the cursor position) and a zooming factor (by steps of 1.414):

Z	Increase the zooming factor
-	Decrease it
0	Reset it
E	Exits from the routine

These commands do not produce effective zooming, press the space bar to do it. For graphical displays, you may use the mouse buttons for the commands <Space> (left mouse button), Z (middle mouse button), and E (right mouse button).

ZOOM X1 X2 Y1 Y2 can be used to define the viewing area by a non-interactive mean. The values must be in paper units (cm).

Use ZOOM OFF to close the zoom window of the current plot, if any.

9 GreG Plot Library

Using GREG as a plot library is now described in the GILDAS programming guide.

10 GreG Character Set

This section includes a copy of the character set and a commented procedure to generate it. It is useful to give the correspondence between the keyboard and special letters in the GREGś character set.

In the roman alphabet, all keyboard keys will give the corresponding ASCII characters with only 4 exceptions :

- The counter quote ‘ will give the double quote "
- The circumflex accent ^ will give the degree sign
- The double quote cannot be used because of SIC character handling
- The backslash \ cannot be used because of GreG character handling

The Script character set has an exact correspondance for all letters and figures, and mathematical symbols corresponding to special characters.

The Greek character set has a rather convenient correspondance for all letters (this is not the alphabetic order which is highly non mnemotechnic). Planets symbols correspond to the figures (0 Sun, 1 Mercury and so on). Other astronomical symbols correspond to the special characters.

The procedure `FONT.GREG` (with the satellite procedure `F.GREG`) generates the three GREG alphabets in simplex and double quality and produce eight metacode files named `FONT1.VEC, ..., FONT8.VEC`. These files are stored in the directory `GAG_DEMO:`. You can plot them on paper using any of the metacode translators available on your site (`HPXY, LWXY, PLXY,` ...) or just invoke the `ZOOM` utility to have a glance at them on an interactive screen.

Satellite procedure `F.GREG` to generate the GREG fonts

This procedure `F.GREG` is called by the `FONT.GREG` procedure to generate the three alphabets in Simplex and Duplex quality :

```
!
! Draws a character in all GreG fonts and quality
! Parameter &1          Y position of character
! Parameter &2          Character to be drawn
!
DRAW TEXT  3 &1 "\\1&2"        ! Roman font, Simplex quality
DRAW TEXT  6 &1 "\\1\\G&2"     ! Greek font, Simplex quality
DRAW TEXT  9 &1 "\\1\\S&2"     ! Script font, Simplex quality
DRAW TEXT 13 &1 "\\2&2"        ! Roman font, Duplex quality
DRAW TEXT 16 &1 "\\2\\G&2"     ! Greek font, Duplex quality
DRAW TEXT 19 &1 "\\2\\S&2"     ! Script font, Duplex quality
```

Procedure FONT.GREG to generate the GREG fonts

```
!
! Generates the 6 alphabets of GreG fonts in 6 columns
!      1         2         3             4        5        6
!    Roman     Greek     Script        Roman    Greek    Script
!    Simplex   Simplex   Simplex       Duplex   Duplex   Duplex
!
SIC VERIFY ON
SET PLOT_PAGE PORTRAIT
SET BOX 0.5 20.5 1 28
SET CHARACTER 1.5
SET COORDINATE BOX
SYMBOL F "@ GAG_DEMO:F.GREG"
!
!    Keyboard    ROMAN FONT    GREEK FONT              SCRIPT FONT
F 24 "   "     ! Space         Space                   Space
F 22 " ! "     ! !             Aries                   Existencial
F 20 " ‘ "     ! Double quote  Taurus                  Up-Down arrow
F 18 " # "     ! #             Gemini                  Included in
F 16 " $ "     ! $             Cancer                  Reunion
F 14 " % "     ! %             Leo                     Includes
F 12 " & "     ! &             Virgo                   Intersection
F 10 " ’ "     ! ’             Libra                   Belongs to
F  8 " ( "     ! (             Scorpius                Integral
F  6 " ) "     ! )             Sagittarius             Circular Integral
F  4 " * "     ! *             Capricornus             Multiply
F  2 " + "     ! +             Aquarius                Plus/Minus
HARDCOPY GAG_DEMO:FONT1.VEC
CLEAR PLOT
!
!    Keyboard    ROMAN FONT    GREEK FONT              SCRIPT FONT
F 24 " , "     ! ,             Pisces                  Divide
F 22 " - "     ! -             Space                   Minus/Plus
F 20 " . "     ! .             Square                  .
F 18 " / "     ! /             Space                   Square root
F 16 " 0 "     ! 0             Sun                     Zero
F 14 " 1 "     ! 1             Mercury
F 12 " 2 "     ! 2             Venus
F 10 " 3 "     ! 3             Earth
F  8 " 4 "     ! 4             Mars
F  6 " 5 "     ! 5             Jupiter
F  4 " 6 "     ! 6             Saturn
F  2 " 7 "     ! 7             Uranus
HARDCOPY GAG_DEMO:FONT2.VEC
CLEAR PLOT
```

```
!
!    Keyboard    ROMAN FONT    GREEK FONT              SCRIPT FONT
F 24 " 8 "     ! 8             Neptun
F 22 " 9 "     ! 9             Pluto
F 20 " : "     ! :             Moon quarter            Space
F 18 " ; "     ! ;             Comet                   Perpendicular
F 16 " < "     ! <             Eight branch star       Less or equal
F 14 " = "     ! =             Ascending node          Equivalent
F 12 " > "     ! >             Descending node         Greater or equal
F 10 " ? "     ! ?             Space                   Different
F  8 " @ "     ! @             Space                   Proportional
F  6 " A "     ! A             Alpha
F  4 " B "     ! B             Beta
F  2 " C "     ! C             Chi
HARDCOPY GAG_DEMO:FONT3.VEC
CLEAR PLOT
!
!    Keyboard    ROMAN FONT    GREEK FONT              SCRIPT FONT
F 24 " D "     ! D             Delta
F 22 " E "     ! E             Epsilon
F 20 " F "     ! F             Phi
F 18 " G "     ! G             Gamma
F 16 " H "     ! H             Eta
F 14 " I "     ! I             Iota
F 12 " J "     ! J             Nabla (Gradient)
F 10 " K "     ! K             Kappa
F  8 " L "     ! L             Lambda
F  6 " M "     ! M             Mu
F  4 " N "     ! N             Nu
F  2 " O "     ! O             Omicron
HARDCOPY GAG_DEMO:FONT4.VEC
CLEAR PLOT
!
!    Keyboard    ROMAN FONT    GREEK FONT              SCRIPT FONT
F 24 " P "     ! P             Pi
F 22 " Q "     ! Q             Theta
F 20 " R "     ! R             Rho
F 18 " S "     ! S             Sigma
F 16 " T "     ! T             Tau
F 14 " U "     ! U             Upsilon
F 12 " V "     ! V             Space
F 10 " W "     ! W             Omega
F  8 " X "     ! X             Xi
F  6 " Y "     ! Y             Psi
F  4 " Z "     ! Z             Zeta
F  2 " [ "     ! [             Dagger                  Approximately
HARDCOPY GAG_DEMO:FONT5.VEC
```

```
CLEAR PLOT
```

```
!
!    Keyboard    ROMAN FONT    GREEK FONT              SCRIPT FONT
F 24 " \ "     ! Unaccessible because this is the " escape" character
F 22 " ] "     ! ]             Double dagger           Approximately
F 20 " ^ "     ! Degree        Paragraph               Chemical eq.
F 18 " _ "     ! Space         Three dots              Left/Right arrow
F 16 " ` "     ! Double quote  Taurus                  Up/Down arrow
F 14 " a "     ! a             alpha
F 12 " b "     ! b             beta
F 10 " c "     ! c             chi
F  8 " d "     ! d             delta
F  6 " e "     ! e             epsilon
F  4 " f "     ! f             phi
F  2 " g "     ! g             gamma
HARDCOPY GAG_DEMO:FONT6.VEC
CLEAR PLOT
!
!    Keyboard    ROMAN FONT    GREEK FONT              SCRIPT FONT
F 24 " h "     ! h             eta
F 22 " i "     ! i             iota
F 20 " j "     ! j             Partial derivative
F 18 " k "     ! k             kappa
F 16 " l "     ! l             lambda
F 14 " m "     ! m             mu
F 12 " n "     ! n             nu
F 10 " o "     ! o             omicron
F  8 " p "     ! p             pi
F  6 " q "     ! q             theta
F  4 " r "     ! r             rho
F  2 " s "     ! s             sigma
HARDCOPY GAG_DEMO:FONT7.VEC
CLEAR PLOT
!
!    Keyboard    ROMAN FONT    GREEK FONT              SCRIPT FONT
F 24 " t "     ! t             tau
F 22 " u "     ! u             upsilon
F 20 " v "     ! v             Infinite
F 18 " w "     ! w             omega
F 16 " x "     ! x             xi
F 14 " y "     ! y             psi
F 12 " z "     ! z             zeta
F 10 " { "     ! {             Large {                 Up arrow
F  8 " | "     ! Vertical bar  Large integral          Right arrow
F  6 " } "     ! }             Large }                 Down arrow
F  4 " ~ "     ! ~             Large root              Left arrow
HARDCOPY GAG_DEMO:FONT8.VEC
EXIT
```

11 Table Processing Tasks

11.1 table-processing

```
GRID_CUBE         A simple gridding task to make a 2D image from a table
GRID_EXTEND       Grid into a cube irregularly sampled data from an input table
GRID_PROJECT      Reproject an input image or cube (through convolution)
GRID_SG           Optimum gridding of irregularly sampled data from an input tabl
LIST              List a table in human readable format
MERGE             Merge two input tables by lines or columns
SORT              Sort a real table
SORTINT           Don't use this task...
TABLE             Produce a table from a formatted file
TABLE_MARGINALIZE  Marginalize a table against 2 columns
```

11.2 GRID_CUBE

GRID_CUBE

This task makes a cube from a table containing data regularly sampled on a 2-d grid, but possibly uncompletely sampled. Several gridding modes are possible.

In mode GRID, since the input data is assumed to be regularly sampled, this gridding task does not use any convolution or interpolation, but just fills a grid with values.

In mode NATURAL, a convolution kernel is used to interpolate the irregularly sampled data using the weight of each individual point.

In mode UNIFORM, the same convolution process is used but the individual points are assumed to have equal weight.

The grid step is specified by the user, but the map size can be determined by the task. The input table can be created by command GRID in CLASS, or using task TABLE from a formatted file.

11.3 GRID_EXTEND

GRID_EXTEND

This task makes a cube from a table containing irregularly sampled data. The data is interpolated/extrapolated using a convolution taking into account the beam size of the observing telescope.

In mode NATURAL, a convolution kernel is used to interpolate the irregu-

larly sampled data using the weight of each individual point.

In mode UNIFORM, the same convolution process is used but the individual points are assumed to have equal weight.

The pixel size is specified by the user, but the map size is determined by the task. The input table can be created by command GRID in CLASS, or using task TABLE from a formatted file.

11.4 GRID_PROJECT

GRID_PROJECT

This task resamples a CLASS table (created by command GRID) to a different projection system and/or center.

11.5 GRID_SG

GRID_SG

Optimum image reconstruction from irregularly sampled data with finite angular resolution.

This task makes a cube from a table containing irregularly sampled data. The data is interpolated/extrapolated using a convolution taking into account the beam size of the observing telescope. The smoothing effect of the convolution can be optionally removed by this task, by Fourier filtering. Fourier filtering is also used to suppress high spatial frequency noise. The resulting image is thus optimal in terms of signal to noise and angular resolution.

In mode NATURAL, a convolution kernel is used to interpolate the irregularly sampled data using the weight of each individual point.

In mode UNIFORM, the same convolution process is used but the individual points are assumed to have equal weight.

The pixel size is specified by the user, but the map size is determined by the task. The input table can be created by command GRID in CLASS, or using task TABLE from a formatted file.

11.6 LIST

LIST

This program lists in free format part of an input table.

The task TABLE does the reverse process.

11.7 MERGE

MERGE

This program merges two input tables by lines or columns. The tables must have the same number of columns or lines, according to the mode.

11.8 SORT

SORT

This program sorts all columns of a given table by ascending order of one of its columns. The same table is used for both input and output. Only single precision real tables are accepted by the present version.

11.9 SORTINT

Don't use this task...

11.10 TABLE

TABLE

This task produces a GILDAS Table from a formatted listing. The table format is recommended if you intend to use your data more than a few (4) times, i.e. in virtually any case. Moreover, the table format can be processed by more programs than the list-directed one. You should set the number of columns exactly, and the number of lines to 0

to allow the program to compute the table size, or to the real number of lines in your formatted file. Never set the number of lines or the number of columns larger than really present or the program will crash.

Task LIST does the reverse process.

11.11 TABLE_MARGINALIZE

TABLE_MARGINALIZE

This taks is used to project (marginalize) a table of N+1 columns, one of which is contains the value of a function of the N others, onto a table of 3 columns, containing the "marginalized" value of the function of only 2 parameters, columns noted X,Y hereafter. The table is assumed to be regularly spaced in (X,Y) values in this current version.

This process is often needed in multi-parameter minimization, e.g. to derive a 2-D Chi^2 surface from an (N-1)-D hypersurface (or equivalentlyfor a Likelihood distribution).

To derive a single value from the N-2 values for each (X,Y) pair, a reduction operation is required. The available operations are MIN (appropriate for Chi^2 projection), MAX (appropriate for Likelihood) MEAN and SUM.

12 Image Processing Tasks

12.1 image-processing

```
BLANKING         Change the blanking value of a GDF file
EXTRACT          Extract a subset (or surset) of a GDF file
FILL_CUBE        Resample a cube by random or regular interpolation
GAUSS_COMPRESS   Gaussian smoothing and then compression of a GDF file
HEADER           List and modify the header (*not* the data) of a GDF file
INTERPOLATE      Resample and smooth an input cube along its first axis
MAKE_CUBE        Output a filled cube from an uncomplete sampled cube
MAP_AVER         Average plans of a 3D data cube
MAP_COMPRESS     Compress an image or a cube (by Fourier truncation)
MAP_EXPAND       Expand an image or a cube (By Fourier expansion)
MAP_INTER        Resample an input data cube along its 3rd axis
MAP_SUM          Sum plans of a 3D data cube
MASK             Mask all planes of an input cube inside or outside a given poly
MASK_3D
SHIFT            Shift an image by Fourier transform
SUM              Sum many weighted images
SWAP             Mirror a 2D image
TRANSPOSE        Transpose input images or cubes
CIMAGE           Create a simple geometrical source model
```

12.2 BLANKING

```
BLANKING
```

Modify the blanking value of a GDF file. This operation has 2 purposes:
1 - modify the blanked data to a new blanking value, and modify the header consistently. This means all the blanked data and only the blanked data in the input file will be blanked in the output file.
2 - patch NaN values to replace them by the blanking value. This is useful when importing external data, as NaN values not ignored by all Gildas commands.

Note that this operation cannot be done through the HEADER program, which only modifies the blanking value of the header but not the corresponding data (e.g. blanked data could become unblanked by doing this).

12.3 EXTRACT

```
EXTRACT
```

Extracts a subset of an input image. The output image can be larger than the subset; in this case the additional pixels are blanked if the output

image is being created, unmodified if it already exists. It works on images of any dimensions, and any subset of the input image can be placed anywhere in the output image.

This task can also be used to build a N+P dimensional image from a set of N dimensional ones, by initializing the output image once with its full dimensions and then placing the (subset of the) input images at the appropriate place in the output image.

12.4 FILL_CUBE

FILL_CUBE

This program resamples an input data cube on a finer grid for the first two dimensions (hence the data cube is treated as an ensemble of images). The output grid may be explicitly determined from the conversion formulae of the two first axis, or implicitly from the number of pixels of the two first axis and the input cube conversion formulae. Two different methods are available for the resampling :

The SLOW method, which is general and takes properly into account the input blanking value. This method is based on the same algorithm as the RANDOM command in GreG. It triangulates the input non-blanked values and uses Lagrange polynomials to interpolate on the finer grid. For optimisation purposes, the same triangulation is used for all planes, which assumes that the same pixels are blanked in all planes. If this is not the case, the individual planes should be extracted, and processed separately.

The FAST method, which ignores the input blanking value. This method is based on the same algorithm as the RESAMPLE command in GreG. It is faster, but should be used only if no input pixel is blanked.

If the data is undersampled, this task is the recommended second step in the data analysis of a cube produced by command ANALYSE\CUBE in CLASS, immediately after the TRANSPOSE program. Task MAKE_CUBE is preferable for oversampled data.

12.5 GAUSS_COMPRESS

GAUSS_COMPRESS

Spatially smooth an image (or 3-D data cube) by a 2-D Gaussian kernel, and compress it in number of pixels by the specified compression factor.

12.6 HEADER

HEADER

A (not so) simple minded routine to list edit and modify the header of a GDF-like file (Image only, Table edition is usually meaningless). It is functionnally equivalent to command "HEADER File" in the GRAPHIC program.

On some systems, editing of header parameters is possible if you have write access to the image.

- To modify a header parameter, position the cursor on it and press key Gold (PF1). You can then enter the new value. When you are happy with the modified value, press Enter.
- To compute the extrema of the image, press key Enter.
- To exit from the edit mode, type <^Z>.

12.7 INTERPOLATE

INTERPOLATE

This program resamples an input data cube ALONG ITS FIRST AXIS. The resampled output cube may have higher or lower resolution than the original one, but extrapolation is strictly forbidden. The program does not handle blanking values.

12.8 MAKE_CUBE

MAKE_CUBE

This is an image construction task which is able to produce a filled image from one containing many blanked pixels. The reconstructed filled image is not constrained to fit exactly the observed data points. On the opposite, the construction is made by the analogy to a flexible plate attached to fixed points by springs: the plate is the analogous of the surface represented by the image, and the fixed points are the analogous of the observed data points. By adjusting the parameter P

P = (plate stiffness) / (springs stiffness)

it is possible to control the fidelity to the original data and the amount of smoothing involved in the image reconstruction. Low values of P mean high fidelity to observed data, and negligible amount of smoothing.

The original grid is first expanded by a factor EXPANSION$, new pixels being attributed the blanking value. Then, the minimization proceeds iteratively to adjust the final image, until convergence is reached. Initially blanked pixels are ignored in the convergence criterium.

The algorithm works on cubes, processing each plane independently. It

can be used as an alternative to FILL_CUBE for oversampled images, but works also for undersampled data.

12.9 MAP_AVER

Average several planes of a 3-D image to produce a 2-D image. This task can be used for example on LMV data cubes to get average intensity images. To convert to integrated intensities, you must multiply the resulting image by NC$[2]-NC$[1]+1.

12.10 MAP_COMPRESS

Compress the first two dimensions of an image or data cube by powers of 2 using Fourier transform.

12.11 MAP_EXPAND

Expand the first two dimensions of an image or data cube by powers of 2 using Fourier transform.

12.12 MAP_INTER

MAP_INTER

This program resamples an input data cube ALONG ITS THIRD AXIS. The resampled output cube may have higher or lower resolution than the original one, but extrapolation is strictly forbidden. The program does not handle blanking values.

12.13 MAP_SUM

MAP_SUM

Task MAP_SUM computes a map of the integrated line flux over a velocity range from a 3-D data cube.

12.14 MASK

MASK

This task masks either the inside or the outside of a polygon in all

planes of a data cube. It is similar to the MASK command in GreG, GRAPHIC or OVERLAY, but it does affect the output image and not an internal copy of it. The polygon must have been created previously using the WRITE POLYGON command in GreG, for example.

12.15 MASK_3D

MASK_3D

Mask a 3-D data cube based on signal being non-zero
in another 3-D data cube. Comparison in all axes
is done based on user coordinates, so data cubes
do not need to have the same sampling.

Axis order should match, but there is no compulsory
ordering of the axes.

12.16 SHIFT

SHIFT

Shift an image by Fourier transform, phase shifting and back transform to image plane. NOT DEBUGGED ?

12.17 SUM

SUM

This program is used to sum many images, handling a weight image in order to produce the average image later on.

```
It computes     X(i,j) = X(i,j) + F * Z(i,j)
and             Y(i,j) = Y(i,j) + F
```

for all non blanked pixels of the input image Z. When called repetitively with the same input/output images X and Y, X contains the weighted sum of all Z images, and Y the weight of each pixels. A parameter is provided to initialise the process.

The last step to obtain the average image is to divide X by Y using program COMBINE with option DIVIDE. You can also use SIC command LET to do so, but SUM and COMBINE will handle properly blanking values.

12.18 SWAP

SWAP

This task swaps an image with respect to first or second axis (e.g. along the X dimension, pixel 1 becomes pixel NX, 2 becomes NX-1 and so

on). This operation is never required for most algorithms because they work in the "User Coordinate" space (such as the contouring command in GRAPHIC...). It is only needed for a few algorithms which work in the pixel space (such as HISTO_CROSS). Pixel order can be reversed along X (first axis) or Y (second axis). The program does not handle data cubes at present..

12.19 TRANSPOSE

TRANSPOSE

A non-general simple-minded routine to tranpose data cubes (or images). The only transposition codes it recognises currently are 312, 231 and 213. Other orders can be added relatively easily if they are needed.

Usually command VECTOR\TRANSPOSE Input Output Order is preferred, except possibly for large images. The transposition takes place in RAM memory if the sic logical SPACE_GILDAS (in megabytes unit) is big enough, else it takes place on disk.

12.20 CIMAGE

This task create an image which can be read from a file or created from a function. The ouput filename is FILEO$.

A- From a FILE: if the logical variable IFILE$ is set to YES an image is read from the input formatted file FILEI$ the column must ordered as : x y z and expect to have standard gdf image structure. For convenience, z should be in Brightness temperature, as for B case.

B- From a FUNCTION: If one of the function is activated a corresponding image using the parameters PARAMETERS$ will be created. Intensity are in Brightness temperature.

```
E_DISK  : Elliptical Disk
E_RING  : Elliptical Ring
E_GAUS  : Elliptical Gaussian
E_EXPO  : Elliptical Exponential
RECT    : Rectangle
POWER   : Power law
PLAN    : Plan
```

Convertion to Jansky is possible if variable JANSKY$ is set to YES. The

image can be mutiplied by a gaussian beam if BEAM$ is set to YES parameters are similar as for function GAUSS.

ONLY ONE function can be computed at the same time, Nevertheless more complex images can be produced using both CIMAGE and COMBINE tasks.

13 Image Analysis Tasks

13.1 image-analysis

```
BACKGROUND      Compute background intensity of an image
CIRCLE          Compute the radial profile of each planes of an input cube
COMBINE         Add, multiply, divide, etc...  two input images
EXTREMA         Compute and store the extrema of a GDF-like file
FIELD_FIND      Simple segmentation of an image based on intensity
FIELD_LIST      Compute statistics on fields of an image
FIELD_STAT      Compute the integrated spectra of a fielded cube
FOURIER         Compute the complex Fourier transform of a real spectra cube
MAKE_BACK       Compute the  background intensity of an input image
MOMENTS         Compute the first 3 moments of an input lmv cube
PLANE           Subtract a plane from an input image
SLICE           Extract a 2D Position-Velocity slice from a 3D LMV cube
SPECTRUM        Extract a spectrum from a 3D LMV cube
SPECTRUM_SUM    Compute an integrated spectrum from a 3D LMV cube
```

13.2 BACKGROUND

BACKGROUND

Computes the background image of a given map. The basic idea is to make a crude mesh model of the background by finding the most likely value of the original map (within some intensity range) for each cell of the crude mesh. The most likely value is found by making an histogram of the intensity distribution in the specified range for all points lying in a circle around the cell center. The circle may (and should) be greater than the cell size. If the number of pixels within the intensity range is too small, no value is attributed to the intermediate mesh.

The intermediate model is then resampled to the original map using a general triangulation technique. This procedure has several advantages over a simpler method which would compute a "smoothed" image as the background, because it is not biased by any emission outside the selected range, and it is able to interpolate over large non sampled area of the intermediate mesh. Other tasks with similar names use other interpolation algorithms. They will hopefully be merged into a single task one (with a switch for the interpolation algorithm).

CAUTION: In the present version, blanking in the input image is not correctly handled. This can usually be worked around by specifiying an apropriate range.

13.3 CIRCLE

CIRCLE

This program computes annular averages on an input cube to produce an output map. Each line of the output map is the radial profile for one particular plane of the input cube. The task can be used to derive the radial profiles, for example in circumstellar envelopes. The radial pixel separation is always the X and Y increment. If the X and Y increments are different, the averages are therefore computed on elliptical rings, despite the name of the task.

13.4 COMBINE

COMBINE

This task makes "combinations" of two input images to produce a third one. The two input images may have the same dimensions, or the first one (Z one) may have less dimensions than the second (Y) one. In the latter case, combinations will occur for all the extra planes of the Y image. For example you can divide all planes of an input (Y) 3-D cube by a 2-D (Z) image, provided each plane of the cube matches the single image...

Operations are

```
        ADD             X = Ay*Y + Az*Z + C
        MULTIPLY        X = AY*Y * AZ*Z + C
        DIVIDE          X = AY*Y / AZ*Z + C
        OPTICAL_DEPTH   X = - LOG (AY*Y / AZ*Z + C)
```

provided Y > TY and Z > TZ , TY and TZ being thersholds for the Y and Z images.

Image combinations may also be done using the SIC arithmetic capabilities, but COMBINE offers the advantage of handling correctly blanking information.

13.5 EXTREMA

EXTREMA

A simple minded routine to compute and store the extrema of a GDF-like file into its header. It is functionnally equivalent to the command "HEADER File /EXTREMA" in the GRAPHIC program.

13.6 FIELD_FIND

FIELD_FIND

Makes the field labelling of an image, i.e. identifies connex areas with image values higher than a given threshold and attribute them a number. The result is an image (of same size as the input one), in which the value of a pixel is the number of the field to which it belongs. A zero value is attributed to pixels under the threshold.

Note that blanked pixels may adversely affect the field labelling...

13.7 FIELD_LIST

FIELD_LIST

This task computes statistics on fields of an image. It accepts as input the image itself and a label image describing the fields. The label image is an image (of same size as the input image), in which the value of a pixel is the number of the field to which it belongs. A zero value is attributed to pixels which do not belong to any field. The label image is usually obtained by running task FIELD_FIND.

The output is a Table file containing :
Col 1 Number of pixels
Col 2 Integrated flux
Col 3 X Abscissa of centroid (i.e., Weighted by pixels value)
Col 4 Y Ordinate of centroid (idem)
Col 5 Major axis of fitted ellipsis (should be correct now)
Col 6 Minor axis of fitted ellipsis (idem)
Col 7 Position angle of fitted ellipsis (idem)

13.8 FIELD_STAT

FIELD_STAT

This task computes the integrated spectrum of a number of fields in a data cube. It requests as input a 3-D cube, and a label image (usually produced by task FIELD_FIND). The output is a table where:
- first column is the channel per channel velocity,
- next even columns contain the number of data points in the corresponding field, repeated for each channel (not an optimal storage indeed!),
- next odd columns are the average spectrum for each field.

13.9 FOURIER

FOURIER

This task computes the complex Fourier transform of a real spectra cube. The algorithm is faster if the number of pixels are powers of two but this is not mandatory.

13.10 MAKE_BACK

MAKE_BACK

Computes the background image of an input image using a thresholding and a smoothing algorithm based on the conjugate gradient method. The background image is computed as follows

- First the image is thresholded between THRESHOLD$[1] and THRESHOLD$[2]. All pixels outside this range are blanked.
- Then the image is smoothed using the conjugate gradient method, with NITER$ iterations and a smoothing parameter P$. Blanked pixels are thus interpolated in the process.

The output image is the background image. P$ should be large enough to yield some smoothing (1 to 100, try...), and NITER$ also to assure convergence especially in "blanked" areas (NITER$ = 20 is typical).

13.11 MOMENTS

MOMENTS

This task extracts the first 3 moments of a cube, e.g. for a LMV cube, the integrated intensity, mean velocity and line width (FWHM). A threshold for detection can be specified. Velocity smoothing before detection can be applied.

13.12 PLANE

PLANE

This is a simple task that subtracts a plane from an image. The plane is determined by least square fitting through all non-blanked pixels of the original map, weighted by a weight image. The latter can be used to account for a non uniform signal to noise ratio, but is more frequently used to ignore some areas (typically the sources) in the fit.

It supersedes an older obsolete version (still available as PLANE_OLD) which fitted a plane through 3 points of the input image.

13.13 SLICE

SLICE

This task extracts a slice from a 3-D Ra-Dec-Velocity cube. The output is a 2-Dimensional Position-Velocity plot.

13.14 SPECTRUM

SPECTRUM

This task extracts a spectrum from a 3-D Ra-Dec-Velocity cube. The output is a Gildas table containing the velocities in its first column, and the spectrum values in the second one. The table provides a header repeating the typical data of the original LMV cube.

13.15 SPECTRUM_SUM

SPECTRUM_SUM

This task computes an integrated spectrum from a 3-D Ra-Dec-Velocity cube, over an area specified by an arbitrary polygon. The output is a Gildas table containing the velocities in its first column, and the spectrum values in the second one. The table provides a header repeating the typical data of the original LMV cube.

14 Astronomical Processing Tasks

14.1 astronomical-processing

```
FLOW            A bipolar flow hunter
REPROJECT       Reproject an input image/cube to a different projection system
```

14.2 FLOW

FLOW

This is a dedicated routine to produce bipolar outflow maps, with optimum signal to noise ratio and little bias. It takes as input a cube (N by NX by NY) with the velocity along the first axis, and produces a pseudo-cube cube (3 by NX by NY) containing the maps of the line width and of the red and blue lobes integrated intensities.

For each spectrum, the algorithm determines the peak channel, then determines on each side of this channel the velocity at a given threshold, given as ratio to peak value. From this velocity, it integrates out to a second threshold. The area found is the contribution to the blue (or red) lobe of the flow.

14.3 REPROJECT

REPROJECT

This task resamples an input image to a different projection and coordinate system. Bilinear interpolation is used. Hence the pixel size (increment) of the output image shoud be smaller than the input image one. The task works on data cubes, processing them plane by plane.

For its needs, the task will allocate memory up to the value provided by the Sic logical SPACE_GILDAS. You can tune this value by putting e.g. the following line in the file ~/.gag.dico to enlarge its capabilities (units MB):
SPACE_GILDAS 256

15 Smoothing Tasks

15.1 smoothing

```
DG_SMOOTH        Conjugate Gradient smoothing
GAUSS_SMOOTH     2D Gaussian smoothing in the Fourier plane
NOISE_SMOOTH     Noise cheating enhancement smoothing
SMOOTH           General smoothing algorithm by convolution with a (small) patte
```

15.2 DG_SMOOTH

```
DG_SMOOTH
Smoothes an image using the Conjugate Gradient Algorithm.
(Author: Didier GIRARD, Groupe d'Astrophysique)
```

The smoothed image is the equilibrium state of a thin flexible plate constrained to pass near each height datum by a spring attached between it and the plate. The smoothing is controled by the "Smoothing Parameter" P :

P = (plate stiffness) / (springs stiffness)

A low value for P (0.001) means high fidelity to the original data and should be used for high signal to noise ratios. If the data are noisy, use higher values of P (0.1 to 10). The algorithm is iterative and needs a work space equal to 3 input maps. It usually converges in 10 iterations, and can be restarted if you save the work files. Timing is of the order of 2 seconds of microVAX II CPU time for a 128 by 128 map. It takes into account blanked pixels properly.

15.3 GAUSS_SMOOTH

```
GAUSS_SMOOTH
```

This task performs a 2D smoothing by an elliptical gaussian. If the input file is a 3D cube (or 4D hypercube), the 2D gaussian is applied repeatedly on the first 2 dimensions (i.e. each velocity plane for a LMV cube).

The algorithm works in the Fourier plane and the first 2 dimensions (in pixels) should therefore be powers of two (but need not be equal). It is much faster than the equivalent sky plane algorithm, but you should beware of aliasing effects when the size of the convolving gaussian becomes a sizeable fraction of the map (say 30%).

Note also that, because of the round trip in the Fourier plane, the blanking values can NOT be ignored. This means that each pixel with a blanking value will contribute (pollute) the overall smoothed image in return. In other words, you should avoid images with blank values, or at

least, set them to a reasonable dummy background value (e.g. 0).

15.4 NOISE_SMOOTH

NOISE_SMOOTH

Smoothes an input image using the noise cheating enhancement method. This method works only for strictly positive images. Values for adjacent pixels are summed until a given total is reached. Then, the total is divided by the number of pixels added and the result is used for the output pixel value. This smoothing is very non linear (in particular no smoothing occur on pixels stronger than the smoothing threshold). A parameter allows to restrict the averaging to nearby pixels only: in this case the output image is not necessarily strictly positive.

15.5 SMOOTH

SMOOTH

Smooths an input map using various methods, all based upon a convolving kernel of 5 points large only. This method is crude, but very fast, and supports blanking in principle... Data cubes are processed plane by plane.

1. BOX A simple 5 by 5 boxcar smoothing. This is a very strong smoothing...
2. GAUSS A gaussian smoothing. The gaussian is sampled on a 5 by 5 grid so it must not be too broad. 3 pixels seem a maximum. Use task GAUSS_SMOOTH if you want to smooth with a broader gaussian, but beware it does not handle properly blanked pixels.
3. HANNING Smoothing by a 5 by 5 pyramid, with weights 3 2 1.
4. USER User defined smoothing coefficients on a 5 by 5 grid, assuming biaxial symmetry. Hence 6 coefficients only are required, S00 S10 S11 S20 S21 S22. The corresponding smoothing kernel is :

```
S22 S21 S20 S21 S22
S21 S11 S10 S11 S21
S20 S10 S00 S10 S20
S21 S11 S10 S11 S21
S22 S21 S20 S21 S22
```

Such a generalised "smoothing" enables some image enhancement based on gradients (e.g. with weights 4 -1 0 0 0 0). The "smoothed" image is normalised by the sum of absolute values of the coefficients.

16 Correlation Analysis Tasks

16.1 correlation-analysis

```
CORRELATE        Correlation image of two input images or data cubes
HISTO_CLOUD      Cross histogram of two input images (Table output)
HISTO_CROSS      Cross histogram of two input images/cubes (Image output)
HISTO_DOUBLE     Histogram of an image as a function of another one
HISTO_SIMPLE     Histogram of an image or of a table
HISTO_TABLE      Cross histogram of column tables
MINIMIZE         Find best linear correlation between two images
REGRESSION       Compute the linear regression from a cross histogram
CORRELATE        Correlation image of two input images or data cubes
TABLE_DENSITY     Density of points from 2 columns of a table
```

16.2 CORRELATE

```
CORRELATE
```

Computes correlation of two images or data cubes. The result is an image (data cube) containing

```
Out(i,j) = < In1(k-i,l-j)*In2(k,l) >         averaged over k,l
For mode correlation (MODE$ = YES)
```

or

```
Out(i,j) = - < In1(k-i,l-j)**2 + In2(k,l)**2
             - 2 * In1(k-i,l-j)*In2(k,l) >   averaged over k,l
```

For mode square (MODE$ = NO). The correlation is higher when Out(i,j) is near 0. With the minus sign, this means that maximum values indicate highest correlations.

Actually, linear conversion formulas are used to keep the correlation image meaningful in user coordinates. The input images must match.

When used for example to recenter images, the position of the maximum of the correlation image yields the required recentering. MODE$ YES (Correlation) is to be used when the input distribution has a finite extent, while MODE$ NO (Square) can be used in any case, but is somewhat slower of course.

16.3 HISTO_CLOUD

```
HISTO_CLOUD
```

Makes the cross histogram of two input images. The result is a table of two columns:

- First column : value of pixel (I,J) of first image

- Second column : value of pixel (I,J) of second image

Using the GreG command POINT on this output table will produce a cloud plot of the correlation between the two images. This program is reasonably well adapted for small images, but you should use HISTO_CROSS for large images.

16.4 HISTO_CROSS

HISTO_CROSS

Computes the cross histogram of two input images/cubes. The output has the same rank as the input arrays : 2 if images as input, 3 if cubes. Both inputs must have the same rank. If the input cubes are 3D data cubes, the third axis must be the same for both. If n1 and n2 are the numbers of bins for the first and the second input cube respectively, the result has dimensions [n1,n2] or [n1,n2,nchan] where nchan is the third dimension of the input cubes. The value at a given (I,J) is thus the number of pixels in the input images that have the value corresponding to slot I in the first image and to slot J in the second one. For cubes, this is done in each plane. You can then sum (see SIC\COMPUTE) to have the cross histrogram for the whole cube.

If the tolerance on the blanking value is positive, the task takes into account the blanking values of the input cubes.

The output image can be used as input to task REGRESSION to evaluate some statistical parameters of the correlation. See also HISTO_CLOUD for a slightly different information.

16.5 HISTO_DOUBLE

HISTO_DOUBLE

Computes the histogram of an image (Y_image) as a function of a second one (Z_image). This gives an information similar to, but slightly different from the cross histogram (cf HISTO_CROSS). The program computes histogram of the mean value and standard deviation. The result is a table of 4 Columns, in which

1) the first column contains the mean value of the Y_image (average of all pixels in the Y_image for which the Z_image value is included in the corresponding slot)
2) the second the standard deviation (of the Y_image values).
3) the third the number of pixels of the Y_image used to compute the mean and deviation.
4) the fourth column contains the histogram abscissa (actual value of the input Z_image)

16.6 HISTO_SIMPLE

HISTO_SIMPLE

Computes the histogram of an image (or of a table). A subset of the image may be specified. The result is a table with 2 columns : Column 1 contains the number of input image pixels in the interval, Column 2 contains the middle value of the interval.

16.7 HISTO_TABLE

HISTO_TABLE

Computes the cross histogram of two columns of a table. The result is an a 2-D image where the value of pixel (I,J) is the number of points in the input table for which the first column value correspond to bin I, and the second column value to bin J.

16.8 MINIMIZE

MINIMIZE

This task finds the best linear combination of two input arrays, in the form

```
X(i,j) = A*Y(i,j) + B
```

The results are A and B of course, written in MINIMIZE.GILDAS.

16.9 REGRESSION

REGRESSION

This task computes the best least square linear regression between two images. It uses as input a cross histogram of the two images which must have been created previously by program HISTO_CROSS.

16.10 CORRELATE

CORRELATE

Computes correlation of two images or data cubes. The result is an image (data cube) containing

```
Out(i,j) = < In1(k-i,l-j)*In2(k,l) >          averaged over k,l
For mode correlation (MODE$ = YES)
```

or

```
Out(i,j) = < In1(k-i,l-j)**2 + In2(k,l)**2
```

```
                  - 2 * In1(k-i,l-j)*In2(k,l) >   averaged over k,l
     For mode square (MODE$ = NO)
```

Actually, linear conversion formulas are used to keep the correlation image meaningful in user coordinates. The input images must match.

When used for example to recenter images, the position of the maximum of the correlation image (or equivalently of the minimum of the sum of squares image) yields the required recentering. MODE$ YES (Correlation) is to be used when the input distribution has a finite extent, while MODE$ NO (Square) can be used in any case, but is somewhat slower of course.

16.11 TABLE_DENSITY

```
    Compute a 2-D image with the density of points
from 2 columns of an input table. Also create a table
containing only the "isolated" points, those with a
density below some threshold.

The task is used by the  "plot-triangle.greg" procedure
to display correlation analysis of N parameters, from a
M x N table containing M valid samples of the N parameters.
```

17 Model Fitting Tasks

17.1 model-fitting

```
GAUSS_1D        Multi component one-dimension gaussian fitting
GAUSS_2D        Single component two-dimension gaussian fitting
```

17.2 GAUSS_1D

GAUSS_1D

This task makes a multi-component non-linear gaussian fit into columns of a table.

It fits a function Y = f(X) where f is the sum of up to five gaussian, and X and Y data are taken in specified columns of the input table. The method is identical to that used by the GAUSS command in CLASS (simplex followed by conjugate gradient). The format for input of initial parameters is also similar. All messages are sent to a specified output file. The fitted profiles can be kept in separate columns of the input table.

17.3 GAUSS_2D

GAUSS_2D

This task fits a single 2 dimensional elliptical gaussian to an image. All coordinates are USER coordinates, not pixels. Each parameter is followed by a code to indicate whether it is fixed (code 1) or variable (code 0).

If the input image is actually a cube, a gaussian is fitted to each plane.

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