CLIC
Continuum and Line Interferometer Calibration

R. Lucas[1]

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

This document describes the calibration software for the IRAM Plateau de Bure Interferometer. Related information is available in:

- IRAM Plateau de Bure Interferometer: Users Guide
- IRAM Plateau de Bure Interferometer: Foreign Commands
- IRAM Plateau de Bure Interferometer: Trouble Shooting Guide
- IRAM Plateau de Bure Interferometer: Frequency Setup
- IRAM Plateau de Bure Interferometer: Atmospheric Calibration
- GreG, Grenoble Graphic
- GILDAS, Grenoble Image and Line Data Analysis System

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1 Introduction

This document gives a description of the **CLIC** software, developed to calibrate the data taken with the IRAM millimeter-wave interferometer on Plateau de Bure. **CLIC** stands for "Continuum and Line Interferometer Calibration". The way the data must be calibrated is very much dependent on the acquisition procedures and the backend hardware. For that reason it was felt easier to develop a dedicated program that to try to use an existing package such as **AIPS**. The situation is different for mapping software, for which our needs are certainly covered by the capabilities of **AIPS**. Thus a gateway from **CLIC** calibrated visibility files into the **AIPS** world is provided.

We outline now the different steps in data calibration. The (complex) visibility W measured on the baseline from antenna i to antenna j at frequency channel k is related to the true object visibility V_{ij} by

$$W_{ijk} = g_i(t)g_j^*(t)b_{ijk}(t)V_{ij}(u_k(t), v_k(t)) + noiseterm \tag{1}$$

where $u_k(t)$ and $v_k(t)$ are the spatial frequencies corresponding to baseline ij at time t and frequency k, and we assume the object has a flat spectrum. Calibrating the data is computing the complex "calibration curves" $g_i(t)$ and $b_{ijk}(t)$. For the relatively narrow bandpass of millimeter astronomy, $u_k(t)$ and $v_k(t)$ are almost independent of the frequency channel k (even the sideband separation is only 3 % of the observing frequency).

$b_{ijk}(t)$ is the bandpass of the detection system, and is usually almost constant with time. It can be formally decomposed in a product of RF bandpass, caused by receivers and cables and usually with weak dependence on frequency, and IF bandpass, caused by the backend (spectral and continuum correlators at Bure).

For the $g_i(t)$, we must separate the calibration of amplitude and phases since amplitude and phase errors have very different origins. The amplitude corrections is related to several effects: atmospheric absorption, receiver gain, antenna gain (affected by pointing errors, defocussing, surface status and systematic elevation effects), and correlation losses due to phase noise. Phase errors may come from delay errors, baseline errors, or a slow drift in atmospheric or receiver phases.

- *Amplitude calibration*: Atmospheric absorption and receiver gain are derived in the same way as for single dish data, the correction factors being determined from "chopper wheel calibrations" being performed at regular intervals (typically 10–15 minutes). This in the same time corrects for the amplitude passband (except for antenna chromatism effects). The atmospheric model calculations are done on-line to help monitoring data quality, and applied to the data. However, the calibration parameters are stored in the headers as well as the overall amplitude factor applied. In this way, the model calculations can always be repeated at any stage in the data reduction process, with the possibility of correcting wrong atmospheric parameters.

- *IF Passband Calibration*: Phase errors introduced in the backend are measured by connecting all correlator inputs to the same source of white noise (a noise generator in the IF). Ideally all outputs should give 100% correlated signals. The phases then are the channel-to-channel phase errors. Normally this operation should be done every time the spectral correlator setup is changed. It is actually done as often as the amplitude calibration, since it can be done during antenna motion from one source to the next, and since it provides a good means to trace down hardware problems in the backend.

- *Phase Calibration* is necessary to correct the raw visibilities for instrumental and atmospheric short–term phase fluctuations. This is done by repeatedly observing a nearby point source for which the measured phases should be zero if delays are correctly tracked. The phase closure relations may also be used. If the calibrator is very close to the source, this will also correct to first order baseline errors.

  The visibilities amplitudes measured on the calibration source, if strong enough, give an estimate of the additional amplitude corrections introduced by pointing and focussing inaccuracies and atmospheric phase jitter. They are commonly used to calibrate the source amplitude relatively to the flux of the phase calibrator, thus eliminating to first order the decorrelation effect due to the atmospheric phase fluctuations.

- *RF Passband Calibration*: Ideally the phase calibration should be done separately for each receiver channel (but calibrators are not strong enough). However if one assumes that phase fluctuations are not frequency–dependent one may calibrate the relative phases of the channels on a strong source, before or after the observations. Actually only the RF passband needs observing a source in the sky for this, since the passband of the correlators may be calibrated in autocorrelation mode on a noise source (see above). RF passband calibration may be necessary only for broad band spectra or objects where a high channel to channel dynamic range is needed.

Amplitude calibration and IF passband calibration have now been moved into the acquisition software. They are however described in section 4.1. Instrumental phase and RF passband calibrations might need more user intervention, depending on the data quality, and are described later, after a section dedicated to the data display capabilities of **CLIC**. Finally some specific operations, such as baseline calibration, are explained.

2 The Commands

CLIC commands may be separated into several groups, as shown in the following table:

Group of commands	*Section of this manual*	*Commands*
General purpose	all	`SAVE, SET, SHOW`
Data retrieval	3.1	`COMPRESS, DUMP, DROP, FILE, FIND, FLAG, MARK, MASK, HEADER, IGNORE, LIST, MASK, NEW_DATA, TABLE, WRITE`
Data display	3.2	`CURSOR, PLOT, RESIDUALS`
Calibration	4.1, 4.3	`SOLVE, ATMOSPHERE, STORE`

3 Data Access

3.1 Data Storage and Retrieval

Visibility data and header information are stored on files in a format which is a simple extension of the one used by the single dish **CLASS** program. The file organisation is exactly the same as in **CLASS**; except for some additional index entries, specific to interferometric data. Observation headers are also organised in sections, most of which are interferometer-specific. However, the length of the data section may vary, depending on the number of data records written sequentially. Each data record contains a short data header with the values of some fast varying parameters such as time, U and V coordinates, source direction vector, ...

The Input and Output files are selected by the `FILE` command (syntax: as in **CLASS**).

Most commands deal with all observations in the Current Index. The Current Index is filled by means of the command `FIND`. Selection criteria are mostly identical to the ones in **CLASS**, with some additions such as Hour Angle or Calibration Status. Commands `DROP` and `IGNORE` have the same meaning as in **CLASS**. Commands such as `GET` and `WRITE` are provided for test purposes only.

Depending on whether the input and output files are identical or not commands which output data will either modify data in place, or write new versions of the data observations. Command `COMPRESS`, is normally used to time-compress data. To simply transfer data from one file to another, the command `COPY` should be preferred.

Finally command `TABLE` outputs a UV Data Table suitable for use in mapping programs (either **GILDAS** tasks, or **AIPS** tasks after format conversion by **GFITS**).

3.2 Data Display

The **CLIC** program includes the one dimensional part of **GreG** (SIC language GREG1). All graphic display is done internally via **GreG** commands or subroutines. So we refer to the **GreG** documentation for commands like `DEVICE`, `HARDCOPY`, ... which must be issued to obtain a graphic display. [1]

The **CLIC** display may do two kinds of plotting: time-like or spectral-like. By default, the time-like mode is selected (`SET MODE TIME`). In this mode, two quantities are plotted one against each other, in one or several **GreG** boxe Both quantities are time functions, such as time itself, or hour angle, or amplitude (or phase) in a selected channel.

In spectral-like mode (`SET MODE SPEC`), the quantity in abs is a spectral coordinate, such as channel number, frequency or velocity. The ordinate is then amplitude or phase. Switching between time mode and spectral mode is done automatically by the `SET X` and `SET Y` commands.

3.2.1 Time-like plots

The defaults plot settings are the following:

```
SET MODE TIME
SET X TIME
SET Y AMPLITUDE PHASE /LIMITS 0 * -180 180
SET ASPECT_RATIO 2.0 AUTO
SET SUBBANDS C01 TO C06
SET BANDS LOWER
SET BASELINES 12 13 23 14 24 34
SET AVERAGING NONE
SET PHASES DEGREES JUMPY
SET PLOT POINTS
```

Thus the `PLOT` command will produce six plots in six **GreG** boxes; one for amplitude versus time and one for phase versus time, for the three baselines linking the three first antennas. The data plotted will be the average of the 6 continuum channels (C01 to C06) for the upper side band. No time averaging will be done (one point plotted for each data point recorded), the phase will be in degrees with no 360 degrees jumps.

The `SET X` and `SET Y` commands are needed to choose the variables to be plotted. In time-like mode the variables may be the components of the visibilities (amplitude, phase, real part or imaginary part), or the baselines coordinates `U`, `V`, `RADIUS` or `ANGLE` (the rectangular or polar coordinates of the baseline vector in the plane perpendicular to the source direction). Other variables are time (in hours of Universal Time), scan number, source direction (`HOUR_ANGLE` and `DECLINATION`), or delays (see the internal help or section 8 for a complete description).

The `SET BANDS` command will select the side bands plotted. Several side bands may be plotted simultaneously. Side bands may obviously be `UPPER` or `LOWER`, or `AVERAGE`, where the weighted average of both side bands will be used to compute the components of the visibilities if any are to be plotted, or `RATIO`, in which case the (unweighted) ratio USB/LSB will be used. The weights for averaging the side bands are entered by the `SET AVERAGING` command.

The `SET SUBBANDS` command is used to specify the sub-bands to be used. Sub-bands are referred to by their mnemonics `C01`, ..., `C06`, for the continuum sub-bands, `L01`, ..., `L06` for the line sub-bands. In **CLIC**, L01 refers to the first available line subband, L02 to the second one, and so on. They correspond to the bands selected in the `SPECTRAL` command in **OBS**. Several continuum sub-bands may be averaged together by specifying a range (e.g. `C01 TO C05`, or `C01 AND C04`, or `C01 AND C03 TO C06`, the latter just excluding `C02`).

For line sub-bands all the channels are averaged together, except if the `/WINDOW` option is used. For instance:

`SET SUBBAND L01 /WINDOW 30 45`

[1] Note that since `SET` and `SHOW` are commands in both **CLIC** and **GreG**, we have predefined a few symbols in **CLIC** so that, e.g. `SET` will execute CLIC\SET . You will have to type `GREG1\SET` to execute a **GreG** `SET` command. But `HELP SET` will be ambiguous; type `HELP CLIC\SET` to get information about the **CLIC** `SET` command.

will average visibilities in channels 30 to 45 of the first line sub-band. However the edge channels (with lower signal–to–noise ratio, due to anti–aliasing filters in the correlators) may be left out, by using e.g. `SET DROP 0.1` to leave out 10% of the bandwidth at each edge of each spectral subband (the default is only 5%). The central channels, possibly affected by the Gibbs phenomenon in case of scontinuum signal in the image subband, are left out by using command `SET GIBBS number`, `number` is the number of channels left out

The `SET BASELINES` command obviously selects the baselines for which data is to be plotted. Baselines are named 12, 13, 23, (14, 24, 34, ...). Note that the numbers here refers the ordinal numbers of the antennas that where connected at the time of the observations. If only two antennas were connected, only one baseline will be in the data, and it will be referred to as "12", even though the antennas you used are labelled "2" and "3" in black paint, and were at this time connected to correlator inputs "1" and "3"! However this hardware information is recorded in the header, for possible needs.

A `SET ANTENNA` command is also available. It is used to plot antenna-related parameters (such as `TSYS`, Elevation, ...) or with autocorrelation data (`SET Y AUTO`). It may also be used (in time-like mode only) with correlation data: in that case,

- amplitude A_i for each antenna is computed from ratios of baseline amplitudes A_{jk} in the following way:
  $A_i = \frac{A_{ij} A_{ik}}{A_{jk}}$
  (averaged over possible antennas j and k, different of i and of each other). This actually is a measurement of the gain of antenna i, if a point source is observed. It is a convenient way of displaying pointing and focussing data, but three antennas at least are needed.

- antenna phases are computed by using the closure relations (the phases of all antennas are computed by a least square fit, assuming that antenna 1 has a phase of zero).

The `SET AVERAGING` command deals with the way data is averaged. Data may be time-averaged by the `PLOT` command; `SET AVERAGING TIME t` will specify the averaging time, while `SET AVERAGING SCAN` will force averaging observation by observation, and `SET AVERAGING NONE` will turn off time averaging. The normal method is to average complex visibilities (`SET AVERAGING METHOD VECTOR`, the default), while an alternate method is to average separately amplitude and phases (`SET AVERAGING METHOD SCALAR`).

Side band averaging, and sub-band averaging are always done in vector method. The weights for side band averaging are specified by the commands `SET AVERAGING UPPER baseline amplitude phase` and `SET AVERAGING LOWER baseline amplitude phase`. These weights should be determined from the data, using plots of both amplitude and phase of the side band ratios.

The plotting may be done either with **GreG** symbols (`SET PLOT POINTS`, the default), or with lines connecting the points (`SET PLOT LINES`), with histograms (`SET PLOT HISTOGRAM`), or with error bars (in the case of visibilities only; type `SET PLOT BARS`).

Finally the command `SET ASPECT_RATIO` selects a default x/y aspect ratio in the cases when several boxes will be plotted. The boxes will be positioned on the screen to approach this ratio as much as possible (`SET ASPECT_RATIO value AUTO`), or will exactly reflect the demanded aspect ratio (`SET ASPECT_RATIO value EXACT`).

After a plot has been obtained, coordinates of special points may be obtained interactively by command `CURSOR`, which calls the interactive graphic cursor. Striking almost any key will give the user coordinates of the cursor, while "E" is used as usual to exit the cursor mode; "K" will delete the selected data point from the current plot (useful to avoid this point in `SOLVE PHASE`); you may also `IGNORE` or `TAG` scans in a given range to a given quality: type N to open a new range, and `I` or `T` to close it (if using `T` you will be prompted for the quality in the range 0-9). Finally "F" may be used in the same manner as "T" to interactively flag bad data points in the data (see section 4.6.2)

After the `PLOT` command, the abscissae and ordinates of the plotted data points are kept in two two-dimensional SIC arrays named `X_DATA` and `Y_DATA`, where the first index is the data point counter (1 to `N_DATA`) and the second index is the box number. Thus the data are available for more specific plots or mathematical operations using the possibilities of SIC and **GreG**.

3.2.2 Spectral-like plots

In spectral-like mode (SET MODE SPECTRAL), the only X variables allowed are Channel number, IF frequency, RF rest frequency, and Velocity, while Y variables are the components of the visibilities, or autocorrelations (SET Y AUTO). SET ANTENNA may be used, but only with autocorrelations. Some SET keywords have a different meaning:
SET SUBBAND: here groups linked be the keyword TO indicate concatenation rather than averaging. For instance SET SUBBAND C01 TO C06 will form a single broad band spectrum with the 6 continuum sub-band visibilities; or SET SUBBAND L01 TO L02 will concatenate the first two line sub-bands to form a single spectrum, plotted in a single box.
SET AVERAGING TIME or SCAN or NONE has no meaning; all data in the current index is averaged to form a single spectrum in any case.

Use of SET DROP and SET GIBBS is the same as in time mode, but their effect here is more obvious on the plots since the channels are plotted individually.

4 Data Calibration Steps

4.1 Real Time Calibration

Under this denomination we group a certain number of calibration operations that need to be done on the visibilities, and on autocorrelation data. These calibration steps are performed by the data acquisition processes (CORREL and RDI) running on the control computer, BURE01::. It is nevertheless useful to briefly describe these operations here. They are:

- *Clipping correction of line correlator data* (the clipping correction for the continuum correlator is performed in real time on the control computer). For this we use the approximation of Kulkarni and Heiles (*Astron.J.***85**, 10, 1413) for correlation data, and a numeric integration using cubic splines for auto correlation data.
- *Fourier transform of autocorrelation data*
- *Fourier transform and sideband separation of correlation data*
- *Correction of phases for delay rounding errors*
- *Reduction of atmospheric calibrations*, using an atmospheric model and recorded atmospheric parameters. A calibration constant (T_{CAL}) is determined, as well as the gains in each channel for each antenna.
- *Reduction of the IF Passband calibration scans.*
- *Amplitude calibration of correlation data* using the last available autocorrelation data, and system temperatures from atmospheric calibrations
- *Calculation of velocity scales* for each sub-band and side band.

The atmospheric calibration may be re-computed off-line by using the command ATMOSPHERE. The atmospheric calibration is normally performed according to parameters given in real time in **OBS**. Each antenna may be set in one of three calibration modes: FILE, AUTO, or TREC. FILE mode (the default) just means that the mode used will be the one given in **OBS** for the corresponding antenna. Any antenna in TREC mode is first used to determine a value of the water content. If more than one is available, an average is made. Then the resulting water content is used for the antennas in AUTO, for which a value of Trec is then determined.

Note that the command ATMOSPHERE may be run several times on the same data. The mode for some antennas may be forced in **CLIC** with commands SET ATMOSPHERE TREC temp /ANTENNA i, or SET ATMOSPHERE AUTO water /ANTENNA i. This may be useful if, by chance, the amplitude calibration parameters were not set to the correct values in **OBS** by the observer. Incorrect calibration parameters may be updated by command MODIFY HEADER.

4.2 A First Look at the Data

Before processing to actually calibrate the data, it is useful to evaluate the data quality. Actually this should be done on the site, as soon as possible after the data has been taken, to take the appropriate action (such as re-observing the source in the current interferometer configuration). We list here the simplest checks to be done on the data (these checks do not require knowledge of the astronomic aims of the observing program):

Plot the system temperature and water vapor content versus time (or versus elevation). Use `SET ANTENNA 1 2 3 4`, `SET Y TSYS WATER`. `TSYS` should have a reasonable dependence on elevation, while `WATER` (the zenith opacity) will reflect any strong variation of atmospheric opacity with time.

Plot the total power output versus time. Use Use `SET ANTENNA 1 2 3 4`, `SET Y TOTAL`. It should display a reasonable elevation dependence.

Plot the calibrator amplitude and phase versus time The phase calibrators are selected from the data set by the command `SET TYPE PHASE`. Both amplitude and phase should ideally be constants.

The amplitude (in kelvins) should be in principle the same as observed in single-dish observations. Check for pointing or focussing problems if the amplitude suddenly drops in baselines connected to one antenna. Check the calibration parameters if the amplitude as a clear dependence on elevation.

If the phase has a sinusoidal dependence on hour-angle, the baseline parameters may be incorrect.

Plot the calibrator amplitude and phase versus IF-frequency. These curves should be relatively flat, since the IF pass-band has been removed during real time calibration. No systematic slope should appear in the phase of the calibrator, if the delay offsets have been measured with sufficient accuracy. If some strange effect is seen in the correlator data (very low amplitude, very strong slope in the phases), you should check the IF passband calibrations.

Plot the IF-passband calibrations (if anything seems wrong with the correlator). These calibrations consist of two observations, an autocorrelation and a correlation.

With `SET Y AMPLITUDE PHASE, SET X I_F` and `SET BASELINE 12 13 23 14 24 34`, you will get the correlation (normalised by the autocorrelation). Amplitudes should be very close to 1., except for possibly the edge channels of each subband. Phases show a systematic slope, varying from one correlator unit to another.

With `SET Y AUTOCORR, SET X I_F` and `SET ANTENNA 1 2 3 4`, you will get the autocorrelation spectrum for each correlator entry. The passbands should be rather smooth.

Bad channels should show up as strong oscillations in either plot.

4.3 Phase Calibration

4.3.1 Determining the calibration curve

The first operation is to select in the current index the calibrator observations performed during the time period when calibration is needed, and to plot the visibilities after having selected the baselines, side bands and/or subbands needed. This is done via `SET BASELINES`, `SET BANDS`, `SET SUBBANDS` commands. Time should be specified as X axis and Phase as Y axis (in `SET MODE TIME`, of course). `SET PHASE CONTINUOUS` should also be specified, otherwise fitting a smooth curve will be difficult.

Then a calibration curve is determined by command `SOLVE PHASE`. By default this command will fit a cubic spline into each measured phase or amplitude. With option `/PLOT`, the curve will be plotted with the data points. The calibration curve is then in memory.

The time interval between knots of the cubic splines is available as a parameter through the `SET STEP` command. Its default value is 3 hours. Additional knots may be introduced with the option `/BREAK`, to match discontinuities or angular points.

Alternatively, with option `/POLYNOMIAL`, a polynomial fit will be made. The degree of the polynomial is automatically chosen, using the statistical errors bars for each data point.

4.3.2 Storing the Phase Calibration Curves

The next step is to store this curve (if satisfactory) in the headers of the observations to be calibrated. This is done after loading those observations into the current index, by the `STORE PHASE` command. Before doing this, you must have selected an output file. This may either be the same as the input file (the headers will then be modified in place), or a new file.

CLIC will not apply the calibration to the data itself before it is processed Calibrated data may be examined however with the `PLOT` command; to do this you have to enter the command `SET PHASE RELATIVE` . This will be switched back to `ABSOLUTE` if you try to use `SOLVE PHASE` on calibrated data.

4.4 Amplitude Calibration

Phases being angles are naturally defined in radians (or degrees). For the amplitude two units might be of interest : flux densities (in Jansky) or brightness temperatures (in Kelvin). In principle, after atmospheric amplitude calibration have been applied, the amplitude naturally comes out in brightness temperature scale, which can be converted just knowing the primary beam size into flux density. However, unavoidable effects such as short term atmospheric phase fluctuations add extra degradations to the amplitude scale.

Accordingly, it is often necessary to refer the amplitude scale to a primary (or secondary) calibrator of known flux density. To summarize, amplitude may be displayed in 3 different modes and 2 units, with the following factor :

Unit \ Mode	`ABSOLUTE`	`RELATIVE`	`SCALED`
`KELVIN`	1	$A_{ij}(t)$	$1/S$
`JANSKY`	$\sqrt{F_i * F_j}$	$A_{ij}(t)/\sqrt{F_i * F_j}$	$1/S$

where the F_i are the efficiencies of antenna in Jy/K, A_{ij} is the amplitude calibration factor (in K/Jy) and S the source flux in Jy.

Calibrating the amplitude usually implies determining both the F_i and A_{ij} functions.

4.4.1 Solving for fluxes

The first step is usually to determine the efficiencies of antenna from sources of known flux. To do that, the `SOLVE FLUX` command forces `SET AMPLITUDE SCALED`. It uses all sources of known flux from the current index to compute the (time averaged) values of the efficiencies F_i. The fluxes of other sources in the current index can then be determined using from the efficiencies. Sources of known flux are specified using the `SET FLUX` command. The sources should have been observed sufficiently closely in time to avoid any variation of the A_{ij} values. Also, good flux determination requires pointing errors to be similar on those sources.

The fluxes (measured or manually entered by `SET FLUX`) can be written to the output file using the `STORE FLUX` command.

4.4.2 Determining the calibration curve

The first operation is to select in the current index the calibrator observations performed during the time period when calibration is needed, and to plot the visibilities after having selected the baselines, side bands and/or subbands needed. This is done via `SET BASELINES`, `SET BANDS`, `SET SUBBANDS` commands. Time should be specified as X axis and amplitude as Y axis (in `SET MODE TIME`, of course).

Then a calibration curve is determined by command `SOLVE AMPLITUDE`. It forces `SET AMPLITUDE ABSOLUTE KELVIN` to determine the calibration curve $A_{ij}(t)$ which is then in memory.

For the type of curve (splines, breaks, polynomials), `SOLVE AMPLITUDE` behaves as the the `SOLVE PHASE` command applies.

4.4.3 Storing the Amplitude Calibration Curves

The next step is to store this curve (if satisfactory) in the headers of the observations to be calibrated. This is done after loading those observations into the current index, by the `STORE AMPLITUDE` command.

CLIC will not apply the calibration to the data itself before it is processed for mapping. Calibrated data may be examined however with the `PLOT` command; using the `SET AMPLITUDE RELATIVE [JANSKY|KELVIN]` command

4.5 RF Passband Calibration

The IF part of the passband shape should have been calibrated out either on-line or by the `SPECTRUM` command. However the RF part remains and must be calibrated using radio sources.

4.5.1 Determining the passband curves

The first operation is to select in the current index the calibrator observations performed during the time period when calibration is needed, and to plot the visibilities after having selected the baselines, side bands and/or subbands needed. This is done via `SET BASELINES`, `SET BANDS`, `SET SUBBANDS` commands. Channel number should be specified as X axis and Phase and/or amplitude as Y axis, `SET MODE SPEC`. You should preferrably use `SET PHASE CONTINUOUS`, since 2π jumps may occur in the passband shape. Then a calibration curve is determined by command `SOLVE RF_PASSBAND`. This command will fit a polynomial into each measured phase or amplitude, for each line subband. For the line subbands the polynomial is by default of degree 0 for amplitude and 1 for phase data. Higher degrees may be specified as arguments to the `SOLVE RF_PASSBAND` command. For the continuum, the ten values are simply stored and will be used as calibration data.

With option `/PLOT`, the curve will be plotted with the data points. The calibration curve is then in memory. These `PLOT` and `SOLVE` operations will have to be done in several steps, if many subbands are used. The curve for each subband and sideband is kept in memory, so that a single `STORE` command is needed.

4.5.2 Storing the passband curves

The next step is to store this curve (if satisfactory) in the headers of the observations to be calibrated. This is done after loading those observations into the current index, by the `STORE RF_PASSBAND` command. Before doing this, you must have selected an output file. This may either be the same as the input file (the headers will then be modified in place), or a new file.

As for instrumental calibration, **CLIC** will not actually apply the calibration the data before it is processed for mapping. Calibrated data may be examined however with the `PLOT` command; to do this you have to enter the command `SET RF_PASSBAND ON` . This will be switched back to OFF if you try to use `SOLVE RF_PASSBAND` on calibrated data.

4.6 Editing the Data

In some (rare) cases the calibration will reveal unpleasant results: the weather was very bad indeed, or something did not work properly. Thus you may consider modifying some header parameters, or even delete some data points. The parameters in the headers (and even the data itself) are all accessible as **SIC** variables. Selection of data records for further use is done by a set of flags in the header of each data record.

4.6.1 Variables

A **SIC** variable may be associated with nearly every header parameter. Variables are normally not enabled; a whole group of variables may be enabled, by means of command `VARIABLES`. For instance:
`VARIABLES ATMOS ON`
will turn on all variables concerning atmospheric parameters. Use `HELP VARIABLES` to consult the list of variables and groups of variables. To examine the content of variables, the observation, and one of the associated may be read in with command `GET /RECORD`.

The edition of the data headers is done is a more powerful way by command `MODIFY HEADER`. This command will perform a loop on the current index, loading each header in turn; for each it will execute a procedure `MODIFY.CLIC`, that you should provide (you may give it another name, and enter it as a second argument to command `MODIFY`). This procedure may contain **SIC** commands (such as `EXAMINE, LET, SAY ...`), or some **CLIC** commands like `HEADER`, `DUMP` ... Its execution `must` end with the special command `GO`, otherwise the loop will be aborted. The command `GO WRITE` will ensure that the modified header is rewritten to disk.

For instance, assume the flux for 3C84 was entered incorrectly as 100 Jy, during an observing session (you do not recall when exactly). The correct flux was 12 Jy. Your `MODIFY.CLIC` might look like:

```
IF FLUX.NE.12 THEN
    LET FLUX = 12
    SAY "Flux updated, scan " 'SCAN'
    GO WRITE
ELSE
    GO
ENDIF
```

You will have to execute the following commands:

```
FIND
VARIABLE POSITION ON ! this is the group for FLUX
VARIABLE GENERAL ON             ! this is the group for SCAN
MODIFY HEADER
```

Note that in the above example, the same result could be obtained more simply by:

```
SET FLUX 3C84 12.
STORE FLUX
```

Command `MODIFY DATA` works in the same way, but it will successively load all the data records of each observation, and execute (by default) the procedure `DATA.CLIC`. The range of this command may however be restricted with options `/AFTER date time` and `/BEFORE date time`, where 'date' is a usual date chain (`jj-mmm-yyyy`), and 'time' the time in hours (sexagesimal notation in understood).

4.6.2 Flags

Each record contains one flag word by antenna, and one flag word by baseline. There may ultimately 32 flags in each word. As for now, both antenna and baseline flag words may contain one flag by subband (named `C01` to `C06`, and `L01` to `L06`; in addition, the antenna flag words may contain flags `LOCK`, `TSYS`, `POINTING`, `SHADOW`, and `DATA`, while the baseline flagwords may contain flag `DATA`.

For instance, if subband flag `C02` is present in baseline 23, subband `C02` will be ignored for further processing of baseline 23 (in particular, it will be absent from plots). If present in antenna 1, baselines 12 and 13 will be affected. Other flags such as `LOCK`, `TSYS`, `POINTING`, `SHADOW`, and `DATA` will affect all subbands of the relevant baselines. Flags should normally be set by the real time system, or the real time calibration step in **CLIC**.

You may wish to use that data anyway, by masking them (command `MASK`). For instance use `MASK C02 /BASELINE 23` if you feel that this subband was usable, but do not be surprised by the results !

You may also want to suppress temporarily some data channels from plots or from output tables, without modifying the data file itself. This is done by command `MARK`. Marked data channels will be ignored just as if they were flagged in the data.

On the opposite, you might have to flag some data yourself. There are several ways of doing this:

- using the command `STORE FLAG` which will flag all the records of all the scans in the current index. For instance

  ```
  FIND /SCAN 5436
  STORE FLAG DATA /BASELINE 12
  ```

will flag baseline 12 for the whole duration of scan 5436. This is the best way to flag one or more complete scans.

- using command MODIFY DATA, with a procedure DATA.CLIC containing the command FLAG. For instance, assume that you want to discard all data where the total power on antenna 2 is lower than some threshold, say 10. You will create a procedure DATA.CLIC:

```
IF DH_TOTAL[2].LT.10. THEN
    FLAG DATA /ANTENNA  2
    GO WRITE
ELSE
    GO
ENDIF
```

  Do not forget to enable variables of group DATA_HEADER, before typing MODIFY DATA.

- interactively, after a GET /RECORD, use the FLAG command to set or reset a flag for this specific record. The UPDATE command will write back the flagged data to the file.

- interactively, with command CURSOR. Assume you have plotted amplitude versus time (with no averaging), you should have one point for each record. Then you can select a range of records in X coordinate: point the cursor to the first point you want to flag, type N (for New range), then go to the last point, type F (for Flag). You will be prompted for the name of the flag to set. This flag will be set for the baseline, or antenna, corresponding to the box you are pointing to with the cursor.

You may get a status of the flags in the data og the current index by issuing command LIST /FLAG.

5 Calibrating the Interferometer

New instrumental constants have to be measured each time the antennas have been moved: delays, antenna coordinates, pointing constants. We describe here the reduction procedures to be used.

5.1 Delay determination

The delay parameters are determined by taking a correlation on a strong source (the strongest available in the sky), and by measuring the variation of phase as SOLVE DELAY /PLOT
is available to measure the delays. The phase should be plotted as a function of IF frequency, over the broadest band available (the correlator should be set up to analyse the 100-600 MHz band by juxtaposition of several 160 MHz subbands). SOLVE DELAY /PLOT, applied to baseline 12, will output the delay to be applied to antenna 1. If the delay is too large, increase the range of search by using the option /SEARCH range (by default the search range is between -100 and +100 nanoseconds).

5.2 Baseline Calibration

We examine here the way to determine the baseline vectors from calibration observations done for instance after an antenna move. Assume the relevant observations are gathered into the current index. One should make a plot of phase versus both Hour Angle and Declination (SET X HOUR_ANGLE DECLINATION and SET Y PHASE, for each sideband separately.

The command SOLVE BASELINE will then do a least square fit and output the baseline vectors. A linear method is used which works only if the starting values (that is the baselines values in the header) are within half a wavelength in any direction of the true values. Different starting values may be given with the /OFFSET baseline dx dy dz option. In that case the phases are first corrected for the given baseline offsets before the fit.

A blind search within a given range may be done. For this enter the option /SEARCH range where range is in meters. All offsets within the given range (in three directions, stepping by half a wavelength) are tried, and the best rms value is kept. A blind search in a 0.01 meter range will take about 4 seconds on the microVAX 3400. This the default if only `SOLVE BASELINE /SEARCH` is given. Rms values on the range 10-20 degrees are expected, if the data was scan averaged, and observing conditions were acceptable.

The program gives for each baseline two series of offsets, and the fitted baseline for record. The first offsets given (`dx, dy, dy`) are relative to the baseline coordinates used while observing, while the second set of offsets (`DX, DY, DZ`) are relative to the "standard values" of the antenna positions. After all available baselines have been fitted, the command `PRINT BASELINE` will produce a command procedure `CLIC-BASELINE.OBS`. This command procedure may be used in **OBS**, in the `CONFIGURE` mode, to update the antenna position offsets.

If `SET ANTENNA 2 3` has been used instead of `SET BASELINE`, then the antenna position offsets of antennas 2 and 3 are directly determined (the position offset of antenna 1 are by definition zero, like antenna phases for this antenna in the `SET ANTENNA` mode. This mode is preferable since baseline closured is ensured.

Residuals may be examined by entering `RESIDUALS BASELINE`; phases should be independent of hour angle and declination.

Phase data can later modified in previous data to reflect this baseline change (if a previous value proved to be wrong) with `MODIFY BASELINE FITTED`.

If `SET X HOUR DECL TIME` is specified, then plots of phase as a function of time are obtained; `RESIDUALS BASELINE` will also display the variation with time of the residuals. This is useful to detect a time drift of the phases, especially during long observations (to be avoided in any case!). These drifts may be fitted simultaneously with the option `/POLYNOMIAL degree`. In that case a time polynomial (degree up to 3) is added to the fitted phase function.

5.3 Reduction of Pointing and Focussing Scans

This is done by `SOLVE POINTING` and `SOLVE FOCUS` commands.

These commands will scan the current index for the specific data, and fit the data for each antenna. The results may be kept in a data file (Text format): use the option `/OUTPUT filename NEW` or `/OUTPUT filename APPEND` for this.

- for `SOLVE POINTING`, the measured pointing errors in the file may be used to replace the collimations in **OBS** (command `CORRECTIONS`, first two arguments), or the data file be used as a whole to solve for pointing coefficients with the program **POINT** (see the specific documentation on pointing).
- for `SOLVE FOCUS`, the measured error is to be *added* to the foc correction in **OBS** (command `CORRECTIONS`, third argument).

In both cases, option `/PLOT` will produce a graphic display of each fitted curve.

5.4 Reduction of Skydip Scans

This is done by `SOLVE SKYDIP`.

These commands will scan the current index for the specific data, and fit the data for each antenna. The data may be used to solve for the forward efficiency and the water vapor content (default), or to solve for the receiver temperatures and the water vapor contents. Note that at the frequencies currently used, the results for the water content are not very reliable, since the dominant absorption around 90 GHz is oxygen in good weather conditions.

6 A Few Receipes

We give here a few commonly used sequence of commands, to be used as examples.

6.1 Finding the best delay offsets

```
FILE IN INTER_DATA:01-dec-1992 ! load the current data file
SET SUBBANDS L01 to L04        ! use all subbands, which
                               ! should be have close to equal phase offsets.
                               ! delay is more accurately determined.
SET BAND LOWER                 ! select lower side band for instance
SET Y PHASE                    !
SET X I_FREQ                   ! Intermediate frequency  as X axis
SET SCAN 1234                  ! or SET NUMBER n
FIND                           !
SOLVE DELAY /PLOT
```

The optimum delay is actually the differential delay between first and last antennas of the baseline in question. It should be entered in the data file for the first antenna, or its opposite entered in the data file for the second antenna (or possibly shared between them along these lines). Be careful to determine the delay with enough precision, in order not to introduce a slope in the phases (1 nanosecond produces 0.5 turn in the 500 MHz passband).

6.2 Baseline determination

6.2.1 a rough, simple way

Here we just plot the data of lower sideband.

```
!
FILE I INTER_DATA:01-dec-1992
SET SCAN 2393 2440               ! select data by scan number
SET PROCEDURE CORR               ! discard AUTOs and possible other scans
FIND
PLOT                             ! giving it a glance does not hurt ...
SET ANTENNA 2 3                  ! use antenna mode
SET SUBBANDS C01 TO C06          ! should be OK
SET BANDS UPPER LOWER            ! side bands separately
SET PHASE JUMPY                  ! best for baseline solving
SET Y PHASE                      ! amplitude not needed
SET X HOUR_ANGLE DECLINATION
PLOT                             ! phases should be displayed
SOLVE BAS/SEARCH                 ! should normally be enough.
                                 ! ...wait a few seconds ...
PAUSE                            ! keep a log of the results !
                                 ! (both side bands should agree)
PRINT BASELINE                   ! to have the results in a OBS procedure
RESIDUALS BASELINE               ! phases should be flat.
```

6.2.2 more sophisticated

In this we first process the data into a secondary file, perform a RF passband calibration to be able to average continuum subbands and sidebands more accurately, and solve for the baseline with a search loop.

```
!
FILE I INTER_DATA:01-dec-1992         !  Load the raw data
SET SCAN 2393 2440                    ! select data by scan number
SET PROCEDURE CORR                    ! only correlations
FIND
LIST                                  ! as a check
```

```
FILE O W00-N15-E23 NEW              ! open a secondary data file
COMPRESS 60                         ! compress to 1 minute,
                                    ! (this saves plotting time)
!
! Select the compressed data file and do passband calibration on 3c273
!
FILE BOTH W00-N15-E23               ! reopen for both input and output
FIND
PLOT                                ! giving it a glance does not hurt ...
SET SOURCE 3C273                    ! the strongest souce
SET MODE SPEC                       ! actually not needed
SET X I_F                           !
SET PHASE CONTINUOUS                !
SET RF FREQUENCY                    ! use frequency dependent mode
SET Y AMPLITUDE  PHASE
SET SUBBANDS L01 TO L06
FIND
LIST
SET BANDS UPPER                     ! do upper side band fist
SOLVE RF_PASSBAND 5 10 /PLOT        ! degrees as actually needed ...
SET BANDS LOWER                     ! Then lower side band
SOLVE RF_PASSBAND 5 10 /PLOT
SET SOURCE *                        ! come back to all sources
FIND
STORE RF_PASSBAND                   ! in place, in the data headers
!
! Now solve for baseline, using average of subbands 1 to 6
!
SET RF_PASSBAND ON  FR              ! from now on, plot calibrated data
SET MODE TIME                       ! switch back to time mode
SET SUBBANDS C01 TO C06             ! now subbands may be averaged
SET PHASE JUMPY                     ! best for baseline solving
SET Y PHASE                         ! amplitude not needed
SET X HOUR_ANGLE DECLINATION
SET BANDS AVERAGE                   ! double side band
PLOT                                ! phases should be displayed
SOLVE BAS/SEARCH                    ! should normally be enough.
                                    ! ...wait a few seconds ...
PRINT BASELINE
PAUSE                               ! keep a log of the results !
RESIDUALS BASELINE                  ! phases should be flat.
```

7 Producing Images

Images may be produced either by **AIPS** or **GILDAS**. The first step in any direction is to produce a UV Data Table from calibrated data. This is done with **CLIC** command `TABLE`.

7.1 Creating a UV Table

You will have first to select which band and subbands are to be used, with command `SET SELECTION`. The format is

```
SET SELECTION key band subbands
```

'key' may be LINE or CONTINUUM; use CONTINUUM to obtain a table with a single channel, and LINE to obtain a table with multi-channel data. 'band' may be USB, LSB, or DSB (the latter is allowed for continuum mode only, and produces two records: one for each sideband). Finally 'SUBBANDS' is a group of subbands, like C01 to C06 or L01 to L02, to be averaged in continuum mode, and concatenated in line mode (overlapping spectral bands will cause a resampling to occur).

The table itself will be a file in the Gildas Data Format, of dimensions $[3N_C + 7, N_V]$, for N_C channels and N_V visibilities. The $3N_C$ lines contain:

1. U in meters
2. V in meters
3. W in meters
4. Observation date (integer **CLASS** day number)
5. Time in seconds since above date
6. Number of start antenna
7. First frequency point (real part)
8. First frequency point (imaginary part)
9. First frequency point (weight)
10. Same for second frequency point, and so on

The data weights are controlled by command SET WEIGHTS. SET WEIGHT TSYS ON will turn on weighting by $1/T_{SYS}^2$, and SET WEIGHT CALIBRATION ON will turn on weighting by $1/F_{CAL}^2$, where F_{CAL} is the amplitude instrumental calibration factor (if amplitudes are relative). Both weighting factors may be applied simultaneously. If both factors are OFF, data is weighted proportionally to observing time.

Do not forget to SET PHASE RELATIVE, SET RF ON, and SET AMPLITUDE RELATIVE before you invoke command TABLE, otherwise you will tabulate uncalibrated data. The command TABLE itself should contain the name of the table:
TABLE Name Status [/RESAMPLE nc ref val res code]
where 'Status' is NEW to create a new table or OLD to extend an existing one (default). The default and recommended file extension for the UV Table is .UVT.

Option /RESAMPLE resamples the spectrum to a different velocity or frequency resolution, or to select a part of the spectrum only; see internal help for details.

7.2 Going AIPS

You should first convert your table into UVFITS format. This is done by the program **GFITS**. To invoke in, type GFITS under VMS. The commands are:

```
SET STYLE UVFITS        ! Select type of FITS format
IMAGE name.uvt          ! Define input table
FILE OUT name.uvfits    ! Define output FITS file
WRITE                   ! Write FITS file
EXIT
```

The output file 'name.uvfits' will be accepted by **AIPS** task UVLOD (use INFILE name.uvfits). You may also produce a UVFITS file on tape for further reduction at any site running **AIPS**.

Another possibly is the task GILDAS_FITS available in **GILDAS** (using the programs VECTOR, GRAPHIC, or OVERLAY), with command RUN GILDAS_FITS/EDIT. The initialisation file will be

```
! GILDAS_FITS: Gildas to Disk FITS translator
!          (items)                           (user answers)
TASK\FILE "Input Gildas File" IN$            name.uvt
TASK\FILE "Output FITS file" FITS$           name.uvfits
TASK\INTEGER "Number of bits" NBIT$          16 ! or 32 or -16 or -32
TASK\CHARACTER "Style of FITS file" STYLE$   UVFITS
TASK\GO
```

7.3 Mapping facilities in GILDAS

- The UV Table should first be sorted by task `UVSORT`, to obtain a UV Sorted Table.
- From the UV Sorted Table, task `DFT` produces images by Direct Fourier Transform, a simple way, but slow and only practical for continuum images.
- Task `UVMAP` produces images by gridding and Fast Fourier Transform of a UV Sorted Table.
- Task `CLEAN` is available for deconvolution with several variants of the CLEAN algorithm.

See the **GILDAS** documentation for further details.

8 CLIC Language Internal Help

We give here a *fac simile* of the internal HELP file for **CLIC**. Please consult the internal help itself, which is normally kept up to date.

8.1 Language

```
                          CLIC\ Command Language Summary

                 Continuum and Line Interferometric Calibration

   INFO           : (HELP CLIC\ INFO) gives a list of recent modifications
   ATMOSPHERE     : Perform atmospheric calibration.
   CHECK          : Check the data for amplitude gain instabilities
   COMPRESS       : Compress data
   COPY           : Copy data
   CURSOR         : Call the interactive graphic cursor
   DROP num [ver] : Take a scan out of the current index.
   DUMP           : List some informations on the R spectrum.
   FILE type name : Define the input/output files.
   FIND           : Search the input file for observations.
   GET [N]        : Read a scan in the input file.
   HEADER         : Display some header information on the R spectrum.
   IGNORE list    : Ignore scans from the Input file.
   MARK           : Force data to be treated as if flagged.
   MONITOR        : process calibrations for phase correction parameters.
   LIST [name]    : List header information about an ensemble of scans.
   MASK           : Cause some flags to be ignored.
   MINMAX         : compute extremal amplitudes in data
   MODIFY         : Edit and change the scan header (and data).
   NEW_DATA       : Wait until new data present in input file.
   RESIDUALS      : Plot residuals from last SOLVE operation
   PLOT           : Plot data according to display options
   PRINT          : produces an output text file (PRINT BASELINE).
   SET            : Enter a value for a parameter.
   SOLVE          : Solve for calibration functions.
   STORE          : Store calibration functions.
   TABLE          : Create a UV data Table for mapping purposes.
   TAG qual list  : Change the quality of scans in the output file.
   VARIABLES      : enable/disable CLIC variables
```

8.1.1 Language INFO

```
       Main modifications to CLIC since the MAR99 version:
 [24-sep-1999] FIND /RECEIVER is now available
 [24-sep-1999] FIND will not be case sensitive for Source  names  and  Line
   names.

       Main modifications to CLIC since the JUL98 version:
 [29-jan-1999] SET X TCHOP, TCOLD, TCABIN, TDEWAR1, ..., TDEWAR3: Plot some
   temperatures recorded in the receiver cabin.

 [13-jan-1999] SET PHASE ATM /ANT  i  j  :  The  phase  correction  can  be
   validated independently  for the different antennas.
```

[24-Nov-1998] SET X GROUNDEMIS, EMISSION, AIRMASS: new items to plot.

[16-oct-1998] SET SCAN, FIND/SCAN: now accept a more general scan list s1 s2 s3 s4 ...

Main modifications to CLIC since the APR98 version:

[19-may-1998] MODIFY FOCUS: to correct the phases according to the actual focus
position used (should be used only on data prior to November 1996,
or April 1998 for the few projects using HIGH lock).

[28-apr-1998] SET SELECTION CONT /WINDOW * is now allowed to reset frequency windows in the building of continuum tables from line subbands.

[28-apr-1998] LIST/SHORT will now log the scan numbers is an array S_GROUP[2,N_GROUP]

[25-apr-1998] LIST /OFFSET will give the list of position offsets in the current index (useful for a mosaic session).

Main modifications to CLIC since the NOV97 version:

[16-feb-1998] STORE CORRECTION AUTO [tmin] : tmin is now accessible (in minutes)

[30-jan-1998] SOLVE FLUX now gives the decorrelation factor relative to the efficiencies logged in the scan headers.

[24-nov-1997] SOLVE FIVE [/PLOT] now possible for five point pointing scans. SOLVE TOTAL/PRINT available.

Main modifications to CLIC since the APR97 version:

[08-oct-1997] FILE /DIRECTORY: Open a window to edit interactively the raw data file directories.

[03-sep-1997] SET AMPLITUDE UNSCALED: to reset the SET AMPLITUDE SCALED state (if needed).

[26-aug-1997] SET Y ATMVALIDITY: plots the validity of the phase correction (values 0 or 1) as stored by STORE CORRECTION

[26-aug-1997] SOLVE GAIN SCAN to solve gain scan by scan (instead of averaging all scans)

[21-aug-1997] SET Y WINDAVERAGE, WINDDIRAV, WINDTOP, WINDDIRTOP: plots the wind variables (average, direction of average, maximum, direction of maximum)

[17-aug-1997] After a FIND the scans are now time ordered even across the 9999/0001 scan numbering boundary.

[17-aug-1997] STORE CORRECTION SELF works like AUTO, but the phase correction valitity is based on the amplitude of each scan, whether or not it is a phase calibrator.

[27-jul-1997] GET n /HEADER to access the header vatiables of a given observation without acessing the data itself (i.e. the header file only is needed).

[25-jul-1997] SET OBSERVED n1 n2 : use integer representation of dates made possible

[22-jul-1997] variable SHORTFILE available after FILE IN : contains the file name without directory or extension.

[04-jun-1997] TABLE /RESAMPLE nchan rchan value inc V|F The syntax of /RESAMPLE has
been changed for compatibility with CLASS: One may now enter the velocity or frequency offset at the reference channel.

[22-may-1997] FILE /WINDOW Open data files via a file browser of the windowing system.

[20-may-1997] SET PHASE ATMOSPHERE NOFILE bypasses the effect of STORE CORRECTION.

[20-may-1997] It is now HIGHLY RECOMMENDED to use the extension ".hpb" when creating header files for calibration.

[20-may-1997] FILE RAW [project] [date] [/WINDOW] This command may be used to open raw data files residing in the directories IPB_DATA:, IPB_DATA1:, IPB_DATA2:, ... assuming they have kept teir original names jj-mmm-yyy-pppp.ipb, (with date and project name), and to create header files for calibration.

Main modifications to CLIC since the DEC96 version:

[07-apr-1997] FITS [name] FITS will now create a fits file (named name-l0i) with each selected line subband.

[04-apr-1997] SET SELECTION LINE DSB This is now allowed in LINE mode, and means that the side band will be automatically selected when the TABLE command is issued, to match the desired frequency range.

[03-mar-1997] SOLVE FLUX [NOREFERENCE] Use the default efficiencies rather than a reference source to set the flux scale.

[03-mar-1997] SOLVE FLUX [BEST n] Average the results of the n antennas giving the highest fluxes to compute the source flux.

[12-feb-1997] COPY HEADERS|DATA [[NO]BASE] [[NO]]ANTENNA 1st argument is now mandatory; second and/or third select which calibration section is created.

[08-jan-1997] STORE CORRECTION GOOD|BAD|AUTO Store, in the header of each scan, whether the atmospheric phase correction will be applied when SET PHASE ATMOSPHERE is used.

```
    Main modifications to CLIC since the NOV95 version:

[29-nov-1996] SET WRITE DATA|NODATA now renamed to SET COPY DATA|NODATA.

[12-nov-1996] STORE QUALITY qual ; change the data quality in the  current
  index (equivalent to a loop of TAG commands).

[12-nov-1996] LIST /VARIABLE variables /FORMAT formats : lists the  header
  variables for scans in the current index; may also be used with /SHORT.

[04-nov-1996] SOLVE POINT, SOLVE FOCUS, SOLVE GAIN, SOLVE DELAY  now  have
  an option /PRINT to write an OBS procedure in directory INTEROBS:

[17-oct-1996] SOLVE HOLOGRAPHY [FREE r1 r2..] : some panel  rings  may  be
  released from the paraboloid fit.

SET Y AZ_ERR and ELERR ; AZ_PH and  EL_PH  :  plot  pointing  errors,  and
  horizontal coordinates of the phase tracking center.

[04-jun-1996]
SET Y AZ_ERR and ELERR ; AZ_PH and  EL_PH  :  plot  pointing  errors,  and
  horizontal coordinates of the phase tracking center.

[27-may-1996]
MODIFY  ANTENNA|BASELINE  /OFFSET  89|96  The  argument  to   /OFFSET   is
  mandatory,  and  selects  either  the  old (89) or the new (96) standard
  station coordinates.

[14-may-1996]
ATMOSPHERE now checks the efficiencies on phase calibrators, assuming  the
  flux in the header is correct.

[10-may-1996]
- FIND /SOURCE s1 s2 .. sn is now supported.  - FIND /SCAN n1 n2 will  now
  loop across 9999/0000 if n1 > n2.

[29-apr-1996]
- CLIC is now dimensioned for FIVE antennas.

[29-apr-1996]
- SET X|Y PARAL_ANGLE:
   The parallactic angle can be plotted.

[14-apr-1996]
- SET COPY DATA|NODATA:
   A new data access mode. See HELP SET COPY.
- SET BASELINES ALL, SET ANTENNAS ALL:
   Use all the baselines, in the data by default. See HELP SET BASELINES,
- SET SUBBANDS ALL, SET SUBBANDS LINE, SET SUBBANDS CONT:
   Use all the subbands in the data, switch  between  line  and  continuum
  subbands.
- SET PHASE EXTERNAL|INTERNAL and STORE PHASE /RECEIVER:
   A new mode to use the other receiver as a  phase  reference  for  phase
  calibration.  See  HELP  SET  PHASE,  HELP  SOLVE PHASE.  See also STORE
```

```
  PHASE.

[07-mar-1996]
- Command PHASE CONTINUOUS:
   to recover from a real time problem due to jumps of the LO2.

[07-feb-1996]
- Command MODIFY AXES:
   to correct for non intersection of the azimut and elevation  axes.  See
  HELP  MODIFY  AXES.  SOLVE  BASELINE has also been modified to solve for
  this parameter using elevation as an X axis.

[17-jan-1996]
- Command MODIFY BUG 1:
   to correct for a calibration bug affecting data between 11-nov-1995 and
  09-jan-1996.

[20-dec-1995]
- Command  PLOT /NOFRAME pen
   used to overlay a plot with the previous one, using a different color.

[28-nov-1995]
- SET PROJECT resets the RF mode to OFF.

      Main modifications to CLIC since the JAN95 version:

[09-nov-1995]
- Implementation of the atmospheric correction.
   See command MONITOR, and SET PHASE ATMOSPHERE.

[08-sep-1995]
- Command SET SORT RECEIVER|SCAN

[25-jun-1995]
- Command SET TIME_ORIGIN

[08-jun-1995]
- command SET UV_RANGE:
   data will not be plotted ouside of this range.
```

8.2 ATMOSPHERE

```
        [CLIC\]ATMOSPHERE [DETECTOR|CORRELATOR] [/NOWRITE]

        Recompute the atmospheric (transparency) calibration from the  data
  and  the  informations  provided  by  the  SET  ATMOSPHERE command.  The
  operations are:
    - Compute atmospheric models from calibration scans, using either  the
      continuum  DETECTORs  or  the  continuum  CORRELATOR  to measure the
      atmospheric emission.  The data on the atmospheric monitor (the  1.3
      mm)  receiver  will  also  be  used  to compute the phase correction
```

coefficients.
- Apply the new model to the observations and write (update) the recalibrated data if option /NOWRITE is not present.

8.3 CHECK

CLIC\CHECK Threshold The continuum correlator had occasional instabilities in some of the 30 subbands. This command attempts to find out possible misfunctions of some subbands by comparing the amplitude of a subband to the mean amplitude of the 10 subbands of the same baseline. Threshold is the detection threshold (expressed in standard deviations from mean value). This command process only the current record.

An example of use is

```
VARIABLE DESCRIPTOR ON  ! Turn on Descriptor variables.
SET TYPE PHASE          ! Use only on continuum sources,
                        !   otherwise no signal...
FIND
FOR I 1 TO FOUND
  GET NEXT
  FOR J 1 TO R_NDUMPS   ! Process record by record
    GET/RECORD J
    CHECK 2.0           ! 2 sigma is severe limit. 3.0 is a normal value.
  NEXT
NEXT
```

While these instabilities tend to smear out with time, a strong misfunction may influence the result. Data should be flagged accordingly, specially before bandpass calibration. Checking the source data itself is more difficult, since the signal may be too weak.

8.4 COMPRESS

CLIC\COMPRESS timemax uvmax

Compress data in the current index by averaging successive records in individual scans. 'timemax' is the maximum averaging time in seconds. Data with baseline orientation differing by more 'uvmax' in meters in the UV plane are not averaged, as well as data flagged differently.

Defaults for timemax and uvmax are 60 seconds and 7.5 meters respectively. An output file must have been opened to receive the compressed data.

Use command COPY rather than COMPRESS to copy the whole current index to a new file.

For data taken after September 1992 (new correlator), the command will only compress the temporal data (data header and continuum subbands), since the spectral data is already compressed to 1 record per scan.

8.5 COPY

```
CLIC\COPY HEADERS|[NO]DATA [[NO]BASE] [[NO]ANTENNA]
```

```
Copy contents of the  current  index  to  the  ouput  file.   The  first
argument  is mandatory and controls whether the data section is actually
written in the output file.

COPY DATA selects the old mode which has been used so far.

COPY HEADERS selects a new mode  in  which  the  data  file,  originally
written  at  Plateau  de  Bure  is  later only used in a read-only mode.
Further modifications are written in an output file that  contains  only
the header sections, with e.g. calibration sections. In that output file
the data sections are not  written  but  replaced  by  pointers  to  the
original  file,  which  can  now  reside on a CD-ROM.  When this file is
later opened for input, CLIC will look for  the  data  sections  in  the
original  (read-only)  data  file.   The  original data file may be kept
locally (then it must have one of the  extensions  ".ipb",  ".IPB;1"  or
".IPB")  or  reside  in any directory, which is pointed to by one of the
logical names "IPB_DATA:", "IPB_DATA1:" to "IPB_DATA9:".   The  original
file  name  MUST  BE  UNCHANGED,  apart from the extension. It is HIGHLY
RECOMMENDED to use the extension ".hpb" for the new file containing  the
headers.
Example:
Assume the original file is "14-apr-1996-f081.ipb", retrieved from the
DAT tapes. Create a header file:
clic\file in 14-apr-1996-f081.ipb
clic\find
clic\file out f081-b2.hpb new
clic\copy headers

Assume the file was on CDROM. Create a header file:
sic\log ipb_data: "/CDROM"
clic\file in "!ipb_data:F404F081.IPB"
clic\find
clic\file out f081-b2.hpb new
clic\copy headers
!
! open f081-b2 for input/output, but do not write the data any more:
file both f081-b2
find
solve phase /plot
store phase
! ...
and so on as usual, except that the new file "f081-b2.ipb" contains
only the headers and is much smaller than "14-apr-1996-f081.ipb-data".

- Most commands are available in  this  new  mode,  even  commands  that
affect  data  amplitudes  phases  such as ATMOSPHERE, MODIFY BASELINE or
MODIFY DELAY. The phase factors are kept in the headers and applied only
when the data will be later read again.

- There need not be a one to one  correspondence  between  the  original
```

".ipb-data" file contents and the ".ipb" header file. That is the header file may refer to only part of the scans in the .ipb-data file (e.g. omit the IFPB or POINT scans), and it may refer to several

Now arguments [NO]BASE and [NO]ANTENNA control whether respectively the baseline antenna-based calibration sections are written in the headers. Antenna-based cal is now the default and omitting the baseline-based sections saves a lot of space only the antenna-based sections will be created; do not forget to use COPY HEADE if you foresee you will need baselined-based calibration; or use COPY HEADERS for not so recent Bure data in which the baselined-based sections have been cre (otherwise those seldom used sections will use half the header space).

8.6 CURSOR

```
CLIC\CURSOR mode
```

Call the interactive cursor, if available on your graphic terminal. This enables you to measure point coordinates, and perform some data editing. One of the data points is selected according to the argument 'mode'. In mode D the closest data point from the cursor is selected; in mode X (the default) the data point with closest X coordinate is selected; in mode Y the data point with closest Y coordinate is selected.

- Press any key to get the coordinates of the selected point.
- Press 'K' to delete the selected point from the current plot buffers (type PLOT SAME to replot the buffers).
- Press 'N' to initiate a new range for Ignore, Tag, and Flag (see below)
- Press 'I' to ignore all scans in the current range (initiated by scans. This works only with time-like plots, and is to be used preferrably for coordinates that are monotonous functions of time (scan number, observation number, time, ...
- Press 'T' to tag all scans in the current range (initiated by 'N'). This is equivalent to typing the TAG command for the same scans. You will be prompted for a quality in the range 0 to 9. Same comments as with 'I'. The input and output files must be equal.
- Press 'F' to flag all records in the current range (initiated by affect the baseline or antenna corresponding to the box you are pointing at. Same comments as with 'I'. The input and output files must be equal.
- Press 'E' to exit the cursor mode.

8.7 DROP

```
CLIC\DROP Obs [Ver]
```

Remove an Observation from the current index. The version number must be specified if it is not the last in the input file, even if it is the last version in the current index.

8.8 DUMP

```
    CLIC\DUMP [Argument]
A debugging command.

  - DUMP HEADER argument : lists a certain number of informations
    about the Observation header. Argument may be HEAD, GENERAL,
    POSITION, INTERFEROMETER, FREQUENCY, ATMOSPHERE, MONITOR,
    CONTINNUM, LINE, SCANNING, IC (Instrumental calibration), AIC
    (Antenna-based Instrumental calibration), PC (RF Passband
    calibration), APC (Antenna-based RF Passband calibration), DD (Data
    Descriptor) ...
  - DUMP DATA : lists the data associated parameters.
  - DUMP FILE : lists information about the input and output file
  - DUMP INDEX : lists information about the current index.
  - DUMP CONTINUUM : dumps the continuum data.
  - DUMP LINE c1 c2 : dumps the spectral data from channel c1 to c2.
    DUMP LINE c1 c2 /PLOT will plot the spectral data amplitude
    as a function of channel number.
  - DUMP VIRTUAL : gives the virtual memory and paging file
    quotas.
DUMP DATA, DUMP LINE and DUMP CONTINUUM will give the phase-corrected or
uncorrected data, depending on the last SET PHASE ATM or SET PHASE NOATM
command issued.
```

8.9 FILE

```
    CLIC\FILE [Type] [Name] [NEW] [SHARED] [/WINDOW] [/DIRECTORY]

Selects the input and output files.
FILE IN name            defines the input file
FILE OUT name [NEW]     defines the output file ;
                        initializes a file if NEW is precised.
FILE BOTH name          selects the same file for input and output.
FILE RAW [proj] [date]  open a raw data file
The default extension can be specified using command SET EXTENSION (.ipb
is recommended for files containing data, .hpb for files containing only
headers).

If the 'Type' is not RAW, with option /WINDOW (if the windowing system
is active), a panel window is created and the file name may be selected
via a file browser ('name' is then used as a filter). Pressing GO will
then open the file.

FILE RAW [proj] [date] will select the first file residing in the
directories IPB_DATA:, IPB_DATA1:, IPB_DATA2:, ... following the
standard name convention used at Plateau de Bure (jj-mmm-yyyy-proj.ipb,
or YMJJPROJ.IPB for CDROMs), which matches the optionally given project
name and date. The names of all the NFILE files matching the project
name and date are put in character array DATAFILE[NFILE] (the integer
variable NFILE is also defined).

With RAW and option /WINDOW (if the windowing system is active), a panel
window is created with a menu to select one of the available files, and
```

```
two action buttons, one for opening the file, the other for  creating  a
header file for calibration.

With RAW and options /WINDOW and /DIRECTORY (if the windowing system  is
active), a panel window is created with a menu to edit the list raw data
file directories (logical names IPB_DATA:, IPB_DATA1:, ...)

The character variable SHORT_FILE  is  available  after  FILE  IN  :  it
contains the file name without directory or extension.


On VAX-VMS, FILE IN Name PATCHED will convert the file to VMS format (if
it was created under  another operating system).
```

8.10 FIND

```
    CLIC\FIND [Append] [New_Data] [/LINE Lname]
 [/NUMBER n1 n2] [/SCAN s1 s2 [s3 s4 ...]] [/QUALITY q]
 [/TELESCOPE Tname] [/PROCEDURE Proc1 Proc2 ...]
 [/TYPE Type] [/SOURCE s1 s2 ... sn] [/OFFSET o1 o2]

FIND performs a search in the input file   to   build   a   new   index,
according  to  selection  criteria  defined  by  the SET command.  These
criteria may be temporarily modified by the following options :

/LINE Lname         search by line name
/NUMBER n1 n2       search for the specified range of observation numbers
/SCAN s1 s2 [s3 s4] search for the specified range(s) of scan numbers
/OFFSET a1 a2       search for these offsets
/PROCEDURE p1  pn   search by procedure name(s)
/QUALITY q          search for the data of quality better than Q.
/SOURCE s1 ... sn   search by source name
/TELESCOPE Tname    search for the specified telescope name
/TYPE Type          search by source type (OBJECT, PHASE, or BANDPASS)
/RECEIVER number    search by receiver number
FIND /SCAN s1 s2 [s3 s4 ..] will loop across the 9999/0001 border if  s1
(s3)  is  larger than s2 (s4). Using several source names in FIND/SOURCE
is now supported. Source  name  and  Line  name  matching  is  not  case
sensitive.

The current index is ordered by scan number or receiver number depending
on  the  last command SET SORT. However the scan ordering is done modulo
9999 (i.e. the time order  is  respected  if  the  9999/0001  transition
occurs in the current index).

FIND by default overwrites the current index.  Found observations may be
appended  to  the  current  index by specifying the argument APPEND ; an
index compression occurs to avoid duplication of scans in the index.

FIND does not return an error  if  the   index   is   empty,   but   the
variable  FOUND  is  set  to  0.   FOUND  is always set to the number of
observations in the index.

Argument NEW_DATA can be used to wait until new data is present  in  the
```

input file. This possibility is intended for sites where data acquisition is done in CLIC format (Plateau de Bure) to use CLIC as an automated quick look facility. The behaviour is similar to that of command NEW_DATA, but all selection criteria are considered and no switching to a new observation type occurs.

8.11 FITS

```
CLIC\FITS name
```

Create for each selected line subband, a FITS file containing the spectral data. For autocorrelation data the data from all antennas are averaged. For correlation data, the complex data form all baselines are averaged and the real part of the resulting visibility is used. The fits file names are e.g. name-l01.fits, name-l02.fits, name-l03.fits (one fits file is created for each subband), if one has specified SET SUBBAND l01 l02 l03.

8.12 FLAG

```
CLIC\FLAG f1 f2 ...  /ANTENNA i1 [...] [/BASELINE b1 [...]]
[/RESET]
```

Flag the current record (obtained by GET /RECORD) with flags f1 ... Flags may be relative to antennas or baselines. /ANTENNA or /BASELINE must be given, with lists of antenna numbers or baseline names as arguments.

/ANTENNA ALL will flag all antennas, /BASELINE ALL will flag all baselines. These are the default.

Supported flag names are:
- C01 to C10 for bad individual continuum correlator subbands
- L01 to L06 for bad individual spectral correlator subbands
- DATA for bad data
- TSYS for too high system temperature (antenna based only)
- LOCK for out of lock local oscillator (antenna based only)
- POINTING for poor pointing (antenna based only)
- SHADOW for antenna being shadowed by another antenna (antenna based only)
- SATURATION for too high total power on a particular antenna.

Use option /RESET to suppress flags that were accidentally set.

Give FLAG with no argument (but with options) to list the flags of the current record.

Use command UPDATE to write the flagged data to disk. If more than one record is to be flagged, command STORE FLAG should be preferred.

8.13 GET

```
CLIC\GET [N] [/RECORD r] [/HEADER]
```

GET copies R into T, and loads the Observation number N in R. The current index initialized by FIND is first explored, then, if needed, the whole input file. If N is absent, the previous (last read) Observation is recovered. If N is FIRST, the first Observation of the current index is loaded. If N is NEXT, the next Observation in the current index is loaded.

If option /RECORD is present, only record r is loaded. Otherwise, the average record is loaded; it will contain the phase-corrected or uncorrected data depending on the last SET PHASE [ATM]|[NOATM] command.

If option /HEADER is present, only the scan header is read. No data record is accessed. This command does not access the data file if only the header file is available.

8.14 HEADER

```
CLIC\HEADER
```

Displays some header information on current observation. The FULL format is used, with the informations selected in command SET FORMAT written. The lines written contain (in output order, but not all lines are necessarily present)

```
1.  General information line :
    Observation number and version
    Scan number
    Procedure name
    Source name and type
    Line name
    Telescope name
    Date of observation
    Date of last reduction

2.  Interferometer Configuration line :
    Number of antennas
    Station numbers
    Number of baselines

3.  Position information line
    RA or L :  right ascension or longitude (or azimuth)
    DEC or B :  declination or latitude (or elevation)
    Epoch if equatorial coordinates are used
    Offsets in current units
    Type of coordinate (Eq, Ga, Ho)

4.  Quality information line :
    Tau:  opacity at zenith
    Tsys:  system temperature (outside atmosphere).
    Number of records
    Time:  total integration time on source (minutes)
    El:  elevation of source

5.  Spectral information lines :
    N:  number of subbands
```

```
    N:  number of channels
    I0:  reference channel (real)
    F0:  rest frequency at reference channel
    Df:  frequency resolution (signed)

6.  Calibration information line :
    B_ef:  Beam efficiency of telescope
    F_ef:  Forward efficiency of telescope
    G_im:  Gain in image band

7.  Calibration status line :
    Atmospheric calibration done
    Instrumental calibration done
    Passband calibration done

8.  Pointing corrections line :

9.  Atmospheric information lines (2) :
    H2O_:  millimeter of precipitable water vapor
    Pamb:  ambient pressure
    Tamb:  ambient (receiver cabin) temperature
    Tchop:  Chopper temperature
    Tcold:  Cold load temperature
    Tatm:  Atmospheric temperature in the signal band
    Tau:  Zenith opacity in the signal band
    Tatm_I:  Atmospheric temperature in the image band
    Tau_I:  Zenith opacity in the signal band
```

8.15 IGNORE

```
    CLIC\IGNORE List_of_Observations

This command can be used to declare the specified list of
Observations (from the INPUT file) to be ignored in all FIND operations.
They effectively become invisible to CLIC (except in a LIST IN command),
until a FILE IN command is typed again.  The input file is not
physically modified however.  The list of observation may have the same
format as the index list of a FOR command.
```

8.16 LIST

```
    CLIC\LIST [Name] [/SHORT] [/BRIEF] [/LONG]  [/FLAG]  [/OUTPUT File]
[/PROJECT]  [/SOURCE]  [/VARIABLE  var-list  [/FORMAT format-list]]
[/OFFSET]

List header information about an ensemble of observations.  LIST is used
for a quick look to observation headers, in a more or less detailed
format.  Name specifies the file to be listed :  IN or OUT ; if Name  is
not present, the current index is listed.  A medium-sized format is used
by default.
  /SHORT          : Gives only one line for a set of scans with same
                        parameters; IFPB and CALI are not listed.
```

```
                  the first and last scan of each group  are  logged
  in
                  array S_GROUP[2,N_GROUP], N_GROUP is the number of
                  groups.
/BRIEF          : Brief format (Observation numbers and version
                  numbers)
/LONG           : Long format (not allowed for the output file)
/OUTPUT File    : Send the list to a disk file instead of the terminal
/FLAG           : list data flags for current index.
/PROJECT        : list the observing projects in the current index.
                  the number of differents offset positions is in
                  variable N_OFFPOS
                  the offsets are in array OFFPOS[2,N_OFFPOS]
/SOURCE         : list the observed sources in the current index.
                  the number of differents  source  is  in  variable
  N_SOURCE
                  the    source    names    in    character    array
  C_SOURCE[N_SOURCE]
/OFFSET         : list the observed position offsets for  the  current
  index.
/VARIABLE varst the content of  the  header  variables  in  the  list.
  These  variables  must  have  been  defined by command VARIABLE.  If
  /FORMAT format_list is also given, each  variable  in  the  list  is
  printed  according  to  the associated format item. The format items
  must match the variable types. With option /SHORT, a line is printed
  only  if  at least one of the variables has changed, and is preceded
  by the corresponding scan number range.
example:
LIST /VARIABLE FREQUENCY LFCEN[2] /FORMAT f10.3 f6.3 /SHORT gives  the
  sky rest frequency and the central IF frequency of subband L02, as a
  function of scan numbers. To define these variables: use VARIABLE RF
  and VARIABLE LINE.
```

The list will be ordered by scan numbers or by receiver number, depending on the command SET SORT [SCAN]|[RECEIVER].

8.17 MARK

```
CLIC\MARK f1 f2 ...  [/ANTENNA i ][/BASELINE ij] [/RESET]
```

Set the antenna or baseline mark words.

To decide whether data should be used, CLIC uses the logical OR of the data flag words with the corresponding mark words. Thus data from some subbands may be [temporarily] ignored even if unflagged. Flags may be relative to antennas or baselines. /ANTENNA or /BASELINE must be given, with antenna numbers or baseline names as arguments. Several antennas and baselines may be given simultaneously. Use /ANTENNA ALL or /BASELINE ALL for all antennas or all baselines.

Flag names f1 f2 ... are alphanumeric codes. Valid codes are subband names (C01 to C10, L01 to L06), DATA, POINTING, SHADOW, TSYS, SATURATION and LOCK.

Use option /RESET to reset flags that were accidentally set in the mark words.

MARK with no arguments (just options) will list the MARK words currently in use.

8.18 MASK

```
CLIC\MASK f1 f2 ...  [/ANTENNA i][/BASELINE ij] [/RESET]
```

Set the antenna or baseline mask words

Data flagged will normally not be processed by calibration commands. However flags set in the corresponding mask word will be ignored, causing data to be processed anyway. Flags may be relative to antennas or baselines. /ANTENNA or /BASELINE must be given, with antenna numbers or baseline names as arguments.

Flag names f1 f2 ... are alphanumeric codes. Valid codes are subband names (C01 to C10, L01 to L04), DATA, POINTING, SHADOW, TSYS and LOCK.

Use option /RESET to reset flags that were accidentally set in the mask words.

MASK with no arguments (just options) will list the mask words currently in use.

8.19 MINMAX

```
CLIC\MINMAX
```

This command is used to compute extremal amplitudes in all continuum, line data, USB and LSB. Results are stored in variables C_MAXAMP_U, C_MINAMP_U and variables with similar names. This command may be used in a MODIFY DATA loop, to search for bad data.

8.20 MONITOR

```
CLIC\MONITOR delta_time
```

This command is used to prepare the atmospheric radiometric phase correction. It processes the calibration scans to compute the correction factors (i.e. the change of path length for a given change in emission temperature of the atmosphere at the atmospheric monitor frequency (normally 1.3 mm).

The scans in the current index are grouped in intervals of maximum duration ‘delta_time’ (in seconds); source changes will also be used to separate intervals. In each interval a straight line is fitted in the variation of atmospheric emission as a function of time; this line will be the reference value for the atmospheric correction, i.e. the correction at time t is proportional to the difference between the atmospheric emission at time t and the reference at time t. This scheme is used to avoid contaminating the correction with total power drifts of non-atmospheric origin (changes in receiver noise and gain, and changes in ground noise).

MONITOR 0 will use for each scan the average of the atmospheric emission as the reference value. This will cause the correction to average to zero in one scan: the average phase is not changed, only the coherence is restored leading to an improved amplitude.

8.21 MODIFY

```
CLIC\MODIFY Item [Values...]
```

This is a command to change some parameters relevant to data acquisition, such as baseline values, time, position of phase center, are equal.

8.21.1 MODIFY BASELINE

```
CLIC\MODIFY BASELINE b1 x1 y1 z1 [b2 x2 y2 z2 ...] [/OFFSET 89|96]
CLIC\MODIFY BASELINE FITTED
```

Modify the vector coordinates for baseline b1 to be: x1, y1, z1 (meters), and the phases accordingly. Keyword FITTED will load the baseline coordinates the most recenty found by the SOLVE BASELINE command.

Use option /OFFSET 96 to enter baseline coordinates offsets instead (i.e. offsets from the new (1996) standard antenna positions in STATION.DAT). For old procedures, referring to the old (1989) station values, use /OFFSET 89 instead.

Apply to the current index; an output file must be open (may be equal to the input file).

8.21.2 MODIFY ANTENNA

```
CLIC\MODIFY ANTENNA a1 x1 y1 z1 [a2 x2 y2 z2 ...] [/OFFSET 89|96]
CLIC\MODIFY ANTENNA FITTED
```

Modify the vector coordinates for antenna a1 to be: x, y, z (meters), and the phases accordingly. Keyword FITTED will load the antenna coordinates the most recenty found by the SOLVE BASELINE command.

Use option /OFFSET 96 to enter antenna coordinates offsets instead (i.e. offsets from the new (1996) standard antenna positions in STATION.DAT). For the old procedures use /OFFSET 89.

Apply to the current index; an output file must be open (may be equal to the input file).

8.21.3 MODIFY DELAY

```
CLIC\MODIFY DELAY a1 d1  [a2 d2 ...] [/OFFSET]

  Modify the delay for  antenna  a1  to  be:   d1 (nanoseconds),
and  recompute the  phases  accordingly.
```

Use option /OFFSET to enter delay changes with respect to the precious values.

Applies to the current index; an output file must be open (may be equal to the input file).

8.21.4 MODIFY FLUX

```
CLIC\MODIFY FLUX value
```

Modify the flux of the calibrator as stored in the header. In case the calibrator is to be used to calibrate amplitudes, the calibrator amplitude will be divided by this number before plotting. (use SET AMPLITUDE SCALED to do this).

Apply to the current index; an output file must be open (may be equal to the input file).

8.21.5 MODIFY FOCUS

```
CLIC\MODIFY FOCUS antenna1 value1  antenna2 value2 ...
```

Correct the phases for the offsets in focus, introduced to optimize efficiency. A1 is the antenna number, value1 the focus offset in mm, and so on. The phases are normally corrected in real time since 29-nov-1996. Between 29-may-1996 and 29-nov-1996, the focus corrections were logged in the data files. Before 29-may-1996 they are only in the log-obs files. However between 29-nov-1996 and 02-apr-1998, the correction had wrong sign for the few projects using HIGH LOCK.

So use MODIFY FOCUS with NO arguments for data more recent that 29-nov-1996: this should correct the HIGH LOCK problem. Between 29-may-1996 and 29-nov-1996, MODIFY FOCUS with no arguments will use the focus offsets in the header and apply the corresponding phase offsets.

For older data you may now search for the focus changes in the log files to apply the phase corrections before calibration; or use jumps in the phase calibration just as you had done before.

This command applies to the current index; an output file must be open (may be equal to the input file).

8.21.6 MODIFY SCALE

```
CLIC\MODIFY SCALE amplitude phase
```

Multiply all data in the current index by this (complex) scale factor (in case of emergency only!).

Apply to the current index; an output file must be open (may be equal to the input file).

8.21.7 MODIFY DOPPLER

```
CLIC\MODIFY DOPPLER
```

Computes the Doppler velocity correction, in case it was not taken into account at the time of observing. The LO2 frequency in the header is assumed to be the frequency actually used. A warning is issued if the LO1 frequency in the header is not coherent with the LO2 frequency (which means the phase tracking might be in error, since it uses that LO1 frequency).

The frequencies and line names introduced by SET FREQUENCY are used to define the velocity scales for each subband/sideband.

A related command is MODIFY OBJECT wich change the type of observations from PHASE to OBJECT, before computing the Doppler velocity correction, as in MODIFY DOPPLER.

8.21.8 MODIFY FREQUENCIES

```
CLIC\MODIFY FREQUENCIES
```

The frequencies and line names introduced by SET FREQUENCY are used to re-define the velocity scales for each subband/sideband. By default, the frequency and line name entered in OBS for at data aquisition on the Plateau de Bure is used for all sidebands and subbands.

8.21.9 MODIFY OBJECT

```
CLIC\MODIFY OBJECT
```

This command changes the type of PHASE observations (Phase and Passband calibrations) to tho OBJECT type, then computes the Doppler velocity correction, as for MODIFY DOPPLER. The LO2 frequency in the header is assumed to be the frequency actually used. A warning is issued if the LO1 frequency in the header is not coherent with the LO2 frequency (which means the phase tracking might be in error, since it uses that LO1 frequency).

The frequencies and line names introduced by SET FREQUENCY are used to define the velocity scales for each subband/sideband.

8.21.10 MODIFY POSITION

```
CLIC\MODIFY POSITION EQ epoch R.A. Dec.
```

Modify the source (phase center) position. This precesses the phase accordingly. Note that this cannot change the antenna pointing center. Typical use of this command is to correct positions of inaccurate phase calibrators.

8.21.11 MODIFY TIME

```
CLIC\MODIFY TIME DUT1
```

Modify the time constant DUT1 (in seconds) . For very high accuracy astrometry, DUT1 may need to be adjusted afterwards to correct for irregularities for the earth rotation. The "a priori" estimates may be wrong. Another case is the leap second, if they are introduced asynchronously with the DUT1 constant...

8.21.12 MODIFY REFERENCE

```
CLIC\MODIFY REFERENCE UPPER|LOWER r1 r2 r3 r4
```

The reference channels in the available line subbands are changed to the new values. Use with caution: this command is actually changing the frequency and velocity scale of your data.

8.21.13 MODIFY VELOCITY

```
CLIC\MODIFY VELOCITY UPPER|LOWER v1 v2 v3 v4
```

The reference velocities in the available line subbands are changed to the new values. Use with caution: this command is actually changing the frequency and velocity scale of your data.

8.21.14 MODIFY HEADER

```
CLIC\MODIFY HEADER procedure
```

This is a general command to edit the header of the scans in the current index.. CLIC enters a loop in which all the headers are read successively. For each header the procedure 'procedure' (default extension ".CLIC") is executed. This procedure may only contain the following commands : DUMP, HEADER, GO, or any SIC command that acts on variables.

The command GO [WRITE] must end the procedure. With GO WRITE, the scan header will be updated; with only GO, the scan header is not updated and CLIC loads the next scan header in the current index. If no GO command in excountered in the procedure, the loop is aborted.

If a PAUSE command is found in the procedure, the PAUSE is executed, but the prompt changes to "MODIFY>". The same commands as above may then be executed from the keyboard; "QUIT ALL" may be used to abort the loop.

8.21.15 MODIFY DATA

```
CLIC\MODIFY DATA procedure
```

This is a general command to edit the data headers of the scans in the current index. CLIC enters a loop in which all the data header of all records of all scans in the current index are read successively. For each record the procedure 'procedure' (default extension ".CLIC") is executed. This procedure may only contain the following commands : DUMP, HEADER, FLAG, MINMAX, GO, or any SIC command that acts on variables.

The command GO [WRITE] must end the procedure. With GO WRITE, the data record will be updated; with only GO, the data record is not updated and CLIC loads the next record from the current index. If no GO command in excountered in the procedure, the loop is aborted.

If a PAUSE command is found in the procedure, the PAUSE is executed, but the prompt changes to "MODIFY>". The same commands as above may then be executed from the keyboard; "QUIT ALL" may be used to abort the loop.

8.21.16 MODIFY PHASE_SIGN

```
CLIC\MODIFY PHASE_SIGN
```

Change the sign of all phases of the data in the current index. This command is intended for recovering data taken in a preliminary status of the new correlator software.

8.21.17 MODIFY AXES

```
CLIC\MODIFY AXES a1 x1 [a2 x2 ...]
```

Correct the phases for the offset of the elevation axis with respect to the azimuth axis. This effect, if different for differnt antennas, causes a phase offset proportional to frequency and to the cosine of elevation. a1 is the antenna number, x1 the offset between axes in meters. The actual values should be at most 1 mm, and may be measured using the command SOLVE BASELINE, using SET X ELEVATION in addition to Hour angle and declination.

8.21.18 MODIFY BUG

```
CLIC\MODIFY BUG number
```

This command is reserved for the correction of nasty bugs in the data acquisition, and worthwhile. The number is used for identification.

Current accepted values:
- 1 Affecting data taken between 11-nov-1995 and 09-jan-1996. Bug in RDI found by S. Guilloteau. The continuum data was erroneously calibrated in the real-time aquisition. As result, the continuum data did not agree with the average of the spectral data. For instance plotting data with "set sub C02 L02" as a function of time gives different results for C02 and L02. The result would affect line intensities if, as is usually the case, the amplitude calibration is done with the continuum subbands.

Correction: the current index should contain both atmosphere calibrations and correlation data; the data file should be open for both input and output. This command should not affect data taken before 11-nov-1995 and after 09-jan-1996; be careful for the last day since the hour is not checked, and RDI was corrected at 3pm.

8.22 NEW_DATA

```
[CLIC\]NEW_DATA [time] [tries]
```

Waits until new data has been written to the input file, then makes a new index from all new data. The type of observation can be changed by this command, but the index will contain only observations of one type. Selection criteria defined by command SET are ignored.

This command can be used to make a quick look or analysis of data produced by a real time acquisition system. Caution : only two programs should access the input file simultaneously, one for writing the other for reading.

The first argument is the time interval between two consecutive inspections of the file index; the second is the allowed number of unsuccessful attempts to find new data in the file. The defaults are 10 seconds and 12 tries (two-minute timeout).

8.23 PLOT

```
CLIC\PLOT keyword [/NOFRAME [pen]] [/RECORD list] [/APPEND]
[/IDENTIFY] [/RESET]
```

Plot data according to options selected by CLIC\SET command. PLOT will clear the screen before plotting (the default with PLOT ALL and PLOT FIRST), while PLOT /NOFRAME will only plot the data itself, in the same boxes, optionally using a different pen (useful to overlay plots).

Parameters:
- CLIC\PLOT [ALL] Erases the screen and plots all data in the current index (default).
- CLIC\PLOT FIRST Plots data from the first observation in the current index.
- CLIC\PLOT NEXT Plots data from the next observation in the current index.
- CLIC\PLOT number Plots data from the observation of the given number (must be in the current index).
- CLIC\PLOT SAME Plots again the last plotted buffers (with possibly new options, such as line type, limits, ...).
- CLIC\PLOT /NOFRAME [pen] Do not erase the screen, and plots data in the present boxes, optionally with a new pen. This may be used for comparing data or in conjunction with PLOT /APPEND.
- CLIC\PLOT /RECORD list will plot only some records for the observation(s). "list" is of the format n1 to n2 n3 n4 to n5, as with SIC\FOR command.

CLIC\PLOT /IDENTIFY [COLOUR] will plot a different GREG symbol for each source (if SET PLOT POINT is currently active). Using optional argument COLOUR will produce points differing by colour rather than by symbol shape.

CLIC\PLOT /RESET Reset the time origin (and, by consequence, the time-dependent amplitude and phase calibration curves) before plotting.

CLIC\PLOT /APPEND will not reset the previous buffers before reading data and plotting. This may be used at the Plateau de Bure for incrementally plotting new data just after it is written on disk.

8.24 PRINT

```
CLIC\PRINT parameter
```

Prepares a procedure for further use.

```
CLIC\PRINT BASELINE
```

Prepares a procedure to be used in OBS to enter the most recently fitted baseline parameters. This procedure also contains (but commented out) the CLIC\MODIFY command to edit previous data to the same fitted baseline parameters.

```
CLIC\PRINT DELAY
```

Prepares a procedure to be used in OBS to enter the most recently fitted delay parameters.

```
CLIC\PRINT FLUXES
```

Prepares a procedure to be used in CLIC to re-enter the most recently determined source fluxes.

8.25 RESIDUALS

```
CLIC\RESIDUALS Item
```

Clear the graphic screen and plot the residuals from last SOLVE command. Item can only be "BASELINE" up to now.

8.26 SAVE

```
CLIC\SAVE Name [STILL UNIMPLEMENTED]
```

SAVE creates a procedure file of name "Name.clic", containing all the current parameters of the program. This file may be executed at any time using the @ command : just type "@@ name" after the CLIC> prompt, or pass "@ name" as a parameter when invoking CLIC (by typing "CLIC @ name"). This file is composed of standard CLIC commands, and may be edited with any text editor.

8.27 SET

```
CLIC\SET something [value1 [value2 [...]]]
```

This command is used to set a value for a CLIC parameter. If no value argument is given, the default will be restored.

8.27.1 SET AMPLITUDE

```
CLIC\SET AMPLITUDE ABSOLUTE|RELATIVE|SCALED [KELVIN|JANSKY]
[BASELINE|ANTENNA]
```

This command decides which scaling factor is applied to the data for plotting and writing the final Table, in subsequent PLOT and TABLE commands:

- ABSOLUTE means that the relative amplitude calibration is not applied;
- RELATIVE means that the relative amplitude calibration, as determined with SOLVE AMPLITUDE, and stored with STORE AMPLITUDE, is applied;
- SCALED means that the absolute amplitude is divided by the source flux
- ANTENNA|BASELINE switches between Antenna-based and Baseline-based amplitude calibrations. This switch will be active for SOLVE AMPLITUDE (calibration curve determination), STORE AMPLITUDE (calibration curve store operation), and SET AMPLITUDE RELATIVE (for application). Both baseline-based and antenna-based calibration curves may be stored alongside in the data header, independently of each other.

SCALED is only used for the command SOLVE AMPLITUDE (this command actually forces SET AMPLITUDE SCALED KELVIN).

The second keyword indicates if conversion between Janskys and Kelvins is to be done. With SET AMPLITUDE ABSOLUTE, the amplitudes are normally in Kelvins of main-beam brightness temperature, so the default is KELVIN. With SET AMPLITUDE RELATIVE, the amplitudes are in Janskys, since a calibrator of known flux has been used for reference. The default is then JANSKY. If the default is overridden (SET AMPLITUDE ABSOLUTE JANSKY or SET AMPLITUDE RELATIVE KELVIN), conversion factors are taken from the scan headers; these factors may be determined by SOLVE FLUX, and stored by STORE FLUX.

8.27.2 SET ANGLE

```
CLIC\SET ANGLE Unit
```

Specify the angle unit for offsets. May be R[adian], D[egree], M[inute of arc], S[econd of arc]. Default is MINUTE. The ANGLE unit is also used to display Continuum drifts.

8.27.3 SET ANTENNAS

```
CLIC\SET ANTENNAS [a1 a2 ...]
CLIC\SET ANTENNAS ALL
```

Selects the antennas for which data will be displayed by command PLOT. Valid antennas are currently 1, 2, and 3. This command is exclusive with commands SET BASELINES and SET TRIANGLES. Parameters which may be displayed in this antenna-mode are obvious antenna based parameters such as cable phase, LO-phase and rate, ... with SET Y AMPLITUDE and when more than 3 antennas are available in the data, antenna amplitude is computed by averaging all possible "triangular ratios" of baseline amplitudes. with SET Y PHASE a phase is attributed to each antenna by setting the phase of antenna 1 to zero, and making use of closure relations for other antennas (least square fit). This is useful for fitting baselines for instance (it enables one to determine directly antenna position offsets).

SET ANTENNA with no other antenna selects all antennas used for the baselines previously in use.

SET ANTENNA ALL will select all the antennas available in the first scan of the current index, for each command accessing the data (e.g. PLOT). This is now the default.

8.27.4 SET AVERAGING

```
CLIC\SET AVERAGING mode
```

Selects averaging of data plotted (the data in the file is unaffected).

1. NONE : all data points are plotted
2. SCAN : data is averaged within each scan; on point is plotted per scan.
3. TIME dt : data is averaged in time intervals of length dt (seconds). Data of consecutive scans is NOT averaged together.
4. METHOD VECTOR : complex visibilities are averaged as complex numbers.
5. METHOD SCALAR : amplitude and phases of visibilities are averaged separately.

See also SET BINNING for another way of averaging data.

8.27.5 SET ASPECT_RATIO

```
CLIC\SET ASPECT_RATIO value [AUTO|EXACT]
```

Choose a default aspect ratio (x_size/y_size) for boxes plotted by command PLOT. If several boxes must be plotted (depending on subbands, baselines, or side bands selected), the plot page will be partitioned in order to:

i) in AUTO mode: approach this aspect ratio for each box while filling the whole page ;

ii) in EXACT mode: use this aspect ratio for each box (part of the plot page will be left blank).

The default is 2.0 AUTO.

8.27.6 SET ATMOSPHERE

```
CLIC\SET ATMOSPHERE argument value [/RECEIVER i]
```

```
Selects the way atmospheric calibration is done by  command  ATMOSPHERE.
Argument may be FILE, AUTO, TREC, or MANUAL.

  -  In FILE mode the actual mode is taken from  the  data  header,   as
    given in the OBS program.
  - In TREC mode the receiver temperature is assumed known, to  set  the
    scale  of  measured sky temperature and optical depth, and determine
    the system noise temperature.  The  receiver  temperature  is  taken
    from  the  data  header,  as  given  in  OBS.  It may be forced to a
    different value by giving it as second argument 'value', or  by  the
    SET TREC command.
  -  In AUTO mode the water wapor content is  assumed  known;  it  is
    determined  from  the  antennas  in TREC mode, if any, or taken from
    the data header, or forced  to  the  value  given  in  the  second
    argument 'value', or by the SET WATER command.
These parameters, together with the wheather station data, are  used  to
compute  the system noise temperature for each antenna.  In MANUAL mode,
no model atmosphere is used,  but  the  values  of  optical  depths  and
atmospheric temperatures stored in the data.
```

8.27.7 SET BANDS

```
CLIC\SET BANDS b1 b2 ...
```

```
Selects the sidebands for which data will be displayed by command  PLOT.
Valid codes are currently "UPPER", "LOWER", "AVERAGE", "DIFFERENCE", and
"RATIO".  In "AVERAGE", "DIFFERENCE" or  "RATIO"  modes,  the  sidebands
visibilities are combined after correction for their relative phases, as
determined  by  the  RF  bandpass  calibration.   If  no   RF   bandpass
calibration  is  available  (i.e.  stored  with  the data), the relative
phases are obtained  by  averaging  the  continuum  subbands  (which  is
useless if no continuum emission is detected).
```

8.27.8 SET BASELINES

```
CLIC\SET BASELINES [b1 b2 ...]
CLIC\SET BASELINES ALL
```

```
Selects the baselines for which data will be displayed by command  PLOT.
Valid  codes  are currently "12", "13", "23".  This command is exclusive
with commands SET ANTENNAS and SET TRIANGLES.

SET BASELINE with no other antenna selects all baselines connecting  the
antennas previously in use.

SET BASELINE ALL will select all the baselines available  in  the  first
scan  of  the  current  index, for each command accessing the data (e.g.
PLOT).  This is now the default.
```

8.27.9 SET BINNING

```
CLIC\SET BINNING size position
CLIC\SET BINNING OFF
```

Selects data averaging in bins of the parameter in the X coordinate array. Bins are defined by the size of intervals, and the position of one of the intervals (in units of the X coordinate). SET BINNING OFF will turn this mode off. Note that this averaging in bins occurs AFTER the averaging selected by SET AVERAGE (normally use SET AVERAGING NONE). SET BINNING is particularly useful for plotting data as a function of UV coordinates.

A command SET X used to change the X units will automatically reset the binning OFF.

8.27.10 SET CLOSURE

```
CLIC\SET CLOSURE b1 w1 b2 w2 ...
```

Select weights to be used for each baseline in using the closure relations. (this is done by a least squares resolution of an overdetermined system, in antenna mode). You may wish to give more weight to the shorter baselines. Default weights are equal.

8.27.11 SET CRITERIA

CLIC\SET CRITERIA /DEFAULT Reset all the search criteria for command FIND to their default values. All the observations in the file will be found.

8.27.12 SET /DEFAULT

```
CLIC\SET [CRITERIA|ALL] /DEFAULT
```

Select the default values for all the parameters, or for selection criteria only.

8.27.13 SET DATA

```
CLIC\SET DATA np nb
```

Extend the size of the plot buffers to contain nb boxes of np points each.

8.27.14 SET DEFAULT

```
CLIC\SET DEFAULT (or SET /DEFAULT)
```

Reset all the SET parameters to their default values.

8.27.15 SET DROP

```
CLIC\SET DROP low high
```

Give the fraction of the passband to be left out at the low-frequency and at the high frequency ends of each spectral correlator subband. This is used by further PLOT and TABLE commands. The default is 5% of the bandwidth at both ends.

8.27.16 SET ERRORS

```
CLIC\SET ERROR NOISE|ATMOSPHERE
```

Controls the way the error bars for phase plots in time mode are computed.

- with NOISE the errors are computed according to the system noise only.
- with ATMOSPHERE the rms phase fluctuations as measured when compressing the data, are included in the error bars.

8.27.17 SET EXTENSION

```
CLIC\SET EXTENSION string
```

Use 'string' as the default extension for the FILE command. The default is ".ipb". Other possible values are ".ipb-raw", ".ipb-comp", ".ipb-cal", and ".ipb".

8.27.18 SET FLUX

```
CLIC\SET FLUX name value [frequency] [date] [/RESET]
```

Enters 'value' as the flux of source 'name' (in janskys). The flux of reference sources must be entered in CLIC, as an input to command SOLVE FLUX. If the flux of a source is entered by SET FLUX, this source will be a reference source for determining the antenna efficiencies, and the fluxes of other objects.

After CLIC\SET FLUX name *, source 'name' will not be a reference source any more. Its flux may then be re-determined by a subsequent SOLVE FLUX command.

Use command SHOW FLUX to list the fluxes known to the current CLIC session.

One may optionally enter a frequency (in GHz) and a date (jj-mmm-yyyy). The frequencies and dates are checked in that case by STORE FLUX and SOLVE FLUX. Matching is within 1 GHz for frequencies and 1 week for dates.

If /RESET is given, all entries with the given source name are deleted from the flux list. SET FLUX ALL /RESET will empty the flux list.

8.27.19 SET FORMAT

```
CLIC\SET FORMAT type
```

Set the format of the title of observations plotted. The same format is used by the LIST command. The format may be BRIEF

(Observation number and version, Source name, Line name, Telescope name and position offsets), LONG or FULL which is similar to the long format, but also displays the list of original Scans. The default is BRIEF. FULL format is always used for command HEADER.

Other keywords can be specified to indicate which type of information should be written for the LONG and FULL formats. This is done by command CLIC\SET FORMAT Keyword [ON] [OFF] (ON to write the information corresponding to the specified keyword, OFF to ignore it). The keywords are

- INTERFEROMETER for the number of antennas, baselines, ..
- POSITION for position of the source, offsets, type of coordinates and Epoch
- QUALITY for the Opacity, System temperature, Elevation, Integration time.
- SPECTRAL for the number of subbands, channels, reference channel, rest frequency, frequency resolution.
- CALIBRATION for the beam and forward efficiencies and the gain image ratio.
- STATUS for the status of different possible calibration operations.
- ATMOSPHERE for the water vapor content, pressure, temperatures and opacities in signal and image bands.

A line of general information is always written in any case.

8.27.20 SET FREQUENCY

```
CLIC\SET FREQUENCY subband sideband name freq
CLIC\SET FREQUENCY ALL name freq
```

Select the line name and frequency to be used to define the velocity scale, in spectral-mode plots, for the given sub-band and sideband. 'subband' may be C for continuum or L01 to L04 for spectral correlator subbands; 'sideband' must be either USB or LSB; 'name' is a (max. 12 character) mnemonic for the line name; 'freq' is the rest frequency in MHz. If the line name is '*', then the default frequency entered prior to the observation will be used to compute the velocity scale for the corresponding sub-band.

This information will be used by all subsequent SPECTRUM and MODIFY DOPPLER commands.

SET FREQUENCY ALL will fill in the given frequency for all subbands.

8.27.21 SET GAIN_IMAGE

CLIC\SET GAIN_IMAGE value /ANTENNA i Give the value of the relative gain for the receiver image side band, to be used by the command ATMOSPHERE. Use * instead of the value to force the use of the numbers stored in the file.

8.27.22 SET GIBBS

```
CLIC\SET GIBBS  number
```

Give the number of channels to be masked on each side of the central frequency, for the correlator subbands which are obtained by juxtaposition of both sidebands of a common (third) local oscillator. Due to the Gibbs effect, a few channels are corrupted by a contribution of the image sideband of the first local oscillator, which may contain signal if the source has continuum emission. This is used by further PLOT and TABLE commands. The default is 0, which is relevant for line sources with no continuum emission.

8.27.23 SET HOUR_ANGLE

```
CLIC\SET HOUR_ANGLE first last
```

FIND will select all observations with hour angles in the specified range (in hours). Default is * * (no selection by Hour Angle).

8.27.24 SET IC

```
CLIC\SET IC status
```

FIND will select observations according to the status of Instrumental (Phase) Calibration (IC). 'status' may be YES to select observations already calibrated, NO to select still uncalibrated observations, * to disregard this selection criterion.

8.27.25 SET LEVEL

```
CLIC\SET LEVEL number
```

Set the threshold severity level for messages to be output on the terminal. A reasonable value is 4.

8.27.26 SET LINE

```
CLIC\SET LINE NAME
```

FIND will select all observations according to the specified line name. Default is *. A syntax like NAM* can be used to find observations with line names beginning by NAM.

8.27.27 SET MODE

```
CLIC\SET MODE type
```

Selects which kind of data are displayed. "type" stands for TIME or SPEC. In TIME mode, the underlying parameter is time, i.e. two time-dependent parameters are plotted one against each other, for instance phase versus time, or amplitude versus hour-angle. In SPECtral mode, the underlying parameter is frequency, for instance amplitude versus velocity.

8.27.28 SET NUMBER

```
CLIC\SET NUMBER n1 n2
```

FIND will select all Observations with numbers between n1 and n2. Default is * *.

8.27.29 SET OBSERVED

```
CLIC\SET OBSERVED d1 d2
```

FIND will select all Observations with observing dates between d1 and d2. Default is * *. d1 and d2 are normally in explicit form (jj-mmm-yyyy) but internal day numbers are also accepted (i.e. something like SET OBSERVED DOBS-1 DOBS+1 is possible).

8.27.30 SET OFFSETS

```
CLIC\SET OFFSETS o1 o2
```

FIND will select all observations with offsets between o1 and o2. Default is * *.

8.27.31 SET PC

```
CLIC\SET PC status
```

FIND will select observations according to the status of RF Passband Calibration (PC). 'status' may be YES to select observations already calibrated, NO to select still uncalibrated observations, * to disregard this selection criterion.

8.27.32 SET PHASE

CLIC\SET PHASE [ABSOLUTE|RELATIVE] [ANTENNA|BASELINE] [DEGREES|RADIANS] [JUMPY|CONTINUOUS] [ATMOSPHERE|NOATMOSPHERE] [FILE|NOFILE] [INTERNAL|EXTERNAL]

CLIC\SET PHASE [ABSOLUTE|RELATIVE]

This command decides which phase correction is applied to the data for plotting and writing the final Table, in subsequent PLOT and TABLE. ABSOLUTE means do not use the phase calibration determined by the SOLVE PHASE command, RELATIVE means apply it.

CLIC\SET PHASE ANTENNA|BASELINE

Switch between Antenna-based and Baseline-based phase calibrations. This switch will be active for SOLVE PHASE (calibration curve determination), STORE PHASE (calibration curve store operation), and SET PHASE RELATIVE (for application). Both baseline-based and antenna-based calibration curves may be stored alongside in the data header, independently of each other.

CLIC\SET PHASE [ATMOSPHERE|NOATMOSPHERE]

Switch ON and OFF the atmospheric phase correction. The atmospheric phase correction is based on monitoring the atmosphere water vapor emission using the 1.3 mm receivers. The correction parameters are in

```
  the  atmospheric  monitor  header  section, and are computed by commands
  MONITOR or ATMOSPHERE (this is normally done in real time for data taken
  since  November  1995). However the command MONITOR should still be used
  to precise the reference for the correction (see command MONITOR).  With
  SET  PHASE  ATMOSPHERE  the phase-corrected spectral data, if available,
  will be used.

  Note that the phase correction will  NOT  be  applied  if  it  has  been
  declared  invalid  for  a given scan, using the command STORE CORRECTION
  BAD or AUTO, except  if  SET  PHASE  NOFILE  is  in  effect.  See  these
  commands.

CLIC\SET PHASE [FILE|NOFILE]
    Turn ON of OFF the effect of the STORE CORRECTION command.

  - If SET PHASE ATMOSPHERE FILE, the information on the validity  of  the
  phase correction declared by STORE CORRECTION BAD or AUTO, will be used,
  and the phase correction will be done only on scans validated  by  STORE
  CORRECTION.

  - If SET PHASE ATMOSPHERE NOFILE, this information will be bypassed, and
  the phase correction will be done for all scans.

CLIC\SET PHASE [INTERNAL|EXTERNAL]
    Switch between two modes of phase calibration.

  INTERNAL is the standard mode (default).

  In EXTERNAL mode the calibration curve from another receiver may be used
  (as  stored  by  STORE  PHASE  /RECEIVER r). On the top of this a second
  order calibration curve may be determined (using SOLVE PHASE) and stored
  as  usual. This does not erase any INTERNAL calibration curve previously
  stored.

  for example, using receiver 2:

  SET PHASE INTERNAL RELATIVE: use the phase curve determined from rec.  2
  only

  SET PHASE EXTERNAL ABSOLUTE: use the phase curve from  rec  1  only,  as
  stored with STORE PHASE /RECEIVER 1

  SET PHASE EXTERNAL RELATIVE: use the phase curve from rec 2,  determined
  on  top  of  the  phase  curve from receiver 1, by using SOLVE PHASE and
  STORE PHASE with SET PHASE EXTERNAL in effect.

CLIC\SET PHASE arguments ...
    Selects the way phases are determined.  With  arguments  DEGREES   the
  phases are expressed in degrees of angle, with RADIANS in radians ; with
  argument JUMPY  no  attempt  is  made  to  suppress  2pi  jumps  :   the
  determination  is  always [-pi,pi] ; while with argument "CONTINUOUS n",
  the phase jumps are limited to +/- pi,  that  is  the  phase  is  always
  chosen  in  the  range  [previous-pi,previous+pi]; n being the number of
  points averaged together to estimate the 'previous' phase (default is 1,
```

higher values are to be used in noisy cases).

8.27.33 SET PLANET

```
CLIC\SET PLANET *|P|S
```

[Limited help available] Planet model to be used by SOLVE FLUX

* = default (elliptical disc)

P = same with primary beam attenuation

S filename : use data in file filename

8.27.34 SET PLOT

```
CLIC\SET PLOT type
```

Selects the way the data are displayed. "type" stands for LINE, POINTS, HISTOGRAM, or BARS. In POINTS type, the current GreG marker is used. In BARS type (valid only for the visibility data), 1-sigma error bars are drawn.

8.27.35 SET PROCEDURE

```
CLIC\SET PROCEDURE p
```

FIND will select observations done under procedure 'p'. This may be: CORRELATION, AUTOCORR, ONOFF, CALIBRATE, POINTING, FOCUSSING, IF_PASSBAND, DELAY, or GAIN_RATIO. SET PROCEDURE * will disable procedure as a selection criterion.

8.27.36 SET PROJECT

```
CLIC\SET PROJECT n
```

FIND will select observations done fro Observing Project number n. Project numbers are positive integers. SET PROJECT * will disable project number as a selection criterion.

8.27.37 SET QUALITY

```
CLIC\SET QUALITY q
```

FIND will select only observations of quality better than Q (i.e. less than Q). When originally written, unless the real time acquisition system detected a severe problem, all observations have quality 0, a priori the best. The quality flag of an observation can be changed using the TAG command. See HELP TAG for the recommended quality scale.

8.27.38 SET RANGE

```
CLIC\SET RANGE West East South North
```

FIND will select all observations with offsets in the specified range. Default is * * * *.

8.27.39 SET RECEIVER

```
CLIC\SET RECEIVER number|*
```

Use the receiver number as a selection criterion. The default is SET RECEIVER * : observations with both receivers will be selected.

8.27.40 SET RECORD

```
CLIC\SET RECORD list
```

Will force all further PLOT commands to use only the records as given in the list (e.g. r1 r2 r3 to r4 by r5 ...). Very seldom needed. Use SET RECORD 1 to 1000000 to reset it.

8.27.41 SET REDUCED

```
CLIC\SET REDUCED d1 d2
```

FIND will select all observations with reduction dates between d1 and d2. Default is * *.

8.27.42 SET REFERENCE

```
CLIC\SET REFERENCE antenna_number
```

Enter the logical number of the antenna used as reference for antenna-based calibrations (both RF passband and phase calibrations). Default is 1.

8.27.43 SET RF_PASSBAND

```
CLIC\SET RF_PASSBAND [ON|OFF] [CHANNEL|FREQUENCY]
    [FILE|MEMORY] [ANTENNA|BASELINE]
```

ON|OFF : switch on or off the application of RF passband calibration curve in plotting the data. The RF passband calibration curve is solved for by SOLVE RF_PASSBAND and stored with the data by STORE RF_PASSBAND. Subsequent PLOT commands will use or not this curve according to the status of SET RF_PASSBAND, which is displayed with the plot.

CHANNEL|FREQUENCY : use either the channel dependent passband curves or the frequency dependent passband curve. The channel-dependent passband curves must be determined separately for each subband (continuum and spectral), while the frequency-dependent passband curve is determined by using SOLVE RF_PASSBAND on the continuum correlator, and is used for both the continuum and spectral correlators (this will not work for data taken before July 14th 1990).

MEMORY|FILE : use either the passband curves just determined by SOLVE RF_PASSBAND, and still [resent in the program memory, or

```
    the passband curves previously stored in the  data  headers  of  the
    input  file by a previous command STORE RF_PASSBAND.
  ANTENNA|BASELINE : Switch between Antenna-based and Baseline-based  RF
    passband  calibrations.  This  switch  will  be  active for SOLVE RF
    (passband determination), STORE RF (passband store  operation),  and
    SET  RF  ON  (for  passband  application).  Both baseline-based and
    antenna-based calibration curves may be stored alongside in the data
    header, independently of each other.
```

8.27.44 SET SCAN

```
    CLIC\SET SCAN s1 s2 [s3 s4 ...]

FIND will select all observations with Scan numbers between s1  and  s2,
or  s3  and  s4  ....  The  Scan  number,  attributed  by  the  on-line
acquisition system may be different from the observation number which is
used by CLIC to refer to the observations.  Default is * *.
```

8.27.45 SET SELECTION

```
    CLIC\SET SELECTION mode band subband-range  [FREQ  freqout]  /WINDOW
fmin fmax [fmin2 fmax2 ...]

Choose the type of data selection to be done  by  command  TABLE,  which
creates a UV data Table for mapping software.

- The first argument 'mode' may be CONTINUUM or LINE, to prepare  single
channel or multiple channel maps.

- The second argument is the sideband to be used,  UPPER  or  LOWER,  or
DSB.   DSB  may be used in conjunction with CONTINUUM: in this case, two
separate visibility points are written, one for each sideband. DSB  used
in  conjunction  with  LINE means that the side band will be selected to
match the desired frequency range (as given in the command TABLE),  thus
allowing  to  mix  in the same table data from USB and LSB, if different
frequency setups have been used in different configurations.

- The third argument is a subband range as for SET SUBBANDS command.  In
Continuum mode subbands are averaged, in spectral mode they are combined
to produce a single spectrum.  The syntax is, e.g.
    SET SELECTION n1 TO n3
    to include subbands from n1 to n3; or SET SELECTION n1 TO n3 and n4
    to include subbands from n1 to n3 and subband n4.

The default is : SET SELECTION CONTINUUM, DSB, L01 TO L06

Arguments "FREQ freqout" are  used  only  for  CONTINUUM  tables.  They
define  the  frequency (in MHz) used for mapping purposes.  U and V (for
each side band in DSB mode) will be scaled to this frequency.   This  is
intended  to  combine  maps  obtained in continuum at slightly different
frequencies.  The default for  freqout  will  be  the  actual  observing
frequency,  or  the frequency used for previous data if data is appended
to a previously existing table by the TABLE command.

Option /WINDOW  is  used  to  avoid  spectral  lines  when  producing  a
```

continuum table from spectral correlator data. The first two rest frequencies (in MHz) give the first frequency window in which data is to be used, the next two give the second frequency window, ... etc.

8.27.46 SET SPECTRUM

```
CLIC\SET SPECTRUM ON|OFF
```

Switch on or off the automatic processing of data by command PLOT. If SPECTRUM is ON, all quasi real time processing that is normally done by SPECTRUM command will be done by command PLOT while reading the data. Note that, like in command SPECTRUM the result will depend on the order at which the data is read; ideally the data should be read in the natural time order.

8.27.47 SET SOURCE

```
CLIC\SET SOURCE name1 name2 ... namen
```

FIND will select all scans according to the specified source names. Default is *. Syntax like NAM* can be used to find all observations with source name beginning by NAM.

8.27.48 SET SORT

```
CLIC\SET SORT RECEIVER|SCAN
```

The output of LIST and LIST/SHORT may be sorted primarily be receiver number or scan number. Use SET SORT to switch between the two modes.

8.27.49 SET STEP

```
CLIC\SET STEP t_step
```

Select the time interval parameter to be used by the SOLVE PHASE and SOLVE AMPLITUDE command (time interval between knots of the cubic spline functions). Value is in hours (default 3 hours).

8.27.50 SET SUBBANDS

```
CLIC\SET SUBBANDS n1 n2 ... [/WINDOW f1 l1 f2 l2 ...]
CLIC\SET SUBBANDS ALL
CLIC\SET SUBBANDS EACH
CLIC\SET SUBBANDS LINE|CONT
```

Selects the subbands for which data will be displayed by command PLOT. Valid codes are continuum subbands numbers (C01, C02, ... C10) or line subbands numbers (conventionnaly named L01, L02, L03, and L04 : use L01 if only one subband is present in the data, L01 and L02 if two subbands are present in the data, L01, L02, L03 and L04 if 4 subbands are present in the data). Subbands may be grouped by typing:

SET SUBBANDS n1 to n2 and n3 n4 ... where two quantities will be plotted, the first being either the average of actual subbands n1 to n2 and n3 (in Time Mode), or the concatenation of spectral data from subbands n1 to n2 and n3 (in Spectral Mode); the second being subband n4.

the first scan of the current index, for each command accessing the data. The subband are concatenated (equivalent to e.g. SET SUBBANDS l01 to l06).

the first scan of the current index, for each command accessing the data. The subband are NOT concatenated (equivalent to e.g. SET SUBBANDS l01 l02 l03 l04 l05 l06).

SET SUBBANDS LINE|CONT will switch all subbands to their line/continuum counterpart, e.g. L01 to L04 will be changed to C01 to C04 by SET SUBBBANDS CONT (note that this is also automatically done by switching from spectral mode to time mode).

Use /WINDOW to give first and last channels to be used for line subbands in TIME mode. In this case line data will be integrated in the given window. For example

SET SUBBANDS L01 L02 /WINDOW 1 10 1 10 will plot data from the first ten of the first line subband, as a first quantity, and data from the first 10 channels of the second line subband, as a second quantity.

In spectral mode the window limits may be used to restrict the plot to a certain range, e.g.

SET SUBBANDS L01 TO L02 /WINDOW 2 64

will avoid plotting channels 1 and 61 to 64 of each of the two subbands L01 and L02, since these channels are usually meaningless (these subbands are combined here to a single spectrum; in the mode in which the spectral correlator is split in two subbands of 64 channels). Note: if you want to use both continuum and line subbands, in the same plot page, you should include dummy arguments in the /WINDOW option for the continuum spectra:

SET SUBBANDS C01 to C10 L01 to L02 /WINDOW 0 0 2 64 (two arguments are needed for each resulting spectrum).

8.27.51 SET TELESCOPE

```
CLIC\SET TELESCOPE NAME
```

FIND will select all scans according to the specified telescope name. Default is *. Syntax like NAM* can be used to find all observations with telescope name beginning by NAM.

8.27.52 SET TREC

```
CLIC\SET TIME_ORIGIN *|date
```

Specify the time origin for the abscissa in time plots. This is normally the day for which the first data is plotted, and time is displayed in hours since that day. This day is reset by using PLOT/RESET.

SET TIME_ORIGIN date forces the time origin to the specified day (e.g.

23-NOV-1995).

SET TIME_ORIGIN * reset the default (automatic) behaviour.

8.27.53 SET TREC

```
CLIC\SET TREC  value /ANTENNA i
```

Give the value of the receiver temperature, to be used by the command ATMOSPHERE. Use * instead of the value to force the use of the numbers stored in the file.

8.27.54 SET TRIANGLE

```
CLIC\SET TRIANGLE t1 t2 ...
```

Selects the triangle products for which data will be displayed by command PLOT. Valid triangles : currently only "123" (for three antennas). This command is exclusive with commands SET BASELINES and SET ANTENNAS. This command will be effective only if the triangle products have been computed and stored in the data by commands SPECTRUM/TRIANGLE or COMPRESS/TRIANGLE. In that case the triangle products will have been averaged by these commands; since the phase of the triangle products are closure quantities, the amplitude of the average should not be affected by atmospheric decorrelation.

8.27.55 SET TYPE

```
CLIC\SET TYPE par
```

FIND will select observations of specified type 'par'. This may be OBJECT, PHASE (CALIBRATOR), or RF_PASSBAND (CALIBRATOR). Use argument "*" to disable selection by Source Type.

8.27.56 SET X

```
CLIC\SET X parameter [/LIMITS]
```

Choose the parameter to be plotted along x-axes by command PLOT. Valid parameters are :

Parameters valid in both TIME mode and SPECTRAL mode:

- AMPLITUDE, PHASE, REAL, or IMAGINARY: referring to the visibility in the subband(s), sideband(s), baseline(s) (or antenna(s)) selected by SET SUBBANDS, SET BANDS, SET BASELINES or SET ANTENNAS commands. Only correlation scans will be plotted, not autocorrelations.

- AUTOCORR. : the autocorrelation power measured in the subband(s), antenna(s) selected by SET SUBBANDS, and SET ANTENNAS commands. Only autocorrelation scans will be plotted, (including calibration scans), not correlations.

Parameters valid in SPECTRAL mode only:

CHANNEL : channel number in the correlator (use ony this one if Fourier Transform has not been made).

VELOCITY : normally with respect to LSR.

I_FREQUENCY : the frequency in the second IF (around 350 MHz).

SKY_FREQUENCY : the sky frequency. This should be the line rest frequency if the velocity is correct.

Parameters valid in TIME mode only:

U_COORD, V_COORD, RADIUS, ANGLE: referring to cartesian, or polar coordinates, in the (U,V) plane, of the baseline(s) selected by command SET BASELINES.

TIME: universal time (in hours, origin determined by the first plot made, may be reset by PLOT /RESET).

SCAN: the scan number

NUMBER: the observation number.

RECORD: the record number (1 to the number of plotted points).

HOUR_ANGLE

DECLINATION

RMS_PHASE: the r.m.s. of the phase of the average of the non-flagged subbands of the continuum correlator, in current phase units (degrees or radians). This r.m.s. phase is computed during the data compression.

RMS_AMPLITUDE: the r.m.s. of the amplitude of the average of the non-flagged subbands of the continuum correlator, in current amplitude units (kelvins or janskys). This r.m.s. amplitude is computed during the data compression.

DELAY: as specified for specified baseline (differential, A1-A2 for baseline 12), or for the specified antenna(s).

LO_RATE: as specified for specified baseline (differential, as DELAY), or for the specified antenna(s).

LO_PHASE: as used for specified baseline (differential, as DELAY), or for the specified antenna(s).

CABLE_PHASE: as measured for specified baseline (differential, as DELAY), or for the specified antenna(s).

GAMME: the current range (1 or 2) of the cable phasemeter.

TOTAL_POWER: the total power measured for the given

```
  antenna(s), as measured by the connected detectors.

LAMBDA, BETA, or FOCUS:  the scanning coordinates  for   pointing  and
  focussing  scans  (arc  seconds,  or millimeters), for the specified
  antenna, or the moving antenna if the given  baseline (if  only  one
  is moving).

AZ_CORR: the azimuth collimation correction in arc seconds.

EL_CORR: the elevation collimation correction in arc seconds.

FOC_CORR: the Z focus correction in millimeters.

T00 ...  T04 : general test parameters (in data headers)

T10 ...  T14 : test parameters (antenna based) (in data headers)

TREC:  receiver temperature for the given antenna(s).

TSYS :   Equivalent  system  temperature  for   the   given   baseline
  (Geometrical   mean  of  Tsys  for  both antennas), or for the given
  antenna(s).

PAMB, TAMB, HUMIDITY: measured atmospheric parameters.

WIND_AVERAGE, WIND_DIRAV, WIND_TOP, WIND_DIR_TOP: The wind in m/s  and
  the wind direction in degrees, for 5 min. averages and maxima..

QUALITY: The observation quality as set with commands TAG or CURSOR.

AZIMUTH, ELEVATION: Start azimuth and elevation for each scan.

AZ_ERR, EL_ERR: The tracking errors in arc seconds.

AZ_PH, EL_PH: The azimuth and elevation for each record (as  used  for
  phase tracking).

PARAL_ANGLE: Parallactic angle (angle between the  vertical  direction
  and the meridian plane)

WATER: Water content of atmosphere  (as  set  by  the  programmer,  or
  measured with given antenna).

ATM_EMISSION: From the output of the atmospheric monitor (normally the
  1.3mm  receiver).  This is the measured radiation temperature of the
  atmosphere,  in  Kelvins  of  Rayleigh-Jeans  equivalent   radiation
  temperature.

ATM_POWER: This is the output of the atmospheric monitor (normally the
  1.3mm receiver). It is the actual counts that appear on the monitors
  during observations.


ATM_REFERENCE: The atmospheric emission used as a  reference  for  the
```

phase correction. This is computed by the command MONITOR. The phase correction will be proportional to the difference between the output of the atmospheric monitor and this reference value.

ATM_PHASE: The computed atmospheric phase correction.

ATM_UNCORRPH: The phase uncorrected from atmosphere.

ATM_CORRPH: The phase corrected from atmosphere.

ATM_VALIDITY: 0 or 1 whether the phase correction has been declared valid or not.

CAL_PHASE: The phase instrumental calibration curve.

CAL_AMPLI: The amplitude instrumental calibration curve.

AIR_MASS: The number of air masses (1/sin(elev))

GROUND_EMIS: The ground emission in K (calibrated total power, with sky emission subtracted).

EMISSION: The total power detected in emission in K (ground + sky)

TDEWAR1, TDEWAR2, TDEWAR3: The temperatures in the 3-stage cryogenerators.

TCABIN, TCHOP, TCOLD: The temperatures of the receiver cabin, of the ambient load, and the equivalent temperature of the cold load.

Default are : SET Y AMPLITUDE PHASE.

The /LIMITS option is used to specify fixed limits:

CLIC\SET X TIME /LIMITS t1 t2 where t1 and t2 are the time limits to be used in this example. The codes "*" and "=" may be used. "*" means that the limits are automatically adjusted to the data, separately in each box; "=" means that common limits to all boxes are computed.

For time-like plots, the defaults are "/LIMITS * * ". For frequency-like plots, the defaults are "/LIMITS = =".

8.27.57 SET Y

```
CLIC\SET Y parameter [/LIMITS]
```

Choose the parameter to be plotted along y-axes by command PLOT.

The available parameters are the same as with SET X parameter. Parameters valid in both TIME mode and SPECTRAL mode:

AMPLITUDE, PHASE, REAL, or IMAGINARY: referring to the visibility in the subband(s), sideband(s), baseline(s) (or antenna(s)) selected by SET SUBBANDS, SET BANDS, SET BASELINES or SET ANTENNAS commands. Only correlation scans will be plotted, not autocorrelations.

AUTOCORR. : the autocorrelation power measured in the subband(s), antenna(s) selected by SET SUBBANDS, and SET ANTENNAS commands. Only autocorrelation scans will be plotted, (including calibration scans), not correlations.

Parameters valid in SPECTRAL mode only:

CHANNEL : channel number in the correlator (use ony this one if Fourier Transform has not been made).

VELOCITY : normally with respect to LSR.

I_FREQUENCY : the frequency in the second IF (around 350 MHz).

SKY_FREQUENCY : the sky frequency. This should be the line rest frequency if the velocity is correct.

Parameters valid in TIME mode only:

U_COORD, V_COORD, RADIUS, ANGLE: referring to cartesian, or polar coordinates, in the (U,V) plane, of the baseline(s) selected by command SET BASELINES.

TIME: universal time (in hours, origin determined by the first plot made, may be reset by PLOT /RESET).

SCAN: the scan number

NUMBER: the observation number.

RECORD: the record number (1 to the number of plotted points).

HOUR_ANGLE

DECLINATION

RMS_PHASE: the r.m.s. of the phase of the average of the non-flagged subbands of the continuum correlator, in current phase units (degrees or radians). This r.m.s. phase is computed during the data compression.

RMS_AMPLITUDE: the r.m.s. of the amplitude of the average of the non-flagged subbands of the continuum correlator, in current amplitude units (kelvins or janskys). This r.m.s. amplitude is computed during the data compression.

DELAY: as specified for specified baseline (differential, A1-A2 for baseline 12), or for the specified antenna(s).

LO_RATE: as specified for specified baseline (differential, as

DELAY), or for the specified antenna(s).

LO_PHASE: as used for specified baseline (differential, as DELAY), or for the specified antenna(s).

CABLE_PHASE: as measured for specified baseline (differential, as DELAY), or for the specified antenna(s).

GAMME: the current range (1 or 2) of the cable phasemeter.

TOTAL_POWER: the total power measured for the given antenna(s), as measured by the connected detectors.

LAMBDA, BETA, or FOCUS: the scanning coordinates for pointing and focussing scans (arc seconds, or millimeters), for the specified antenna, or the moving antenna if the given baseline (if only one is moving).

AZ_CORR: the azimuth collimation correction in arc seconds.

EL_CORR: the elevation collimation correction in arc seconds.

FOC_CORR: the Z focus correction in millimeters.

T00 ... T04 : general test parameters (in data headers)

T10 ... T14 : test parameters (antenna based) (in data headers)

TREC: receiver temperature for the given antenna(s).

TSYS : Equivalent system temperature for the given baseline (Geometrical mean of Tsys for both antennas), or for the given antenna(s).

PAMB, TAMB, HUMIDITY: measured atmospheric parameters.

WIND_AVERAGE, WIND_DIRAV, WIND_TOP, WIND_DIR_TOP: The wind in m/s and the wind direction in degrees, for 5 min. averages and maxima..

QUALITY: The observation quality as set with commands TAG or CURSOR.

AZIMUTH, ELEVATION: Start azimuth and elevation for each scan.

AZ_ERR, EL_ERR: The tracking errors in arc seconds.

AZ_PH, EL_PH: The azimuth and elevation for each record (as used for phase tracking).

PARAL_ANGLE: Parallactic angle (angle between the vertical direction and the meridian plane)

WATER: Water content of atmosphere (as set by the programmer, or measured with given antenna).

ATM_EMISSION: From the output of the atmospheric monitor (normally the 1.3mm receiver). This is the measured radiation temperature of the atmosphere, in Kelvins of Rayleigh-Jeans equivalent radiation temperature.

ATM_POWER: This is the output of the atmospheric monitor (normally the 1.3mm receiver). It is the actual counts that appear on the monitors during observations.

ATM_REFERENCE: The atmospheric emission used as a reference for the phase correction. This is computed by the command MONITOR. The phase correction will be proportional to the difference between the output of the atmospheric monitor and this reference value.

ATM_PHASE: The computed atmospheric phase correction.

ATM_UNCORRPH: The phase uncorrected from atmosphere.

ATM_CORRPH: The phase corrected from atmosphere.

ATM_VALIDITY: 0 or 1 whether the phase correction has been declared valid or not.

CAL_PHASE: The phase instrumental calibration curve.

CAL_AMPLI: The amplitude instrumental calibration curve.

AIR_MASS: The number of air masses (1/sin(elev))

GROUND_EMIS: The ground emission in K (calibrated total power, with sky emission subtracted).

EMISSION: The total power detected in emission in K (ground + sky)

TDEWAR1, TDEWAR2, TDEWAR3: The temperatures in the 3-stage cryogenerators.

TCABIN, TCHOP, TCOLD: The temperatures of the receiver cabin, of the ambient load, and the equivalent temperature of the cold load.

Default are : SET Y AMPLITUDE PHASE.

The /LIMITS option is used to specify fixed limits:

CLIC\SET Y AMPLITUDE /LIMITS a1 a2 where a1 and a2 are the amplitude limits to be used in this example. The codes "*" and "=" may be used. "*" means that the limits are automatically adjusted to the data, separately in each box; "=" means that common limits to all boxes are computed.

Default limits are provided for AMPLITUDE and PHASE only (0 * -180 180 if SET PHASE JUMPY is effective, and 0 * * * if SET PHASE DEGREES

CONTINUOUS ; with corresponding values if SET PHASE RADIANS).

8.27.58 SET WATER

```
CLIC\SET WATER  value /ANTENNA i
```

Give the value of the water vapor content (in mm), to be used by the command ATMOSPHERE. Use * instead of the value to force the use of the numbers stored in the file.

8.27.59 SET WEIGHTS

```
CLIC\SET WEIGHTS [TSYS ON|OFF] [CALIBRATION ON|OFF]
```

Selects the way the data is weighted in command TABLE.

With TSYS ON, data is weighted by 1/TSYS**2, where TSYS is the equivalent system temperature (the geometrical mean of system temperature of both antennas, for a given baseline).

With TSYS OFF, this weight factor is turned off.

With CALIBRATION ON, data is also weighted by 1/CAL**2, where CAL is the amplitude instrumental calibration factor (if any). If no amplitude instrumental calibration function is applied (absolute amplitude), this weighting should have no effect.

With CALIBRATION OFF, weights are not affected by amplitude instrumental calibration.

With both TSYS OFF and CALIBRATION OFF, data is weighted proportionally to observing time.

8.27.60 SET COPY

```
CLIC\SET COPY DATA|NODATA
```

This command is used to select the default data access mode on COPY commands.

See the help for COPY.

8.28 SHOW

```
CLIC\SHOW Arg
```

Display some parameter defined by SET. "SHOW ALL" will display all parameters specified by SET (See SET command). "SHOW CRITERIA" will display only selection criteria, "SHOW DISPLAY" will give only the parameters relevant to command PLOT, and "SHOW GENERAL" will give the rest of the parameters.

8.29 SOLVE

CLIC\SOLVE Item

This is a command to determine interferometer parameters from measured data. such as baseline values, or calibration curves.

8.29.1 SOLVE AMPLITUDE

CLIC\SOLVE AMPLITUDE [/PLOT] [/BREAK ...] [/POLYNOMIAL...] [/WEIGHT]

This will fit a mathematical function into the measured amplitude of the sources in the current index (presumably calibrators). This data must have been selected and plotted in axes : SET X TIME and SET Y AMPLITUDE for the baselines and bands of interest, specified by the corresponding SET commands. The calibration function is kept in memory. Command STORE should be used next to store this function in the header of source observations, after a change in the index to select the appropriate scans.

In antenna mode the averaged phase and amplitude closures are computed, as well as their standard deviations. The phase closures should be close to zero, while the amplitude closures should be close to 100%. Strong deviations of amplitude closures from 100% are an indication of amplitude loss on long baselines, due to phase decorrelation during the time averaging. The fit then shows strong systematic errors; if this occurs, baseline based calibration of the amplitudes might be preferred.

Option /PLOT will plot the fitted curve over the data.

Fitted curves may be of two kinds:

- Cubic splines (the default). By default knots are regularly spaced with an interval between knots set by the SET STEP command. Additional knots may be introduced with the option: /BREAK kind time [kind time ...] a break introduced at abscissa 'time' ; 'kind' is an integer in the range 0-3; 0 means that a discontinuity will be present, 1 that the first derivative will be discontinuous, and so on. Several breaks may be introduced; the program will detect an error if too many breaks are introduced, compared to the density of data points.

- Polynomial curves may be used instead. For this the option is: /POLYNOMIAL [degree] indicating the degree of the polynomial (default 0).

Normally the data points are all assigned the same weight for the fit. With option /WEIGHT, the data points are weighted according to their errors. Errors are set to the statistical errors for the amplitudes.

8.29.2 SOLVE HOLOGRAPHY

```
    CLIC\SOLVE HOLOGRAPHY [MO nmodes] [NP npix] [IT niter gain] [FREE r1
r2  ...]  [/OFFSET  x  y  z] [/PLOT [AMP amin amax astep] [PHA pmin pmax
pstep] [ERRORS emin emax estep] [NUMBER]

(Keywords like MO, NP, IT, FREE
 may be given in any order, each must be followed by its arguments; they
are all optional)


This command computes an antenna surface map from a  set  of  holography
measurements.  The  set of scans (procedure HOLO) should have first been
calibrated in phase, amplitude and RF passband relative  to  interspaced
correlation  scans  in  the  direction  of  the source.  The map will be
computed from the first band and subband sets chosen with  commands  SET
BAND  and  SET  SUBBAND.  SET  BAND AVERAGE is recommended for continuum
measurements;  only  continuum  subbands  should  be  used.   For  line
measurements,  the continuum width of one of the correlator units should
match the actual line width for better sensitivity.  The antenna  to  be
studied  should  be  selected  by  command SET ANTENNA i.  Data from the
baselines linking this antenna  (scanned)  to  other  (fixed)  available
antennas are averaged.

The amplitude and phase maps are obtained by Fast Fourier  Transform  of
the  observed  beam  map. The maps will be square (npix by npix pixels).
The default for npix is 64, it should be  greater  than  the  number  of
observed holography scans (usually 16 or 32).

After FFT a gaussian illumination function is fitted in the  amplitudes,
giving  the  offset  from  the center (in meters) and the edge taper (in
dB).  If /PLOT is given, the amplitude map will be shown (in  decibels),
from  -15  to  0 dB, with contours in steps of 3db (these may be changed
using amin, amax and astep).

A lest square fit is used to correct the phases from a  remaining  phase
offset,  pointing  errors,  and focus offsets. The panel rings following
FREE are not used for this fit. If /PLOT is given,  the  antenna  normal
surface errors will be shown, in micrometers, from -500 to 500 mum, with
contours in steps of 100 mum (these may be changed using keyword  ERRORS
followed  by  emin,  emax  and  estep).   If  /PLOT  PHASE is given, the
residual phase map will be plotted instead of surface errors, in radians
from -pi to pi, with contours in steps of 0.2 radian.

If this map shows remaining 2*pi discontinuities, or  if  focus  offsets
larger  that  1mm  are  found,  you  should  try using option /OFFSET to
correct the phases  for  an  offset  (x,y,z  in  meters)  in  the  focus
coordinates, before fitting. This should lead to better rms values.

/PLOT gives also the amplitude illumination pattern, in dB; default plot
limits are -15dB to 0dB by step of 3dB; use /PLOT AMP amin amax astep to
change these settings.  If NUMBER is given  as  a  /PLOT  argument,  the
panels numbers are drawn.
```

The rms values for the phase and the normal surface errors (in radians and micrometers) are given, both with and without amplitude weighting. The contribution of the illumination amplitude distribution and of the observed phase errors to the antenna efficiency are given.

Finally, if nmodes is larger than 0, a listing of panels displacements is computed, and written in a file like "panels-an1.dat". This uses the parameter nmodes which is the number of modes used for each panel: 1 is only the translation mode (normal to the antenna surface); 3 (the usual setting), adds both tilt modes, radial and tangential, but no panel deformation; 4 adds a torsion mode and 5 a motion of the panel center relative to its edges (there are only 5 screws for each panel, thus only 5 possible modes). In the file "panels-an1.dat" a line for each panel is printed. The first two numbers are the panel numbers, followed by up to five screw settings (three only for the inner ring). All screw settings are equal if nmodes was set to 1, only one number is then printed.

If niter is not forced to zero, the fit is obtained iteratively: the panel orthogonal deformation modes are computed from the aperture phase, then the phase change that these deformations would have caused is computed (by doing a FFT to the beam map, doing a cut-off at the observed map size, followed by a FFT back to the aperture plane), and subtracted from the aperture phase; second order panel deformations are computed from these residuals, and so on. The number of iterations niter and a gain to this iterative procedure may be specified ([IT niter gain]); their default values are 5 and 1.0 . Use IT 0 for no iterative procedure at all. At each step the phase residual rms and the rms of panel deformations fitted are given (weighted by the fitted amplitude illumination and counted perpendicularly to the surface).

A gildas image file of the results is kept (e.g. "jj-mmm-yyyy-an1.map"), in which plane 3 in the amplitude in dB, plane 4 the raw phases and plane 2 the residual phase in radians (plane 1 contains the fitted amplitude, i.e. a Gaussian).

8.29.3 SOLVE BASELINE

CLIC\SOLVE BASELINE [/OFFSET b1 dx1 dy1 dz1 b2 ...] [/SEARCH range] [/POLYNOMIAL degree]

This uses a linear method to determine baselines separately and should work only if the starting values are within half a wavelength in any direction of the true values. The baselines to be determined must have been selected by the SET BASELINE command, and the data plotted; plot axes must have been previously selected by : SET X HOUR_ANGLE DECLINATION and SET Y PHASE.

Use option /OFFSET to correct the phases for an offset (dx1,dy1,dz1) in baseline b1 before fitting. This is needed if the baseline was wrong by more than half a wavelength. Offsets are to be given in meters.

The results are given as offsets in meters to be added to the baseline used for data acquisition (which may be read by SIC\EXAMINE BASELINE). The total fitted baseline is also given in meters, as well as the rms of the residuals in phase units. Two sets of offsets are given: the first set (dx, dy, dz) are the offsets with respect to the antenna positions actually used, while the secoond set (DX, DY, DZ) are with respect to the standard antenna coordinates (the default values in OBS).

The /SEARCH option enables an automatic search with starting offsets scanning a 3-d box in dx, dy, dz, by steps of half a wavelength in the three directions. The argument range is in meters (scanning is from -range/2 to +range/2, default -0.005 to 0.005). Only the solution with the minimum rms is kept. Searching one baseline in a 0.01 meter range takes 4 seconds on the micro-vax 3400.

Use command RESIDUALS BASELINE to display the fit residuals (phase should be constant).

With SET ANTENNA in action the antenna position offsets are directly fitted to the antenna phases, ensuring baseline closure.

Use later command PRINT BASELINE to create a procedure file (named CLIC-BASELINE.OBS) containing the antenna position offsets. This procedure file may be executed by the observing program OBS on the control computer BURE01.

With option /POLYNOMIAL degree, and if SET X TIME is used in addition of HOUR_ANGLE and DECLINATION, a polynomial function of time is included in the phase function being fitted. The degree may range from 0 (the default) to 3. In that case command RESIDUALS will also plot the residuals as a function of time.

In one specify elevation as an additional X variable (e.g. SET X HOUR_ANGLE DECLINATION TIME ELEVATION), then an additional parameter is fitted: the offsets between elevation and azimuth axes (or rather the differences between antennas). These differing offsets result in a phase effect proportional to the cosine of elevation. In antenna mode, these offsets are given for each antenna in meters. In baseline mode, only differences are computed.

To further correct for this effect use the command MODIFY AXES. It is foreseen to correct for this effect in real time, when the values are well and unambiguously known.

8.29.4 SOLVE DELAY

```
CLIC\SOLVE DELAY   [/SEARCH range interval] [/PLOT]
```

This uses a linear method to determine delays. The baselines to be determined must have been selected by the SET BASELINE (or SET

ANTENNA) command, and the data plotted; plot axes must have been previously selected by : SET X I_FREQUENCY and SET Y PHASE.

The results are given in nanoseconds.

The /SEARCH option enables an automatic search with starting offsets from -range|2 to +range|2 by steps of given interval. the default range is 200 nanoseconds, with interval of 1 nanosecond.

With SET ANTENNA in action the antenna delays are directly fitted to the antenna phases, ensuring delay closure.

Use later command PRINT DELAY to create a procedure file (named CLIC-DELAY.OBS) containing the fitted antenna delays. This procedure file may be executed by the observing program OBS on the control computer BURE01.

With option /PLOT, the fitted phases pill be plotted over the data.

8.29.5 SOLVE FLUX

```
CLIC\SOLVE FLUX [NOREFERENCE] [BEST n]
```

Calculate the fluxes of the sources in the current index or the antenna efficiencies (Jansky to Kelvin) if the source flux is known. The command can also be used to bootstrap source fluxes from a known source.

It should be used before computing any amplitude calibration, on an index covering a reasonably short time interval to avoid possible efficiency variations.

The commands should be used in the following way:

- The command SET FLUX may be used to define the flux of one, or several of the sources in the current index for which the flux is known. Frequencies and dates may be specified in SET FLUX. Alternatively, the default efficiencies stored in the data header will be used, if NOREFERENCE is present.

- Then the command SOLVE FLUX will use the sources of known flux (optionally with matching frequencies and dates) to determine the efficiencies for all antennas, and compute the fluxes of all other sources using those efficiencies. IF BEST n is present, the antennas giving the highest n fluxes will be used for averaging (n: 1 to the number of available antennas).

  SOLVE FLUX now gives the decorrelation factor relative to the efficiencies logged in the scan headers (assumed to be the standard single-dish efficiencies).

- The command SHOW FLUX will give a list of fluxes either assumed or just determined.

- The command PRINT FLUX will create a procedure that may be used later to reload these fluxes in CLIC, if needed.

- The command STORE FLUX will store the fluxes and efficiencies in the headers of the observations in the current index.

SOLVE FLUX includes a correction for decorrelation effect, using the rms phases computed from the 1-second integration dumps. Use SOLVE FLUX RAW to ignore this correction.

SOLVE FLUX normally requires point sources to be meaningful. There two exceptions to this:

- Planets, at least the smallest ones.
- W3OH, a reasonably strong circumpolar HII region

These sources can be used as flux calibrators. Size effects are corrected for by CLIC, using the ephemerides to determine the planet characteristics, and a simple (but accurate) source model for W3OH.

8.29.6 SOLVE FOCUS

```
CLIC\SOLVE FOCUS [/PLOT] [/COMPRESS] [/PRINT]
```

Find focus corrections from a FOCUS scan. All focus scans in the current index are processed by a parabolic fit. All continuum subbands and both side bands are averaged. SET AVERAG METHOD SCALAR is recommended. The fits may be displayed with option /PLOT.

The option /COMPRESS may be used to average data in a given time interval before processing, to improve the signal-to-noise ratio. Default is 4 seconds.

The presence of option /PRINT produces a procedure file "focus.obs", to be used in OBS for introducing the fitted focus offset.

8.29.7 SOLVE GAIN

```
CLIC\SOLVE GAIN [SCAN] [/PRINT]
```

Compute the receiver gain ratio (Image Side Band over Signal Side band) from correlation data on a continuum source. Compute also the LO1 and LO3 phases that should be used in real time to have zero phases in both side bands.

The data from all the scans in the current index are averaged except if optional argument SCAN is given, in which case the gain ratios are computed for each scan.

Option /PRINT : write a procedure INTER_OBS:gain.obs to set the gains (and phases) in OBS.

8.29.8 SOLVE PHASE

```
    CLIC\SOLVE   PHASE   [/PLOT]   [/BREAK   ...]   [/POLYNOMIAL...]
[/WEIGHT]
```

This will fit a mathematical function into the measured phases of the sources in the current index (presumably calibrators). This data must have been selected and plotted in axes : SET X TIME and SET Y PHASE for the baselines and bands of interest, specified by the corresponding SET commands. Phases should be continuous. The calibration function is kept in memory. Command STORE should be used next to store this function in the header of source observations, after a change in the index to select the appropriate scans.

SOLVE PHASE internally and temporarily resets SET PHASE to ABSOLUTE. The INTERNAL|EXTERNAL mode is kept to allow determining a phase curve on top of an external receiver reference.

Option /PLOT will plot the fitted phase curve over the data.

Fitted curves may be of two kinds:

- Cubic splines (the default). By default knots are regularly spaced with an interval between knots set by the SET STEP command. Additional knots may be introduced with the option: /BREAK kind time [kind time ...] a break introduced at abscissa 'time' ; 'kind' is an integer in the range 0-3; 0 means that a discontinuity will be present, 1 that the first derivative will be discontinuous, and so on. Several breaks may be introduced; the program will detect an error if too many breaks are introduced, compared to the density of data points.

- Polynomial curves may be used instead. For this the option is: /POLYNOMIAL [degree] indicating the degree of the polynomial (default 0).

Normally the data points are all assigned the same weight for the fit. With option /WEIGHT, the data points are weighted according to their errors. Errors computed from the phase rms determined in the data compression.

8.29.9 SOLVE POINTING

```
    CLIC\SOLVE POINTING [beam] [/PLOT]
    [/OUTPUT filename [NEW|APPEND] [FLUX]] [/COMPRESS time] [/PRINT]
```

Find pointing corrections from POINTING scans. All pointing scans in the current index are processed by a gaussian fit. All continuum subbands and both side bands are averaged. SET AVERAG METHOD SCALAR is recommended.

The fits may be displayed with option /PLOT.

The results may be written on a file if /OUTPUT is given. The file is given extension .LIS by default; a new file is opened except if APPEND is given as a second argument of option /OUTPUT. The file is by default in a format suitable for the determination of a pointing model (program POINT at BURE). The presence of optional argument FLUX changes the output format for the determination of relative fluxes (by ASTRO).

The option /COMPRESS may be used to average data in a given time interval before processing, to improve the signal-to-noise ratio. Default is 4 seconds.

Option /PRINT : write a procedure file INTEROBS:pointing.obs to update the pointing corrections in OBS.

8.29.10 SOLVE FIVE

```
CLIC\SOLVE FIVE [beam] [/PLOT]
[/OUTPUT filename [NEW|APPEND] [FLUX]] [/PRINT]
```

Find pointing corrections from FIVE point scans. All five-point scans in the current index are processed by a gaussian fit. All continuum subbands and both side bands are averaged.

The fits may be displayed with option /PLOT.

The results may be written on a file if /OUTPUT is given. The file is given extension .LIS by default; a new file is opened except if APPEND is given as a second argument of option /OUTPUT. The file is by default in a format suitable for the determination of a pointing model (program POINT at BURE). The presence of optional argument FLUX changes the output format for the determination of relative fluxes (by ASTRO).

Option /PRINT : write a procedure file INTER_OBS:pointing.obs to update the pointing corrections in OBS.

8.29.11 SOLVE TOTAL

```
CLIC\SOLVE TOTAL [beam] [/PLOT]  [/PRINT]
[/OUTPUT filename [NEW|APPEND] [FLUX]] [/COMPRESS time] [/PRINT]
```

Find pointing corrections from POINTING scans, but using the total power from each antenna. All pointing scans in the current index are processed by a gaussian fit.

The fits may be displayed with option /PLOT.

The results may be written on a file if /OUTPUT is given. The file is given extension .LIS by default; a new file is opened except if APPEND is given as a second argument of option /OUTPUT. The file is by default in a format suitable for the determination of a pointing model (program POINT at BURE). The presence of optional argument FLUX changes the output format for the determination of relative fluxes (by ASTRO).

The option /COMPRESS may be used to average data in a given time interval before processing, to improve the signal-to-noise ratio. Default is 4 seconds.

Option /PRINT : write a procedure file INTER_OBS:pointing.obs to update the pointing corrections in OBS.

8.29.12 SOLVE RF_PASSBAND

```
CLIC\SOLVE RF_PASSBAND [da] [dp][/PLOT]
```

Solve for passband calibration curves, by fitting it to the amplitudes and phases measured on a strong continuum source (passband calibrator). The behaviour of this command depends on the current mode of rf passband calibration (Frequency or Channel).

- for frequency-dependent rf passabnd calibration: the resolution is normally done using all the spectral subbands plotted together, as a function of intermediate frequency. It should be done separately for upper and lower side bands. A single frequency-dependent polynomial is fitted, a high degree might be necessary for the phase, if band edges are used (up to 20 is feasible).

- for channel dependent rf passband calibration: (i) for continuum, the data itself is directly stored as calibration values (this gives a channel-dependent passband curve). In addition a polynomial is fitted and optionally plotted (this gives a frequency-dependent passband curve).

  (ii) for spectral subbands, polynomials are fitted and optionally plotted, as a channel-dependent passband curve.

The degrees for polynomials are 'da' for amplitude, 'dp' for phase (defaults 0 and 1). X unit must be channel. Spectral subbands must be plotted separately. The current index should contain calibration observations of strong continuum sources. Command STORE should be used next to store this function in the header of source observations.

Both channel dependent and frequency dependent curves will be stored; Use command SET RF_PASSBAND FREQUENCY|CHANNEL to apply one or the other.

Option /PLOT will plot the polynomial fits over the data.

8.29.13 SOLVE SKYDIP

```
CLIC\SOLVE SKYDIP [TREC|EFF] [/PLOT] [/OUTPUT File [NEW]]
```

Compute receiver temperature TREC or antenna forward efficiency EFF from skydip scan. All skydip scans in the current index a solved. A graphic display of the solution can be plotted using the /PLOT option, and data can be written to an output file using the /OUTPUT option.

8.30 STORE

```
CLIC\STORE par
```

Writes calibration (or edition) data in the output file. All scans in the current index are processed. Calibrated data may later be plotted with the PLOT command, after setting INSTRUMENTAL and/or RF_PASSBAND to ON.

8.30.1 STORE AMPLITUDE

```
CLIC\STORE AMPLITUDE [PHASE] [/BAND code] [/SELF]
```

Store the amplitude (and optionally phase) calibration. Storing both calibrations together is more efficient.

With option "/BAND code", one may use the calibration curve determined with one of the sidebands (‘code’ is UPPER, LOWER or AVERAGE), to calibrate both sidebands.

With option "/SELF", the calibration stored will not be the calibration curve determined with the last SOLVE AMPLITUDE [or PHASE], but, for each scan, the visibility corresponding to the first subband set (eg., SET SUB L01 to L03 ...); data from each side band will be used to calibrate the same side band. This provide a simple, easy way to calibrate data taken on strong continuum sources (quasars).

8.30.2 STORE CORRECTION

CLIC\STORE CORRECTION GOOD|BAD|AUTO|SELF [tmin] Stores in the header of each scan (of the current index) the information whether the phase correction is or not declared valid, and should be actually applied when SET PHASE ATM is selected.

If AUTO, that information is determined on the phase calibrators (type PHASE), by comparing the amplitudes with and without the correction. This information is then propagated to the neighbouring source observations (type OBJECT, in a +- tmin minutes time window). ‘tmin’ interval (in time minutes) defaults to 15 minutes.

If SELF, that information is determined on the source, whatever its type may be, by comparing its amplitude with and without the correction.

8.30.3 STORE FLAG

```
CLIC\STORE FLAG f1 f2 ...  [/ANTENNA a1 a2 ...  ] [/BASELINE b1  b2
...] [/BAND b] [/RESET]
```

Flag all data in the current index according to the parameters and option specified. This is equivalent to the following sequence of commands

```
     CLIC\MODIFY DATA
 with a DATA.CLIC procedure containing
     FLAG f1 f2 ... [/ANTENNA a1 a2 ...] [/BASELINE b1 b2 ...] [/RESET]
     GO WRITE
```

but it is simpler and faster (however, all the data records will be flagged).

8.30.4 STORE FLUX

```
CLIC\STORE FLUX
```

```
Store the source fluxes and  antenna  efficiencies  determined  from   a
previous SOLVE FLUX command. Source names, frequencies (within 1GHz)
 and dates (within a week) must match.
```

8.30.5 STORE PHASE

```
CLIC\STORE PHASE [AMPLITUDE] [/BAND code] [/RECEIVER irec]
```

```
Store the phase (and optionally  amplitude)  calibration.   Storing both
calibrations together is more efficient.

With option  "/BAND  code",  one   may   use   the   calibration   curve
determined  with  one  of  the  sidebands  (‘code’  is  UPPER,  LOWER or
AVERAGE), to calibrate both sidebands.

With option "/SELF", the calibration stored will not be the  calibration
curve determined with the last SOLVE PHASE [or AMPLITUDE], but, for each
scan, the visibility corresponding to the first subband  set  (eg.,  SET
SUB  L01 to L03 ...); data from each side band will be used to calibrate
the same side band. This provide a simple, easy way  to  calibrate  data
taken on strong continuum sources (quasars).

With option "/RECEIVER irec", the calibration curves solved  using  data
from  receiver  "irec"  will  be  stored  in  parallel  with  any  other
calibration curve.  This phase curve will  be  selected  by  giving  SET
PHASE EXTERNAL.  (see this command). This has no meaning for amplitudes.

/BAND may be used in conjunction with /RECEIVER.
```

8.30.6 STORE QUALITY

```
CLIC\STORE QUALITY code
```

```
  Store the data quality to be used as  a  selection  criterion.  All  the
  scans  in  the  current  index are tagged. Code may be an integer in the
  range 0-9, or drectly the corresponding quality word:
0 Unknown
1 Excellent
2 Good
3 Fair
4 Average
5 Poor
6 Bad
7 Awful
8 Worst
9 Deleted
```

8.30.7 STORE RF_PASSBAND

```
    CLIC\STORE RF_PASSBAND

Store the Continuum and/or  Line   RF   passband   calibration   curves.
Both   channel   dependent   and  frequency  dependent  curves  will  be
simultaneously stored.  Caution:  Line RF  passbands  should  be  stored
only for consistent spectral correlator configurations.
```

8.31 TABLE

```
    CLIC\TABLE Name Status [/RESAMPLE nc ref val inc code  shape  width]
[/COMPRESS tmax uvmax] [/FREQUENCY name rest-freq] [/DROP  n1 n2] [/FFT]

This command will create a UV data Table from  the  current  index.  not
given, the most recently created table will be  extended.   'Status' may
be  OLD  (default  value  if  not  specified)  to  extend  and  existing
table, or NEW to create a new table.

The bands and subbands used are given by command SET SELECTION (See HELP
SET SELECTION).

The weighting modes are given by command SET WEIGHTS.

Option /RESAMPLE enables to resample data on a new  spectral  grid  (for
line  data).  'nc' is the output number of channels, 'ref' the reference
channel, 'val' the value of velocity or frequency offset  (with  respect
to  the  rest frequency) at the reference channel, 'inc' the resolution,
'code' is "V" if the  value  'val'  and  the  resolution  'inc'  are  in
velocity  units,  "F"  for  frequency units.  The reference channel thus
corresponds to the given 'val' velocity, or to the offset 'val'  in  MHz
from  the  rest  frequency  present  in the header or modified by option
/FREQUENCY.

Resampling is done by default  through  linear  interpolation  of  input
channel data.

Resampling may also be done (using option  /FFT)  in  Fourier  space  by
cut-off  or  extrapolation  (by zeroes) of the Fourier components, after
deconvolution by the channel response of the correlator (due to  on-line
apodization),  and  followed  by  reconvolution  to  produce  frequency
channels of the given shape and width. Allowed shapes are:

  TBox = a box in delay space (unapodized  correlator)
  Ppar = a parabola in delay space (apodized correlator) (the default)
  FBox = a box in frequency space (square filter)
  FTri = a triangle in frequency space (Hanning smoothed square filter)

The width is the channel width in units of channel  separation  (default
1).

Option /FFT is not recommended when joining together several subbands to
produce  a single spectrum, with a limited number of broad channels.  In
those cases using the FFT could produce a spectrum with "holes"  at  the
```

points between subbands with limited overlap.

Option /FREQUENCY is used to redefine the rest frequency (and line name) for the output table. The velocity scale is computed accordingly. This rest frequency will correspond to the reference channel in option RESAMPLE.

Option /DROP enables to drop the first 'n1' and last 'n2' channels in each subband of the OLD spectral correlator. For the NEW spectral correlator (data taken since summer 1992), it is replaced by the commands SET GIBBS and SET DROP.

Option /COMPRESS is used to compress the data before writing the table. This works like the COMPRESS command, but no intermediate file is written.

A UV data Table is a file in the Gildas Data Format, of dimension 2. Each column corresponds to a visibility data point. Lines contain respectively:

1. U in meters
2. V in meters
3. W in meters
4. Observation date (integer CLASS Day Number)
5. Time in seconds since above date
6. Number of start antenna
7. Number of end antenna
8. First frequency point (real part)
9. First frequency point (imaginary part)
10. First frequency point (weight = integration time x frequency width in MHz divided by the product of system temperatures of both antennas); see SET WEIGHTS to select the weighting modes.
11. Same for second frequency point, and so on. The first dimension is then the 3 * nchan + 7, for nchan frequency channels; The second dimension is the number of UV points measured. For use with GreG COLUMN command, this UV Data Table must be transposed by Gildas Task TRANSPOSE.

8.32 TAG

```
CLIC\TAG Quality_Code List_of_Observations
```

Attributes a quality to a given list of Observations. Quality_Code is an integer in the range 0-9, and the recommended quality scale is

0 Unknown
1 Excellent
2 Good
3 Fair
4 Average
5 Poor
6 Bad
7 Awful
8 Worst
9 Deleted

The operation is immediate and occurs in the OUTPUT file for all versions of all Observations specified in the list. If no list is given, the R memory is attributed the specified quality. A FIND operation will only select Observations of quality better than (i.e. less or equal to) the quality specified by the SET QUALITY command, or in the /QUALITY option.

8.33 VARIABLES

```
CLIC\VARIABLES group state
```

This command is used to enable/disable CLIC variables. 'state' may be ON or OFF; 12 groups of variables are available, corresponding to sections in the scan headers.

```
READ_WRITE     Input/Output file information (Global)
GENERAL        General information (Scan based)
POSITION       Source related information (Scan based)
CONFIG         Array configuration related information (Scan based)
RF_SETUP       Receiver related information (Scan based)
CONTINUUM      Continuum correlator related information (Scan based)
LINE           Spectral correlator related information (Scan based)
SCANNING       Special scan information (Record based)
ATMOSPHERE     Atmospheric calibration parameters and results (Scan based)
DESCRIPTOR     Data descriptor information (Scan based)
DATA_HEADER    Data header information (Record based)
DATA_RECORD    Data values (Record based)
```

Scan or Record based variables variables refer to the last read scan or record (explicitely by GET/RECORD, or implicitely by PLOT or other commands).

8.33.1 VARIABLES READ_WRITE

```
CLIC\VARIABLES READ_WRITE ON|OFF
```

Input/Output file related variables

```
IN_FILE          Name if input file
OUT_FILE         Name of output file
INBLOC           Block of observation in input file
IDATA            Address od data section in input observation
INSEC            Number of sections in header
INEXT            Next available block in input file
ONEXT            Next available block in output file
IXNUM            Index number of current observation in input file
ISEC [INSEC]     Header sections
ILEN [INSEC]     Length of header section (words)
IADD [INSEC]     Addresses of header sections (words)
IXNEXT           Next available entry in input file index
OXNEXT           Next available entry in output file index
CXNEXT           Next available entry in current index
INWORD           Number of words in current observation
IDATAL           Length (words) of data section
MODIFY           (Logical) data is open for modify
```

```
SHARE          (Logical) Output file is shared
FOUND          Number of observations in current index
IX_NUM [ ]     Observation numbers in input file index
IX_BLOC [ ]    Blocks numbers of observations in input file
OX_NUM [ ]     Observation numbers in output file index
OX_BLOC [ ]    Blocks numbers of observations in output file
CX_NUM [ ]     Observation numbers in current index
CX_BLOC [ ]    Blocks numbers of observations in current index
```

8.33.2 VARIABLES GENERAL

```
                CLIC\VARIABLES GENERAL ON|OFF

       General information related variables
TELESCOPE                Telescope name
NUMBER                   Observation number
VERSION                  Observation version number
DOBS                     Day of observation (internal format)
DATE_OBSERVED            Day of observation (in clear)
DRED                     Day of last reduction (internal format)
DATE_REDUCED             Day of last reduction (in clear)
DATATYPE                 Type of observation (4 for interferometer data)
RQUAL                    Quality of observation (0-9)
QUALITY                  Quality of observation (Excellent, ... Awful)
SCAN                     Scan number
UTOBS                    Time of observation (radians!)
TIME_OBSERVED            Time of observation (hh:mm:ss.ss)
LSTOBS                   Sidereal time of observation (radians)
AZIMUTH                  Azimuth of source direction (radians)
ELEVATION                Elevation of observation (radians)
TIME                     Integration time (minutes)
PROC                     Procedure used (internal format)
PROCEDURE                Procedure used (in clear)
TYP_OFF                  Type of offsets
```

8.33.3 VARIABLES POSITION

```
                CLIC\VARIABLES POSITION ON|OFF

       Source related information
SOURCE                   Source name
LAMBDA                   Source longitude-like coordinate (radians)
BETA                     Source latitude-like coordinate (radians)
OFF_LAMBDA               Offset in lambda (radians)
OFF_BETA                 Offset in beta (radians)
EPOCH                    Epoch of coordinates (if equatorial)
PROJECTION               Projection used for offsets
FOCUS                    Focus position used
FLUX                     Source flux (Jy) for calibrators
```

8.33.4 VARIABLES CONFIG

```
                CLIC\VARIABLES CONFIG ON|OFF

       Array configuration related information
```

```
NANT                    Number of antennas
NBAS                    Number of baselines
HOUR_ANGLE              Hour angle of observation (hours)
STATION [NANT]          Positions of antennas
PHYS_ANT [NANT]         Antenna physical numbers
CORR_INPUT [NANT]       Correlator input connected for each antenna
START_ANTENNA [NBAS]    First antenna of baseline
END_ANTENNA [NBAS]      Second antenna of baseline
BASELINE [3,NBAS]       Coordinates of baselines (meters)
ANTENNA [3,NANT]        Coordinates of antennas (meters)
AXES_OFFSET [NANT]      Offsets of El axis from Az axes (meters)
```

8.33.5 VARIABLES RF_SETUP

```
                CLIC\VARIABLES RF_SETUP ON|OFF

       Receiver related information
LINE                    Line name (in OBS)
FREQUENCY               Rest Frequency (in OBS) (MHz)
ISB                     Side band (1:upper, 2:lower)
LOCK                    Lock
FLO1                    Frequency of First LO (MHz)
FLO2                    Frequency of Second LO (MHz)
FIF1                    First intermediate frequency (MHz)
VELOCITY                Velocity entered in OBS (km/s)
TYPE_VEL                Velocity type
DOPPLER                  Doppler correction factor (v/c)
```

8.33.6 VARIABLES CONTINUUM

```
                CLIC\VARIABLES CONTINUUM ON|OFF

       Continuum correlator related variables
N_SIDEBANDS             Number of present sidebands
N_SUB_BANDS             Number of continuum sub-bands
NCDAT                   Total number of channels (sidebands x subbands)
CRCH [2]                Reference channel for sideband
CVOFF [2]               Velocity for sideband
CVRES [2]               Velocity resolution
CRFOFF [2]              Rest frequency (MHz)
CRFRES [2]              Frequency resolution
CNAM_U                  Line name for Upper side band
CNAM_L                  Line name for lower side band
CFLO3 [10]              LO3 frequency for subband
CFWID [10]              Width of subband (MHz)
```

8.33.7 VARIABLES LINE

```
            CLIC\VARIABLES LINE ON|OFF

           Spectral correlator related information
N_LINE_BANDS            Number of line subbands
FOURIER                 (Logical) FFT done, data in frequency space
TOTAL_CHANNELS          Total number of line channels
N_CHANNELS [nsubband]          Number of channels in subband
```

```
  FIRST_CHANNEL [nsubband]        First channel in subband
  LFCEN [nsubband]                 LO3 frequency (channel 1)
  LFRES [nsubband]                 Frequency resolution (signed)
  REF_CHANNEL [2,nsubband]        Reference channel for spectrum
  F_RESOLUTION [2,nsubband]       Frequency resolution
  F_OFFSET [2,nsubband]           Rest frequency in reference channel
  V_RESOLUTION [2,nsubband]       Velocity resolution
  V_OFFSET [2,nsubband]           Velocity in reference channel
  R_LILEVU [nsubband,nant] Sampling levels (USB)
  R_LILEVL [nsubband,nant] Sampling levels (LSB)
```

8.33.8 VARIABLES SCANNING

```
                CLIC\VARIABLES SCANNING ON|OFF

       Special scans (Pointing, Focus, Calibrate and Skydip)
  SCAN_TYPE                Type of special scan (1 focus 2,3 point
                             4,5 calibr)
  MOBIL [NANT]             Antennas in motion
  COLL_AZ [NANT]           Collimation in azimuth (arc sec)
  COLL_EL [NANT]           Collimation in elevation (arc sec)
COR_FOC [NANT]           The Z focus correction in mm.
```

8.33.9 VARIABLES ATMOSPHERE

```
                CLIC\VARIABLES ATMOSPHERE ON|OFF

       Atmospheric calibration
  PRESSURE                 Pressure in hectopascals (zero alt.)
  AMBIANT_T                Outside temperature (K)
  ALTITUDE                 Altitude in kilometers
  HUMIDITY                 Humidity in %
  WATER [NANT]             Water content (mm)
  TAU_S [NANT]             Optical depth in signal side band
  TATM_S [NANT]            Temperature of atmosphere in signal side band
  TAU_I [NANT]             Optical depth in image side band
  TATM_I [NANT]            Temperature of atmosphere in image side band
  BEAM_EFF [NANT]          Beam efficiency
  FORWARD_EFF [NANT]       Forward efficiency
  T_CHOPPER [NANT]         Temperature of ambiant load (K)
  T_REC [NANT]             Receiver temperature (K)
  GAIN_IMAGE [NANT]        Gain ratio image/signal
  CHOPPER_COUNTS [NANT]    Measured counts on ambiant load
  SKY_COUNTS [NANT]        Measured counts on sky
  T_SYS_S [NANT]           System temperature (signal band)
  T_SYS_I [NANT]           System temperature (image band)
  CHOPPER_EFF [NANT]       Chopper efficiency
  CAL_MODE [NANT]          Calibration reduction mode
```

8.33.10 VARIABLES DESCRIPTOR

```
                CLIC\VARIABLES DESCRIPTOR ON|OFF

       Data descriptor information
  N_DUMPS                  Number of records
```

```
HEADER_LENGTH           Length of data header (words)
CONT_LENGTH             Length of continuum data (words)
LINE_LENGTH             Length of line data (words)
```

8.33.11 VARIABLES DATA_HEADER

```
CLIC\VARIABLES DATA_HEADER ON|OFF
```

```
       Data header information
DH_DUMP                 Record number
DH_OBS                  Date of observation (in internal format)
DH_DATE                 Date of observation (in clear)
DH_INTEG                Integration time in seconds
DH_SVEC[3]              EQ coordinates of source direction
DH_AFLAG [NANT]         Antenna flag word
DH_TOTAL [NANT]         Total power
DH_DELCON [NANT]        Delay used for continuum correlator (ns)
DH_DELLIN [NANT]        Delay used for line correlator (ns)
DH_DELAYC [NANT]        Computed delay (ns)
DH_DELAY [NANT]         Delay offset (ns)
DH_PHASEC [NANT]        Computed LO1 phase
DH_PHASE [NANT]         LO1 Phase offset
DH_RATE [NANT]          Computed fringe rate
DH_CABLE [NANT]         Phase of IF cable (at LO2 frequency)
DH_OFFFOC [NANT]        Focus offset (mm)
DH_OFFLAM [NANT]        Azimuth offset (arc sec) in pointing scans
DH_OFFBET [NANT]        Elevation offset (arc sec) in pointing scans
DH_UVM [2,NBAS]         U and V for baseline (meters)
DH_RMSPE [2,NANT]       AZ and EL pointing errors (rms, in arc sec.)
DH_UTC                  UT Time (sec)
DH_TIME                 UT Time (hh:mm:ss.ss)
DH_ATFAC [2,NANT]       Atmosphecic calibration factor (K)
                          [sideband,ant]
DH_BFLAG [NBAS]         Baseline Flag word
DH_INFAC [2,2,NBAS]     Instrumental factor
                          [real/imag,upp/lower,baseline]
```

8.33.12 VARIABLES DATA_RECORD

```
CLIC\VARIABLES DATA_RECORD ON|OFF
```

Data values DATA_C [CONT_LENGTH] Continuum data DATA_L [LINE_LENGTH] Line data The following additional variables are computed by command MINMAX:

```
C_AMPMAX_U [NBAS]       Maximum amplitude, continuum, USB
L_AMPMAX_U [NBAS]       Maximum amplitude, line, USB
C_AMPMAX_L [NBAS]       Maximum amplitude, continuum, LSB
L_AMPMAX_L [NBAS]       Maximum amplitude, line, LSB
C_AMPMIN_U [NBAS]       Minimum amplitude, continuum, USB
L_AMPMIN_U [NBAS]       Minimum amplitude, line, USB
C_AMPMIN_L [NBAS]       Minimum amplitude, continuum, LSB
L_AMPMIN_L [NBAS]       Minimum amplitude, line, LSB
```

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