CLIC
Continuum and Line Interferometer Calibration

V. Piétu[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.

Contents

1 Introduction

CLIC is a software developped at IRAM to support the calibration of the data from the NOEMA interferometer. It stands for Continuum and Line Interferometric Calibration and is part of the GILDAS package. We refer to the GILDAS documentation for further information on the GILDAS software. CLIC uses code from the so-called GILDAS kernel like SIC for command interpretation or GREG for the plots. It also uses routines from ASTRO to do astronomical computations. CLIC uses a specific binary format for data files (see section 3) produced at the NOEMA observatory by an online reduction software called RDI, that itself uses the CLIC libraries (for data writing, atmospheric calibration, pointing and focus solving, etc.).

CLIC is also adapted to the NOEMA observatory in terms of commands. It provides the tools to do the required calibrations using the NOEMA nomenclature (for example, the presence of a noise source at NOEMA allows to align all spectral windows connected to a baseband in amplitude and phase, so the passband calibration is then done per baseband and applies to all the spectral windows that pertain to that baseband).

As part of the ALMA project, CLIC has been used to assess the performances of the ALMA antennas through holographies. A branch of CLIC has then been ported to TELCAL, the online calibration software of ALMA. This activity has led to the development of import capabilities, first as TI-FITS, then as ASDM. While these capabilities are deprecated using IRAM HEAD version, branches of CLIC are still used to reduce holographies for ALMA as previously mentioned and for the Yebes 40m telescope (using TI-FITS). IRAM has also developped a package, called MRTHOLO, that process IMB-FITS from the 30m telescope and produces IPB file, for reduction of 30m holographies within CLIC .

The output files after calibration are uv tables, in the GILDAS data format (GDF). Export possibilities are provided throuhg UV-FITS (see MAPPING documentation).

This document describe first how CLIC files are organized, then describes the commands. The details of NOEMA data calibration are left to the documentation of the pipeline.

The appendix contains the online help of CLIC .

2 Formalism

2.1 Nomenclature

For NOEMA, we follow the nomenclature defined in the document "Frequency Band Naming Convention".

The receiver transforms and filters the input RF signals. Its output consists of one or more intermediate frequency bands, that we call IFs. These IFs are eventually then further processed by an IF processor that does another round of transformation and filtering bringing the signal to baseband for further use downstream. That input to the correlator is what we call baseband in this document and in `CLIC` . The correlator then processes the baseband in one or more spectral windows, that are a continuous set of adjacent channels sharing a correlator mode (including channel spacing). A given data set may hold spectral windows with different channel spacing though.

2.2 Frequency and time

2.2.1 Calibration

The goal of the calibration is to estimate and correct for the instrumental gain in order to have an unbiased estimate of the true visibilities. We use a simplified version of the radio-interferometry measurement equation. The (complex) visibility $\widetilde{V}_{ijk}$ measured on the baseline from antenna i to antenna j at frequency channel k is related to the true object visibility V_{ij} by

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

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 $b_{ijk}(t)$.

2.2.2 Frequency dependance

$b_{ijk}(t)$ is the bandpass of the detection system, and is usually almost constant with time. It can be formally decomposed as 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).

2.2.3 Time dependance

For $g_i(t)$, we must separate the calibration of amplitude and phases since amplitude and phase errors have very different origins. The amplitude corrections are 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.

2.3 Noise

2.3.1 Temperatures

The power P_a received by an antenna in a bandwidth $\delta\nu$ is conveniently expressed in term of **antenna temperature,** T_a, which is the temperature for which an equivalent resistor would give the same power P_a, following the Nyquist noise formula:

$$P_a = kT_a\delta\nu \tag{2}$$

As the quantity T_a is affected by the atmospheric absorption $e^{-\tau_{atm}}$ and the antenna foward coupling factor η_f, we define the quantity T_a^* through:

$$T_a^* = \frac{(1+g_{im})}{\eta_f} e^{\tau_{atm}} T_a \tag{3}$$

The $(1+g_{im})$, where g_{im} is the image band rejection factor, accounts for a single sideband signal.

Brightness temperature, T_b, is the Rayleigh-Jeans temperature T_b of an equivalent black-body which would give the same power per unit area per unit frequency and per unit solid angle I_ν as the celestial source:

$$T_b = \frac{c^2}{2k\nu^2} I_\nu \tag{4}$$

For a resolved source, the antenna temperature is equal to the sky brightness temperature. For an unresolved source, the coupling between antenna temperature T_a^* and source flux density $S_\nu$is:

$$T_a^* = \frac{\eta_a A}{2k} S_\nu = \frac{1}{J} S_\nu \tag{5}$$

where $J = \frac{2k}{\eta_a A}$ is the antenna efficiency.

The **noise temperature** is the sum of the various noise contributions:

$$T_{noise} = T_{bg} + T_{sky} + T_{spill} + T_{rec} \tag{6}$$

where T_{bg} is the cosmic background, T_{sky} is the sky noise, T_{spill} is the ground noise pickup and T_{rec} is the receiver noise temperature. The forward efficiency η_f is a property of the antenna that indicates how much coupling there is in the forward hemisphere with respect to the full 4π sphere. With an atmosphere at a physical tempeture T_{atm} and with an opacity τ_{atm} at the observed frequency, the sky noise and ground pickup temperature are expressed as:

$$T_{sky} = \eta_f(1-e^{-\tau_{atm}})T_{atm} \tag{7}$$

$$T_{spill} = (1-\eta_f)T_{ground} \tag{8}$$

T_{sys} is the **system temperature**, the noise equivalent temperature T_{noise} of the receiving chain refered to a perfect antenna located outside the atmosphere and for a single sideband signal:

$$T_{sys} = \frac{1+g_{im}}{\eta_f} e^{\tau_{atm}} T_{noise} \tag{9}$$

2.3.2 Radiometric equation

The radiometric equation (eq. 11) gives the thermal noise σ as a function of observing bandwidth $\delta\nu$, integration time δt, for an array with n antennas, where A is the geometric surface of an antenna and η_a is the aperture efficiency. It also depends on the correlator efficiency η_q and the phase decorrelation factor η_p.

For a baseline, we have the following noise equation:

$$\sigma = \frac{1}{\eta_q\eta_p} \frac{\sqrt{2}k}{\eta_a A} \frac{T_{sys}}{\sqrt{\delta\nu\delta t}} \tag{10}$$

The array point source sensitivity is given by:

$$\sigma = \frac{1}{\eta_q\eta_p} \frac{2k}{\eta_a A} \frac{T_{sys}}{\sqrt{n(n-1)\delta\nu\delta t}} \tag{11}$$

2.3.3 Weights

As usual, the weights W_{ij} associated to a visibility V_{ij} are defined to be: [1]

$$W_{ij} = \frac{1}{\sigma_{ij}^2} \tag{12}$$

2.4 Amplitude and phase

The visibilities are complex numbers, whose real and imaginary parts are measured in the correlator. However, since amplitude and phase distortions have different physical origin, and that amplitude and phase errors have quite distincts consequences in the image plane, one often decomposes the visibilities in amplitude and phase following:

$$V_{ij}(t) = a_{ij}(t)e^{i\varphi_{ij}(t)} \tag{13}$$

2.4.1 Closure relationships

It follows that if the gains are antenna based like in equation 1, we have the following closure relationships:

$$\begin{aligned} \widetilde{\varphi}_{ij} + \widetilde{\varphi}_{jk} - \widetilde{\varphi}_{ik} &= \varphi_{ij} + \varphi_{jk} - \varphi_{ik} && (14) \\ \frac{\widetilde{a}_{ij}\widetilde{a}_{kl}}{\widetilde{a}_{ik}\widetilde{a}_{jl}} &= \frac{a_{ij}a_{kl}}{a_{ik}a_{jl}} && (15) \end{aligned}$$

2.4.2 Statistics

It is worth noting that while the noise in the real and imaginary parts of the visibilities follows gaussian statistics, with a null expected value, the amplitude and phase do not, especially at low signal-to-noise. The amplitude in particular is by definition positively biased, i.e. has a non-null expected value even in the absence of signal.

Figure 1 shows the probability distribution for the amplitude and real part of the visibilities for various signal-to-noise ratios and compares the expected values for both quantities. Figure 2 shows the probability distribution for the phase. It follows that at low signal-to-noise a detection is more easily seen on the phase than on the amplitude.

2.4.3 Averaging

The averaging of phase flucttutations will produce an amplitude decorrelation. For example, a phase jitter with gaussian noise ϕ will introduce a factor $e^{-\phi^2/2}$ of decorrelation if the real and imaginary parts are averaged (this is the classical definition of complex averages). `CLIC` offers the possibility to do averaging on the real and imaginary part or to average amplitude and phase (see `SET AVERAGING` for more details). In the latter case, the amplitude bias may lead to surprising results in the case of low signal-to-noise. For instance, the amplitude of the low spectral resolution windows may not be the same as the high spectral resolution spectral windows. Note also that if the averaging implies a decorrelation, then baseline based factors are introduced and the closure relationship does not hold anymore for amplitude.

[1] The weights in the GILDAS format `.uvt` tables are computed with a bandwidth in MHz and an antenna efficiency in Jy/K (rest of units are S.I.), so there is a factor 10^6 to be applied to the weights to get $1/\text{Jy}^2$ unit for the weights (or 10^{-3} to the sensitivity to get Jy).

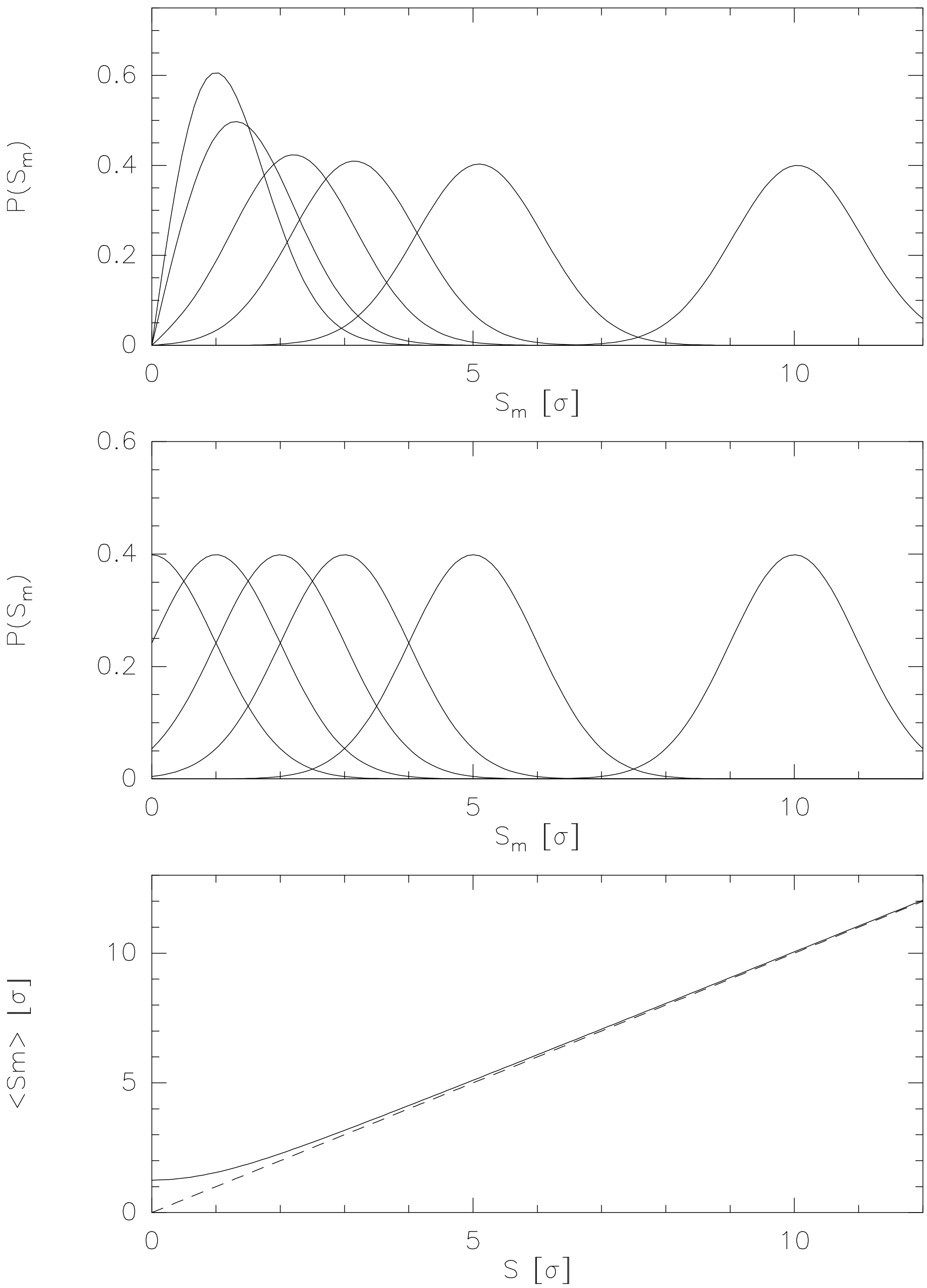

Figure 1: Probability distribution for the amplitude (**Top**) and real part (**Middle**) of the visibilities for various signal-to-noise ratio (0,1,2,3,5,10). Adapted from Wrobel and Walker (1999). **Bottom:** Expected value for the amplitude as a function of signal strength (in unit of σ) for the amplitude (plain curve) and real part (dashed curve).

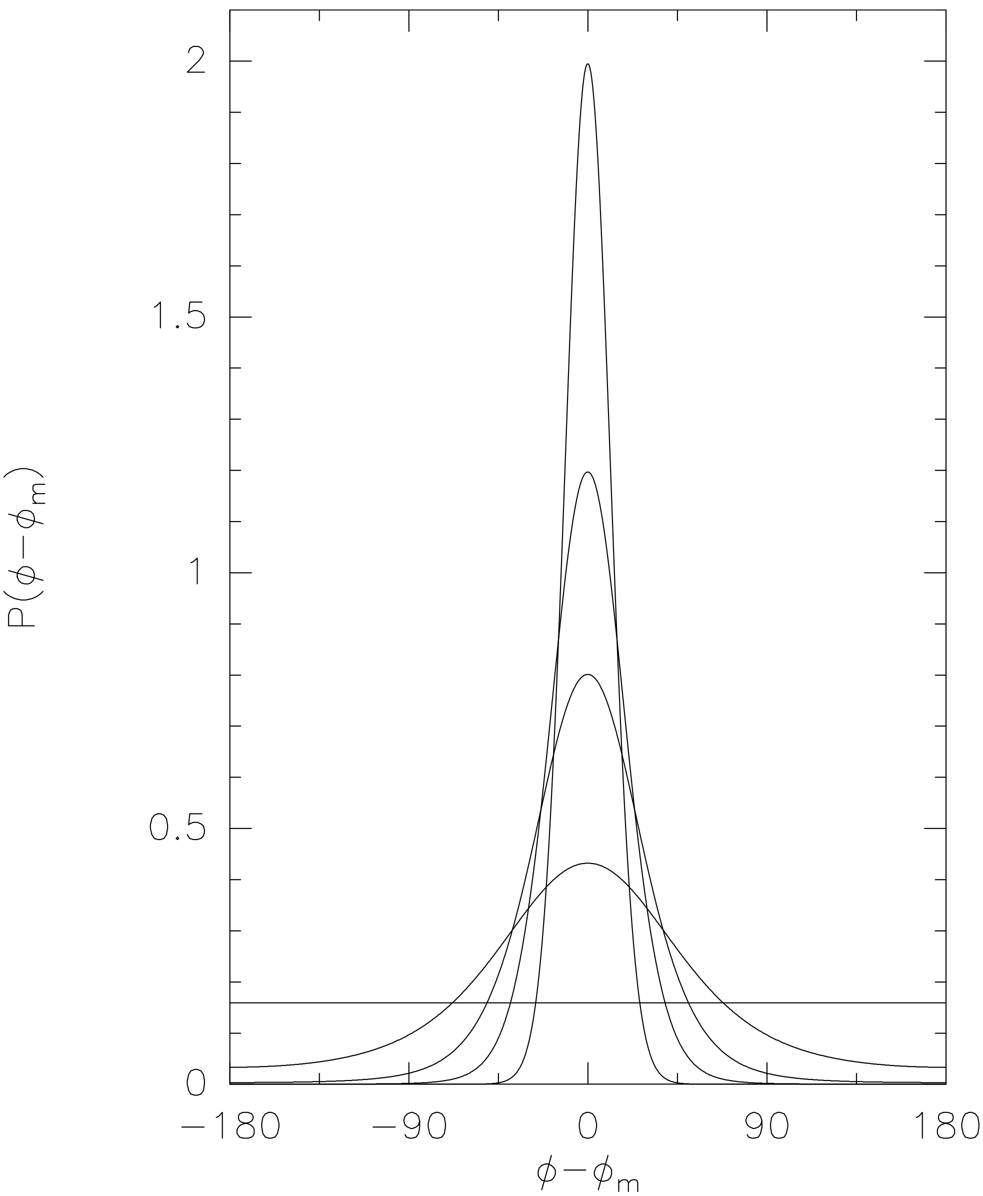

Figure 2: Probability distribution for the phase of the visibilites for various signal-to-noise ratio (0,1,2,3,5). Adapted from Wrobel and Walker (1999).

2.5 Baseline and antennas

In equation 1, the instrumental gain is implicitely described as a product of two antenna gains:

$$G_{ij}(t) = g_i(t) \cdot g_j^*(t) \tag{16}$$

This is usually satisfied, unless averaging in time or frequency introduce a decorrelation. For a point source at the phase center, the true visibilities are constant in the uv plane with value (S,0), where S is the source flux density, so we have a set of equations:

$$\widetilde{V_{ij}} = g_i \cdot g_j^* S \tag{17}$$

or equivalently:

$$\widetilde{\varphi}_{ij} = \phi_j - \phi_i \tag{18}$$

$$\widetilde{a}_{ij} = a_i \cdot a_j \cdot S \tag{19}$$

3 Files

3.1 Principle

The CLIC data format was derived from the CLASS data format, and while there are some specificities unique to CLASS or CLIC , the data format itself is generic enough that in 2013, the low-level routines from both were factorized in a new CLASSIC library. The readers interested in more details are invited to refer to the CLASSIC documentation. In essence, a file is composed of a file header and one or more extension(s). The file header provides information about the file system used to encode the file, so both little endian and big endian are supported. CLASSIC files are fortran direct access, unformated binary files that are accessed record by record. The record length has an impact on the I/O depending on the file system and is stored in the file header. This should be considered for any discussion on performances.

The extensions contain an extension index, and observations. The extension index contains all the observation titles of the observations in the extension. The observation title is composed of 32 4-bytes word (see table 1), allowing a quick search for observations matching any combination of these words without having to read all of the file. Observations are independant and can be read individually, which allows only the desired subset of data to be read. With large datasets of hundreds of gigabytes, it is also important to use memory as efficiently as possible so CLIC uses its own cache. The size of the memory that CLIC has access to is controled by the SPACE_CLIC logical name. It can be set with the command SIC LOGICAL SPACE_CLIC value, with value in MB, unless the unit is specified, e.g. 64GB or a fraction of the RAM size is specified, e.g. 50%. The ideal situation is when the value accessible to CLIC is larger than the size of the raw data file (which is another reason to have as compact as possible the files). This is typically the case on the data reduction machines available at IRAM. This reduces the I/O to reading the file once and writing a few calibrations, before producing large uv tables.

3.2 Index

The index containing the title of all the observations in an input file is read when the file is opened. Starting with the use of CLASSIC , and to allow files with a larger number of observations or records, the version 2 of files uses 8-bytes integers wherever needed. In addition, with version 2, observations do not have to start at the beginning of a record, so no space is left blank in the file. Table 1 describes the content of an observation title.

3.3 Observations

The observations themselves contain the data but also all the metadata associated with the observations. The observation is hence composed of an observation header and data.

3.3.1 Observation Header

In the observation header, a number of sections can be stored. Table 2 displays the list of sections known to CLIC and whether they are present in hpb and IPB files.

3.3.2 Data: dumps

At NOEMA, the correlator outputs a spectrum every second. Storing the spectra every second would result in an huge file. In practice one can average the spectrum to the limit that it does not produce unacceptable beam smearing. Depending on the desired field of view, observing

Word	Starting word	Length	type	unit	comment
bloc	1	2	INTEGER*8	[records]	record number of entry start
word	3	1	INTEGER*4	[4-bytes]	offset in words in record
ver	4	1	INTEGER*4		version of the observation
num	5	2	INTEGER*8		observation number
sourc	7	3	INTEGER*4(3)		source name
line	10	3	INTEGER*4(3)		tuning name
teles	13	3	INTEGER*4(3)		interferometer configuration
dobs	16	1	INTEGER*4	[days]	classic date of observation
dred	17	1	INTEGER*4	[days]	classic date of reduction
off1	18	1	REAL*4	[radian]	lambda offset
off2	19	1	REAL*4	[radian]	beta offset
typec	20	1	INTEGER*4		type of coordinates
kind	21	1	INTEGER*4		data kind
qual	22	1	INTEGER*4		data quality
scan	23	1	INTEGER*4		scan number
proc	24	1	INTEGER*4		procedure type
itype	25	1	INTEGER*4		observation type
houra	26	1	REAL*4	[radian]	jour angle
project	27	2	INTEGER*4(2)		project name
bpc	29	1	INTEGER*4		baseline bandpass cal status
ic	30	1	INTEGER*4		instrumental cal status
recei	31	1	INTEGER*4		receiver band number
ut	32	1	REAL*4	[s]	UT time

Table 1: Version 2 of observation title.

frequency and interferometer configuration, the acceptable averaging time ranges from a few seconds to a few minutes. Two kind of averages are stored in the data. First, every second, a spectral average is produced for each spectral window, resulting in a data point every second. These are refered to as the continuum dumps. Then, for each integration time, two spectra are produced for each spectral window: one is the average of all the spectra obtained within the integration window, the second is the same, but the spectra are corrected for an atmospheric phase before integration. The correction is nowadays coming from the water vapor radiometers, but for some time, a correction using the 1mm receiver total power was also used. These constitutes the line data.

An observation is hence usually composed of $n + 2$ dumps, where n is the integration time in seconds. The first n dumps contain only continuuum data, the last two dumps contain both continuum and line data, for the uncorrected and phase-corrected spectra respectively.

3.3.3 The content of a dump

A dump contains a data header (called DAPS, Data Associated ParametersS, in `CLASS`) and the data themselves. The data header is used to store metadata that vary on the second basis (in opposition to metadata stored in the observation header), such as the uv coordinates, wvr counts, cable phase, etc. It is important to note that the data flags are stored in the data header. The continuum data are then stored along the axis $(spectralwindow, sideband, baseline)$. Optionally

Name	Code	IPB	hpb
General	-2	x	x
Position	-3	x	x
Interferometer	-21	x	x
RF Frequency setup	-22	x	x
Continuum setup	-23	x	x
Line setup	-24	x	x
Scanning parameters	-25	x	x
Atmospheric parameters	-26	x	x
Antenna Passband Cal	-27		x
Baseline Passband Cal	-28		(x)
Instrumental Cal.	-29		(x)
Data descriptor	-30	x	x
Antenna instrumental Cal	-31		x
Atmospheric monitoring	-32	x	x
Data modifiers	-33		x
Raw data file	-34		x
WVR parameters	-35	x	x
ALMA	-36		
Instrument monitoring	-37	x	x

Table 2: `CLIC` sections, code and presence in hpb and IPB files.

(see above), line data are then stored along the axis (*channel*, *sideband*, *baseline*), with spectral windows all stitched together in the *channel* axis.

3.3.4 Scans

As can be seen, `CLIC` understands data dumps and observations. The concept of a scan is a collection of observations (possibly only one) that share an observing intent and have the same scan number. For example, a `CALIBRATE COLD` scan consists of three observations: one on the cold load, one on the hot load and one on the sky.

3.4 IPB file

At NOEMA, `RDI` produces IPB (which stands for Interféromètre du Plateau de Bure) files, one for each track. A track consists of observations of one scientific subproject and last a few hours (typically two to ten hours). The IPB file produced at NOEMA contain sections (-2,-3,-21,-22,-23,-24,-25,-26,-30,-32,-35,-37) and of course the raw data themselves. Following the online atmospheric calibration, data are on a temperature scale in T_a^* (i.e. the coupling factor considered in the atmospheric calibration is the forward efficiency). Contrary to single dish, one does not need to worry about the temperature scale as after amplitude calibration, the visibilities are in Jy. These files are stored in the NOEMA archive and can be accessed from IRAM computers using the `getproj` command.

3.5 hpb file

However, the calibration is not done directly on the IPB files, which, in principle, are never updated offline. Instead, `CLIC` normally works on header files, or hpb files. Before one starts the calibration, the observation headers from the IPB file are copied into the hpb file, and calibration sections are added in the header for later use. The default is to add only the antenna calibration sections, because the instrumental calibrations are usually done per antenna and the baseline sections are much bigger in size. However, one can also create an hpb file with baseline sections if needed (see also table 2).

Besides the calibration sections, designed to store the amplitude/phase gain solutions as a function of time or frequency, two sections are mandatory in the hpb file: the data file section and the data modifier section. The data file section contains the name of the IPB file from which the data were copied and the index number of that observation in the IPB file. The data modifier section contain parameters which modify the data after they are read from the IPB file. This allows to correct the data for e.g. new baselines measurements (see section 4.7 for more details) without modifying the IPB file. This section also contains a flags structure similar to the one in the IPB file. `CLIC` considers the logical .or. of the two flags structure when an hpb file is opened.

After the calibration is complete, one just needs to save the hpb file (and the uv table for analysis) and the IPB file can be deleted. If there is a new need to redo part of the calibration or produce new uv tables one just has to download again the IPB file. Note that any access to the data requires the IPB file to be present on the file system in any of the `IPB_DATA1:` to `IPB_DATA9` logical names containing directories.

3.6 Backward compatibility

NOEMA, previously Plateau de Bure Interferometer (PdBI), has seen continous improvements since its start, with more than five generations of receivers and correlators along with the development of atmospheric phase correction techniques. Given the nature of the `CLIC` data file, this was associated with many, sometimes small, changes of the data format. `CLIC` is designed so that its latest version can read and process any version of the data format and map it in memory to the latest data format. Data of any date can hence be processed with the latest `CLIC` version. Note that writing the data is always done with the latest data format (except if one updates an observation, i.e. modify an existing .hpb file). In practice, the data format used the section length (stored in the file) to see whether there were extensions to a section. With the introduction of `CLASSIC` , a version number is stored with the observation.

4 Commands

In this section, I quickly introduce the commands, in a ordered way to illustrate the `CLIC` philosophy. For more complete information, the reader is directed to the commands `HELP` . The details of the data calibration strategy are refered to the pipeline documentation.

4.1 File

`CLIC` handles primarily two files:

- an input file
- an output file

In case the input file is an hpb file, a third file, the raw data file is also handled by `CLIC` , to be used when data are to be read.

4.1.1 FILE

Command `FILE IN|OUT|BOTH` selects the file to be opened for input/output. These commands also read the input or output file index, and copy a subset of it in memory so that subsequent index searches can proceed even more efficiently. The logic is the same as `CLASS` . If the argument `BOTH` is used, the same file is opened for input and output. Internally, `CLIC` deals with two write mode for files: `NEW` and `UPDATE`. The logic is that if the input file and output file are different, the output file is in `NEW` mode, whereas if the same file is opened for input and output, the output file is in `UPDATE` mode.

The files opened for input and output are displayed with `SHOW FILE`.

4.1.2 COPY

Command `COPY` will copy the observations in the current index (see section 4.2) to the output file. Either the observations header only or the full observation is copied according to command options. In the same vein, the baseline and antenna calibration sections can be included or not, as the bandpass calibration section(s). This choice is to be made at the time of `COPY`, since space has to be reserved for such sections which are updated later in the calibration process.

4.1.3 NEW_DATA

Command `NEW_DATA` waits until new data is written to the input file, then builds a new current index with all the new data. Mainly useful at the observatory.

4.2 Index

In this section, I introduce the commands used to build and manipulate a current index. `CLIC` has a notion of three indexes: an input file index, an output file index and a current index. Practically all `CLIC` commands work on the current index. A notable exception is `FIND` that works on the input index for obvious reasons.

4.2.1 FIND

Command `FIND` will search the input file according to some selection criteria, either specified as command options or set with the `SET` command. The current index will be ordered according to the sorting criteria, set with `SET SORT` command. Some options allows the input file to be updated before the search or to append the results to a previous current index. `FIND` will update the `SIC` variables `FOUND` that gives the number of observations found and `CX_NUM[:]`, a list containing the observation numbers of the current index. These can be used in procedures, as is the case of the pipeline scripts.

4.2.2 LIST

Command `LIST` will list the content of the current index. `LIST IN` or `LIST OUT` list the content of the input or output index. Various options are available to list some specific information or with some formatting. Some options create `SIC` variables: `/SOURCE, /PROJECT, /TELESCOPE` and `/OFFSET`. These variables contain the number of respective items and their values (see the `HELP`).

4.2.3 IGNORE

Command `IGNORE` can be used to declare a list of observations to be ignored in `FIND` commands until a new `FILE IN` command has been typed.

4.2.4 DROP

Command `DROP` can be used to remove an observation from the current index.

4.3 Observation

In this section, I introduce the commands to access the observation. `CLIC` knows only one observation at a time, the current observation. The other observations already read are kept in memory so subsequent calls do not have to read again the corresponding records. The limit to that scheme is the amount of memory. In case, not enough memory is available to get an new observation, `CLIC` will remove the oldest observations in the cache until sufficient room is found.

4.3.1 GET

The main command, if one wants to read an observation is `GET`. One can either get a specific observation in the current header by providing its observation number (number in the left column of a `LIST` output), or go sequentially through the current index with `GET NEXT`. This will read the data and update the current observation.

4.3.2 HEADER

Command `HEADER` displays in the terminal the content of the observation header in a short format. Useful options are `/PLOT` which will produce a plot of the spectral setup similar to what is done in `ASTRO` (see Fig. 3) and /LIST that will list the spectral windows.

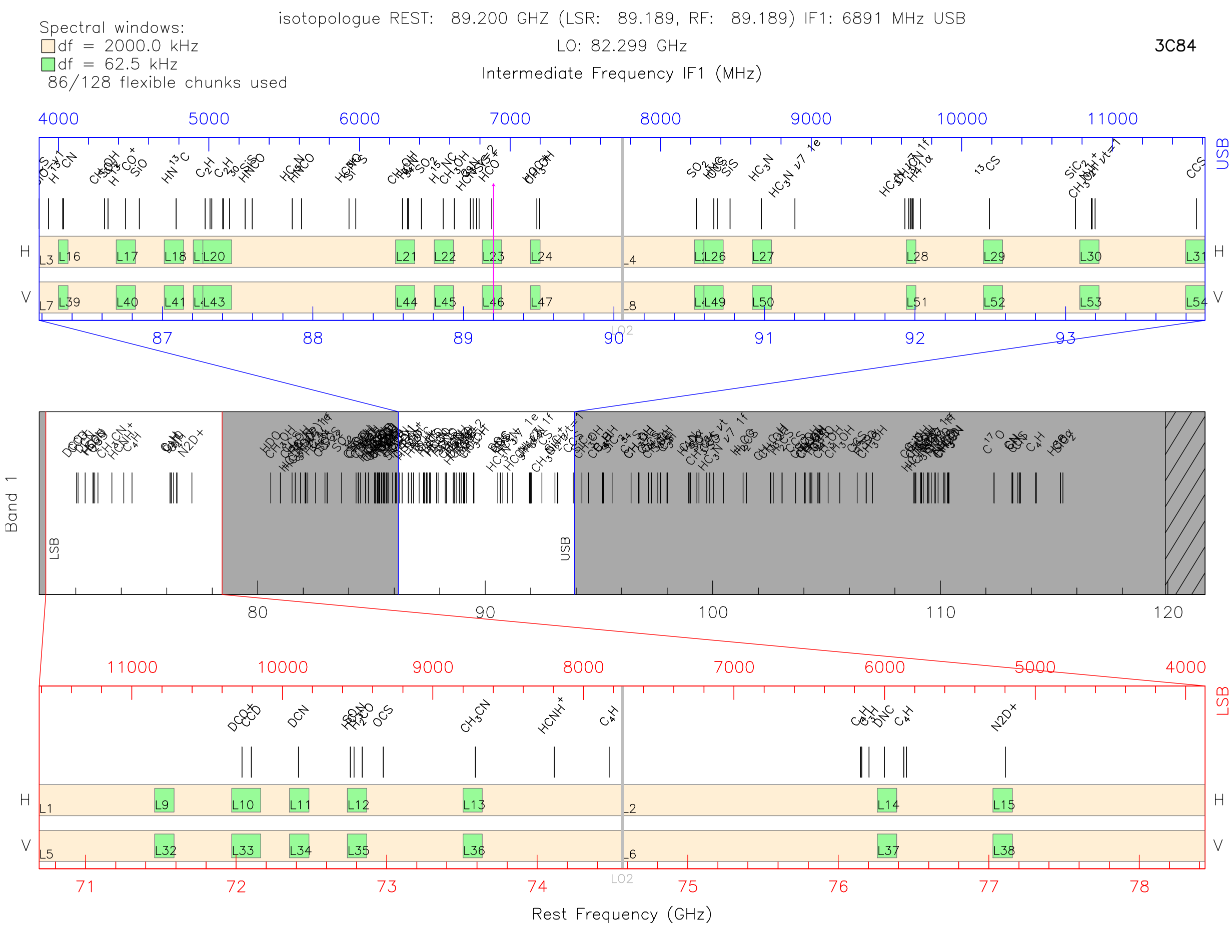

Figure 3: Spectral setup plot produced by `HEADER PLOT` command.

4.3.3 VARIABLE

Command `VARIABLE` creates various `SIC` variables mapping the observation and data headers (see corresponding `HELP` for more details). This allows use in procedures and also to modify some value in the header or data file with the `MODIFY` command. Be very cautious in doing so, because some parameters have to be modified consistently.

4.4 Plotting

This section describes one of the basic functionnality of `CLIC` , its plotting capability, which is a 2 dimensional plot (abcissa and ordinate).

4.4.1 Plot selection

Plotting in `CLIC` is mainly controled by two criteria:

- `SET X` and `SET Y`, this allows you to choose whose quantity to plot. Several X or Y may be set.
- data selection. The selected data is the intersection of the data meeting 3 selection criteria:
  - antenna or baseline,
  - sideband
  - any of the baseband, IF, spectral window or polarisation criteria.

The plot can be either a time or spectral plot, i.e. X data have to be only spectral-like or time-like quantities. The user can provide limits with `/LIMIT` option. Code `"*"` and `"="` may be used. The former means that the limits are automatically adjusted to the data separately in each box, `"="` means that common limits to all boxes are computed.

4.4.2 Data selection

`CLIC` will draw one box for each x,y,antenna (or baseline), sideband, baseband or IF or spectral window or polarisation. Each criteria can be used to define a group or many groups of a value. For example `SET BBAND 1 TO 2` will create one baseband group containg basebands 1 and 2. `SET BBAND 1 2 TO 4 5 AND 6 AND 8` will create 3 basebands groups containing baseband 1, basebands 2, 3, and 4, and basebands 5, 6 and 8. A box will be created for each antenna or baseline, sideband and each of the 3 groups.

`SET ANTENNA` or `SET BASELINE` may be used to specify whether to plot per antenna or per baseline and can be used to plot only a subset of what is in the file. The corresponding antenna or baseline is shown in the left box header of the box (red rectangle number 1 in Fig. 4)

`SET SIDEBAND` is used to control which sidebands to plot. The corresponding sideband is shown in the right header of the box (red rectangle number 3 in Fig. 4).

`SET BBAND, IF, SPW, POL` are used to control how the data are selected. Selecting according to any of these criteria will also select the corresponding control parameter. For example `SET BB 1` will automatically select the corresponding IF, spectral windows and polarisation. The corresponding value is shown in the central header of the box (red rectangle number 2 in Fig. 4).

Both metadata and data can be plotted. The metadata may have a physical origin at a specific point in the signal transport or the hardware, hence have a natural dependency on baseband, IF, or spectral window, so will be selected according to that criteria, and averaged if the group has more than one value.

For data, there are both "continuum" and "line" data in the IPB files (see section 3.3.2). Depending on how the spectral windows are selected, continuum (`SET SPW C1`) or line (`SET SPW L1`) will be used. In case the line data are used, the selection of the phase-corrected spectral dump or uncorrected spectral dump (both are stored in the IPB file) is done according to the `SET PHASE ATM|NOATM` selection. The actual use of phase-corrected data is also conditionned by the validity of the phase correction, which is normally checked on the nearest calibrator. For the phase-corrected to be selected on a baseline requires a valid correction for both antennas.

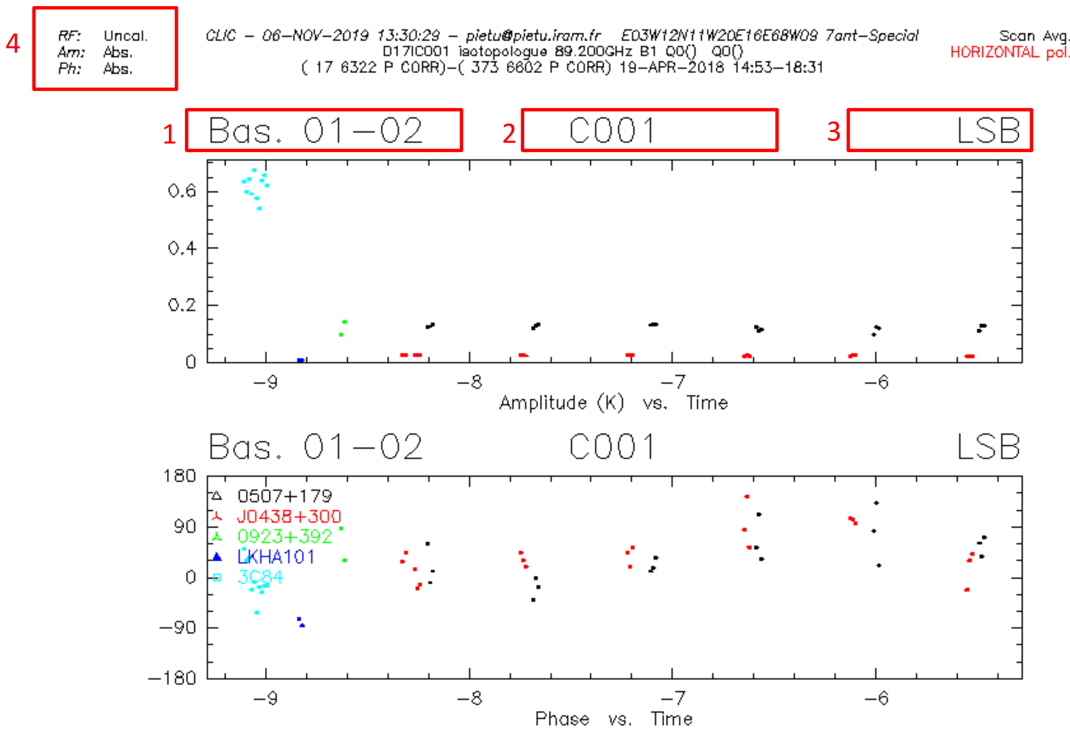

Figure 4: Example of `CLIC` plot. The red rectangles are not part of the original plot and were added to ease identification.

4.4.3 Averaging

The data are averaged in time according to the `SET AVERAGING` command. It is possible to average by scan or time. In addition, this command also controls if the data are averaged as complex numbers (`VECTOR`) or if amplitude and phase are averaged separately (`SCALAR`). Be cautious about the amplitude bias especially in spectral plots where the much lower bandwidth of channels can bring the signal to noise to low values even on calibrators (see section 2.4.2 and 2.4.3).

In addition to and after the time averaging, the data in the plot may be averaged in bins of the x coordinates with the command `SET BINNING`. It is useful to average data in spectral mode. Any `SET X` command resets the binning.

4.4.4 Calibration

Calibration may be applied on the fly before plotting. This is controlled by the following commands (see respective help for more information):

- `SET PHASE RELATIVE|ABSOLUTE`
- `SET AMPLITUDE RELATIVE|ABSOLUTE`: see also Table 3

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

Table 3: Scaling of amplitude depending on unit/mode. J_i is the antenna efficiency in (Jy/K), A_{ij} is the amplitude calibration factor (in K/Jy) and S the source flux (in Jy)

- `SET RF ON|OFF`

The control parameters for calibration are displayed in the left header of the plot (red rectangle number 4 in Fig. 4). Each calibration solution can be antenna or baseline based (provided a solution was computed and stored beforehand, see section 4.5 and 4.6).

4.4.5 PLOT

The plot itself is done with command `PLOT`. Many options are available and the reader is invited to refer to the `HELP` for more details. One handy option is the `/BOX nx ny` that tells `CLIC` to use nx times ny boxes. One can provide code "*" for one of the arguments so that only the number of rows or columns is set.

Another interesting feature of plot is that the content of the plot buffer is available in `SIC` variables: `X_DATA, Y_DATA` and `W_DATA` containing respectively the X values, the Y values and the weights associated to each data point. These values can be used in procedures to do your own computations.

Two options further enrich the possibilities:

- `PLOT /NODRAW` will only update the plot buffers but will not produce a plot
- `PLOT /SAME` will not read data but use the plot buffers to do a plot

Hence one can modify the content of the plot buffers before plotting them.

Another useful option is `/NOFRAME`, that allow to not reset the plot before doing it, which in effect allows to overplot some another set of data on top of a previous plot (with another color if wanted).

4.4.6 CURSOR

Command `CURSOR` calls an interactive cursor, mainly aimed at pinpointing data points and measuring their coordinates. It can also be used for editing although this is not the recommanded way of editing data. See corresponding `HELP` .

4.4.7 BLANK

Command `BLANK` can be used to blank some channels in a given spectral window. Corresponding data will not be displayed (`Y_DATA` value equal to the blanking value, `W_DATA` equal to 0).

4.4.8 Flags

4.5 Solving

In this section, I describe or shortly introduce the SOLVE engines that are available in `CLIC` . I start with the command used in any pipeline reduction, then introduce the commands used for real-time observations or observatory measurements.

4.5.1 SOLVE RF

Command `SOLVE RF` will solve for the spectral variation of the gain. As for the temporal variations, one can either solve for the baseline gain $B_{,ijk}$, or the antenna gains, b_{ik}, with $B_{ijk} = b_{ik}b^*_{jk}$ according to the mode selected with `SET RF ANTENNA|BASELINE`.

To get sufficient signal to noise in each channel, specific observations of a bright source are normally carried out in each project. There are basically two modes for solving RF bandpass. One can either fit a Chebishev polynomial to the data (low signal to noise ratio) or use the data (or a smoothed version of the data) as the RF solution. In the latter case, the actual solution is linearly interpolated between data points. The mode used is controlled by the command `SET RF FREQUENCY|SPECTRUM.`

RF bandpass calibration is done baseband per baseband (see section 2.1). It is hence necessary to select a proper baseband with `SET BBAND` command before solving for the RF. The solution is computed in an intermediate frequency space adapted to each generation of signal transport, selected with `SET X I_F`.

4.5.2 SOLVE FLUX

Command `SOLVE FLUX` is used to derive the flux of the phase calibrators from a known reference (remember quasar fluxes are variable in time). At NOEMA we have two main flux references: MWC349 and LkHα101. Anyhow, the command is generic, as long as the flux of one of the sources is provided.

Visibilities are expressed on an antenna basis and an antenna efficiency is computed for each antenna by dividing the flux of the reference by the observed antenna temperature. Then a selection of the best antennas (i.e. the ones with the best efficiencies) are used to compute the fluxes of the other sources in the current index using the antenna efficiencies.

This of course will only work if the actual antenna efficiencies are constant in the considered time range (either being good the whole time or, which is more difficult to ensure, being equally bad on all sources).

4.5.3 SOLVE AMP PHASE

Commands `SOLVE AMPLITUDE` and `SOLVE PHASE` are used to derive the temporal variation of the gain through its amplitude and phase separately. One can either solve for the baseline gains $G_{ij}(t)$ or the antenna gains $g_i(t)$ (with $G_{ij}(t) = g_i(t)g^*_j(t)$) according to the mode selected with `SET AMPLITUDE ANTENNA|BASELINE`.

In antenna mode, the averaged phase and amplitude closures and their standard deviation are computed, that allows to check for baseline-based errors, mostly in the form of amplitude decorrelation. The solutions are found by fitting directly the baseline-based quantities with the appropriate antenna-based combination (product of amplitudes, difference of phases).

Amplitude is mainly affected by variations of the antenna gain (pointing errors, defocussing, thermal and/or gravitational deformations), receiver gain and variation in the atmospheric absorption not accounted for in the atmospheric calibration (see sec. 4.8.1) in addition to decorrelation due to phase noise. For amplitude calibration, one should use `SET AMPLITUDE SCALED` prior to the `SOLVE` command so that the amplitude, which is on a temperature scale, is divided by the source flux. If the flux calibration is correct, the different sources should have the same values in K/Jy, which is actually the inverse of the antenna efficiency.

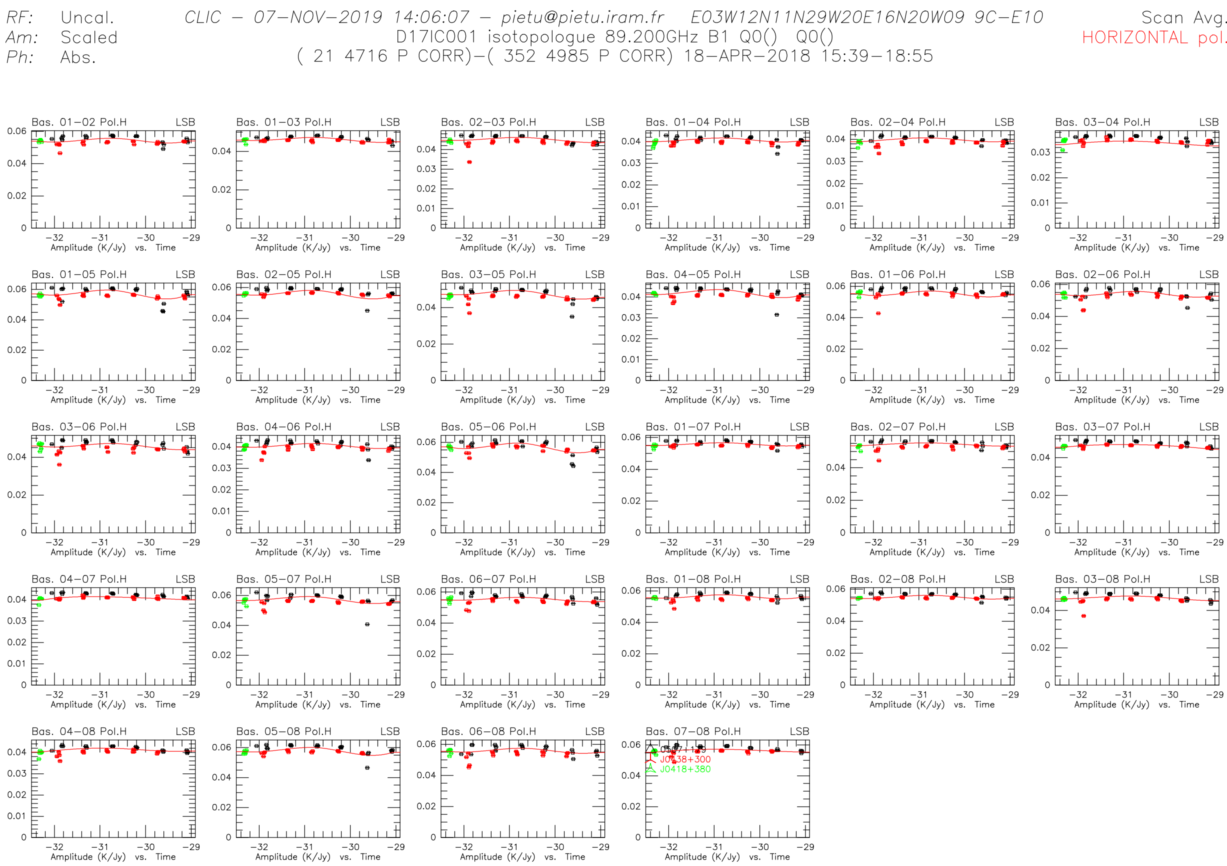

Figure 5: Example of `SOLVE AMPLITUDE /PLOT`.

Phase is affected by delay errors, in the form of baselines or time errors, atmospheric delays or drift in the receiver delay or phase (local oscillators). For the phase in particular, the atmospheric fluctuations introduce changes on a timescale that is usually smaller than the calibration period used for NOEMA. In order not to alias this fast varying component in the calibration, which would increase the final phase noise, it is important to keep in mind that the solution does not need to pass through the data points.

Two mathematical functions can be fitted to the data: cubic splines (the knots spacing is controlled by the `SET STEP` command), which the default, or polynomials through the `/POLYNOM` degree option. It is possible to introduce breaks in the fuction or its derivatives with the `/BREAK` option.

Amplitude and phase calibration is done per IF (see section 2.1) by the combination of `SET POLARISATION` and `SET BAND` commands. In case of a polarized calibrator, the measured amplitude is:

$$\widetilde{A_{ij}} = a_i a_j \left(I + Q\cos(2\chi) + U\sin(2\chi) \right) \tag{20}$$

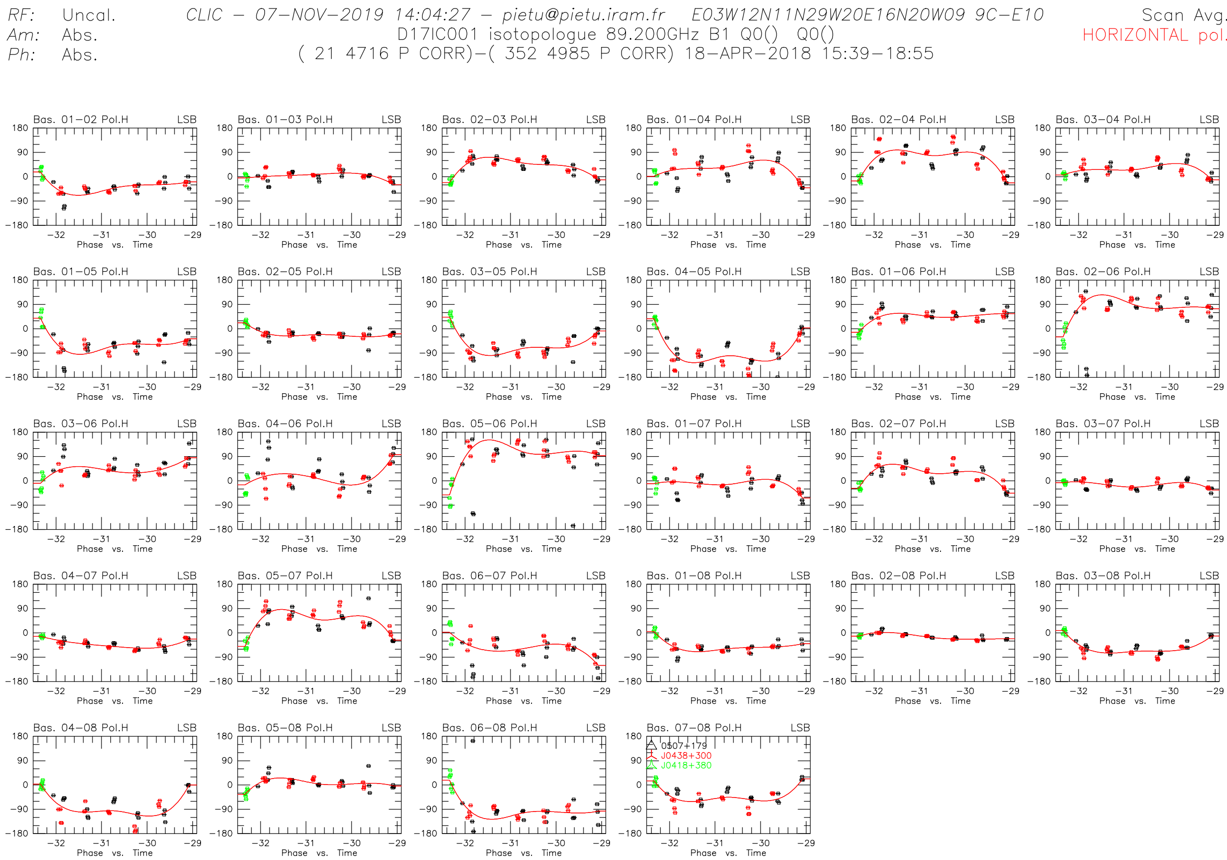

Figure 6: Example of SOLVE PHASE /PLOT.

where χ is the parallactic angle and I, Q, U, V are the Stokes parameters. The (implicit) assumption of constant flux density for the calibrator breaks down if the linear polarisation fraction $P = \frac{\sqrt{Q^2+U^2}}{I}$ is more a few percents. In that case, one should use the average of both polarisation to perform the amplitude calibration (`SET POLARISATION BOTH`).

4.5.4 SOLVE DELAY

Command `SOLVE DELAY` is used mainly at the observatory. After plotting the phase of a calibrator as a function of IF1 frequency, one fits a residual delay $\Delta\tau$ to the data, following:

$$\phi = \pm 2\pi \Delta\tau \nu_{IF1} \tag{21}$$

The $\pm$ sign depend on the sign of the baseband conversion (LSB or USB). It is recommended to use an antenna-like plot to get better signal to noise.

4.5.5 SOLVE GAIN

Command `SOLVE GAIN` is used mainly at the observatory. With Walsh $\frac{\pi}{2}$ switching on the LO1 and demodulation in the backend, the sidebands which are superposed after the LO1 conversion can be separated. This allows the receiver sideband rejection, g_{im}, to be measured by computing the ratio of the image sideband over the signal sideband amplitudes. This is done on the uncalibrated data by dividing each sideband by its T_{sys} and correcting for the possible difference in atmospheric opacity between the sidebands.

This command also derives the mean baseband phases that are fed back to the system so that further online averages do not suffer decorrelation.

4.5.6 SOLVE POINT

Command `SOLVE POINT` is used to reduce pointing scans by fitting a gaussian to the antenna-based visibilities. For that reason, it only works if three antennas or more are present. Else, one antenna has to be fixed, and the baseline visibility is fitted.

4.5.7 SOLVE TOTAL

Command `SOLVE TOTAL` and `SOLVE POINTING /TOTAL` are used to reduce pointing scans by fitting a gaussian to the total power. This requires a strong source.

4.5.8 SOLVE FIVE

Command `SOLVE FIVE` is used to reduce a special pointing pattern where five points in the shape of a cross are observed and a 2D gaussian fitting is done.

4.5.9 SOLVE FOCUS

Command `SOLVE FOCUS` will reduce focusing scans by fitting a gaussian to the offset along the focus in the Z-axis (along the optical axis).

4.5.10 SOLVE SKYDIP

Skydips are special scans where the antenna is moved in elevation at a fixed azimuth. For each elevation (regularly spaced in airmass), total power from the sky, P_{sky}, and the hot load, P_{hot}, are recorded. Since one knows the effective temperature of the hot load, T_{hot}, one can derive either the receiver temperature, T_{rec}, or the forward efficiency ,η_f, via:

$$(T_{hot} + T_{rec}) \times \frac{P_{sky}}{P_{hot}} - T_{rec} = \eta_f \times Airmass \times \tau_{zenith} + (1 - \eta_f) \times T_{ground} \tag{22}$$

4.5.11 SOLVE BASE ; RESIDUAL BASE

The geometrical delay is computed through:

$$\tau_g = \frac{\mathbf{b}.\mathbf{s}}{c} \tag{23}$$

where $\mathbf{b} = (X_{ij}, Y_{ij}, Z_{ij})$ and $\mathbf{s} = (\cos h \cos\delta, -\sin h \cos\delta, \sin\delta)$ are the baseline and source vectors respectively in a referential .

The resulting phase is:

$$\begin{aligned}\phi_{ijk} &= 2\pi\tau_g\nu_{RF} \\ &= \frac{2\pi}{\lambda}\mathbf{b}.\mathbf{s} \\ &= \frac{2\pi}{\lambda_k}\left(X_{ij}\cos h\cos\delta - Y_{ij}\sin h\cos\delta + Z_{ij}\sin\delta\right)\end{aligned} \tag{24}$$

Using sources with known position distributed in hour angle and declination, a least square fit to the observed phases gives is used to derive the antenna position errors.

An additional term can be fitted corresponding to the offset between the azimuth and elevation axis of each antenna. It has a $\cos(El)$ dependance (in that case, data must be plotted as a function of elevation also in addition to the hour angle and declination of the "normal" baseline measurements).

Command `RESIDUAL` baseline will plot the residual phases resulting from the last `SOLVE BASELINE` command.

4.5.12 SOLVE HOLOGRAPHY

Holography is powerful way of caracterizing an antenna. It builds on the fact that there exists a Fourier transform relationship between the far-field antenna beam (including its amplitude and phase) and the (complex) aperture field distribution. A modified Fourier relationship can be derived in the near-field case (far field is $> 2d^2/\lambda$, or 130km for a 15-m antenna at a wavelength of 3.4mm). The interested readers will find in Baars et al. 2007 a lot more of details. `CLIC` can handle both near-field (Fresnel) and far-field (Fraunhofer) measurements.

In essence, a source is scanned with one or more antennas while one or more antennas are pointing at the source. The data are gridded and Fast Fourier Transformed to an aperture plane. The aperture plane is then analyzed in terms of amplitude and phase (left and right plots in Fig. 7)

The amplitude map is normalized and transformed in decibels (dB), so that it peaks at 0dB. In radio-astronomy, the aperture is often tapered to reduce the beam sidelobes. `CLIC` does a fit of this illumination with a 2-d gaussian (2-d parabola in the dB maps) to measure the actual taper and center of illumation. The values are given in the first line of the header.

The phase map is more interesting in that it gives the deviations w.r.t. a perfect surface and can be used to derive corrections to be applied to the individual panels of the parabola. The advantage is also that it can be measured, and panel corrections derived, at any antenna elevation.

A least squares fit to the phase map of the following terms is performed, where (ξ, η) are aperture coordinates, $r = \sqrt{\xi^2 + \eta^2}$ is the radius coordinate from the center of the aperture, f is

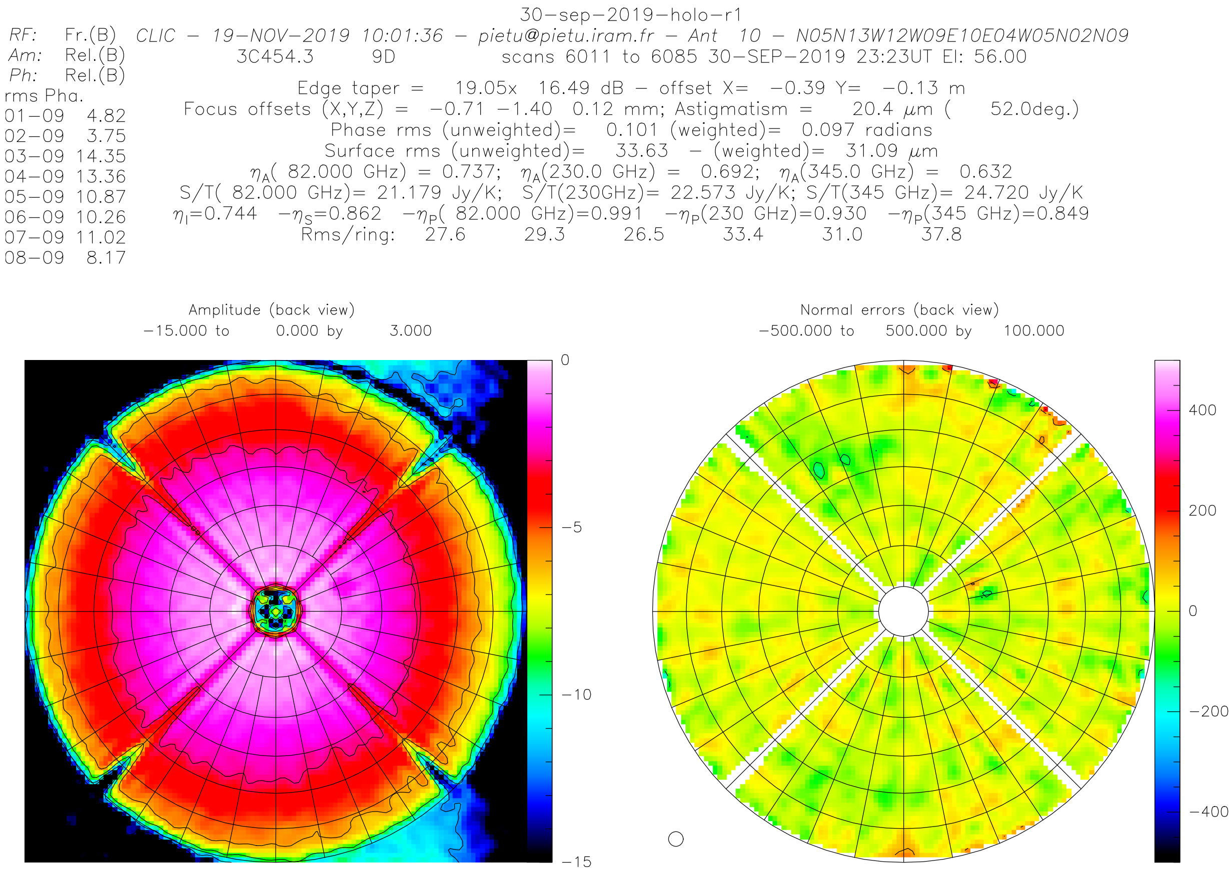

Figure 7: Example of SOLVE HOLOGRAPHY.

the focal length of the antenna:

$$\phi_1(\xi,\eta) = a \tag{25}$$

$$\phi_2(\xi,\eta) = b\xi \tag{26}$$

$$\phi_3(\xi,\eta) = c\eta \tag{27}$$

$$\phi_4(\xi,\eta) = \delta z\left(1-\frac{1-\frac{r^2}{4f^2}}{\sqrt{\frac{r^2}{f^2}+(1-\frac{r^2}{4f^2})^2}}\right) \tag{28}$$

$$\phi_5(\xi,\eta) = \delta x\frac{\xi}{f}\left(1-\frac{1}{\sqrt{\frac{r^2}{f^2}+\left(1-\frac{r^2}{4f^2}\right)^2}}\right) \tag{29}$$

$$\phi_6(\xi,\eta) = \delta y\frac{\eta}{f}\left(1-\frac{1}{\sqrt{\frac{r^2}{f^2}+\left(1-\frac{r^2}{4f^2}\right)^2}}\right) \tag{30}$$

$$\phi_7(\xi,\eta) = a_+\frac{\xi^2-\eta^2}{2f^2} \tag{31}$$

$$\phi_8(\xi,\eta) = a_\times\frac{2\xi\eta}{2f^2} \tag{32}$$

$$\tag{33}$$

a is a constant phase offset, b and c account for pointing offset that would be constant during the observations, δx, δy and δz correspond to focus offsets in the x (horizontal), y (vertical) or z (along optical axis) directions. a_+ and $a_\times$ are the antenna astigmatism along the horizontal or vertical axis, $a_\times$ along directions rotated by 45°. The corresponding astigmatism angle ψ_a is:

$$\psi_a = \frac{\arctan(a_\times, a_+)}{2} \tag{34}$$

In addition, holographies provide an estimate of the actual antenna surface, one can compute the aperture and illumination efficiencies η_A and η_I:

$$\eta_A = \frac{|\int_A A(\xi,\eta)\exp(i\phi(\xi,\eta))d\xi d\eta|^2}{\pi r^2 \int_A A(\xi,\eta)^2 d\xi d\eta} \tag{35}$$

$$\eta_I = \frac{|\int_A A(\xi,\eta)d\xi d\eta|^2}{\pi r^2 \int_A A(\xi,\eta)^2 d\xi d\eta} \tag{36}$$

and the antenna efficiency:

$$J = \frac{2k}{\eta_A \pi r^2} \tag{37}$$

One can also fit panel displacements. According to the panel mode selected, translation only, tilt in both radial and tangential directions, torsion mode and a fit of the inner fifth support point can be fitted.

Finally, one can produce either a phase map or a surface error map. The latter is linked to the former through:

$$\delta p = \delta\phi \times \frac{\lambda}{4\pi} \times \sqrt{1 + \frac{r^2}{4f^2}} \tag{38}$$

The term to the right corresponds to the projection factor between the incident or reflected ray and the normal to the surface.

4.6 Storing

In this section, I describe the command STORE which is used to store various parameters in the header file. These commands are relatively straightforward to use, but there are a few technicalities. Remember that all STORE commands are working on the current index, so be sure it includes the target observations before storing calibrations.

4.6.1 Correction

As explained in section 3.3.2, there are usually two spectra per observation: one which is the simple average of all the dumps within the observations, one for which each individual spectra is corrected by a phase $\phi_j - \phi_i$, where ϕ_i is the correction for atmospheric phase derived from the Water Vapor Radiometer (WVR) for antenna i, prior to the averaging. For older data (before 2006), the 1mm total power data have also been used to monitor atmospheric phases (see HELP MONITOR).

STORE CORRECTION can be used to store in the observation header whether the atmospheric phase correction is valid or not. Besides the GOOD or BAD keywords, keyword AUTO is the one that is recommended to be used. It will compare the amplitude of the phase corrected or uncorrected data (with a bias toward uncorrected data) on calibrators, and then automatically decide which should be used for the science scans according to the closest in time phase calibrator correction validity.

4.6.2 Bandpass

As explained in section 4.5.1, there are two ways to perform a bandpass calibration, a polynomial fit to the calibrator's data or a direct use of the calibrator's data. Accordingly, there are two ways to store an RF bandpass solution in a hpb file.

The historic way is to store the polynomial coefficients in a dedicated section of the hpb file. Because of the way files are handled in CLIC (see section 3), this is only possible if room for the appropriate section (-27 or -28, see Table 2) was reserved at the time of the hpb creation.

When the data or a smoothed version of it is used, one has to use another solution, which is to store the full bandpass solution (interpolated for all data points, including the high spectral resolution spectral windows if there are any). This is done through option STORE RF /SCAN. This solution can also be used to store a bandpass solution obtained through polynomial fitting. The advantage of that solution is that it can be useful to create an hpb file without the bandpass calibration section(s), which is much smaller in size.

4.6.3 Flux and spectral index

Command STORE FLUX will store the fluxes determined by the last SOLVE FLUX command in the file, which is a prerequisite of the amplitude calibration. Spectral index is for now stored with command MODIFY SPIDX so it has to work on an source per source index iteratively.

4.6.4 Amplitude and phase

This is a straightforward operation that will copy the cubic spline or polynomial coefficients from each IF from memory to the relevant calibration section (-29 or -31, see Table 2) of the hpb file (provided it was initialized at hpb creation). One can override this default by forcing it to use a given sideband or polarisation (or average of sidebands or polarisations) to calibrate both polars/sidebands.

4.6.5 Quality

`STORE QUALITY` can be used to store a quality in an observation. In practice, this functionnality is seldomly used except for a `STORE QUALITY 9`, which will prevent further `FIND` command to find this observation.

4.6.6 Flag

`STORE FLAG` is the command to be used if one wants to flag data. Many keywords are available and flags can be stored for antennas or baselines. Two basic kinds of flag exist: the spectral flags, which will flag individual spectral windows and the non-spectral flags, that flag all of the data.

Flags are available at the dump level in the IPB, as they are recorded on the second basis by the online system. In the hpb file, they are stored in the data modified section, and only one value per observation is kept. In the case when one uses an hpb file, the actual flag will be a logical `.or.` of the IPB and hpb flags.

An option exists to store the flags only in memory if they are to be reset after some operation, as it is much more efficient. Command `MASK` allows to mask a given flag, while command `MARK` can be used to set a given flag (for all observations, contrary to the `STORE FLAG /MEMORY` option that works on the current index).

4.7 Modify

The `MODIFY` command is used to modify the data or metadata. The behaviour is not exactly the same for IPB and hpb files. For IPB files, the data are modified. For hpb files, data modifiers are stored in the relevant section of the header and applied on the fly when the data are read from the IPB file.

4.7.1 Geometry

The geometric delay is computed in the following way:

$$\begin{aligned}\tau_g &= \frac{\mathbf{b}.\mathbf{s}}{c} \\ &= \frac{1}{c}\left(X_{ij}\cos h\cos\delta - Y_{ij}\sin h\cos\delta + Z_{ij}\sin\delta\right)\end{aligned} \tag{39}$$

This geometric delay is computed in real-time and applied in the correlator and on the LO for fringe tracking. However, it may be the case (and is quite usual) that after the observation, a better baseline model was determined. Another more unusual case would be new coordinates were determined for an observed source or that the time reference used at the observatory was offset w.r.t. UT1 time. All these can be corrected after the observations and the phases recomputed with commands `MODIFY ANTENNA, MODIFY BASELINE, MODIFY POSITION` or `MODIFY TIME`. In all cases, equation 39 is used with the updated parameters provided by the user.

4.7.2 Phases

There are another set of commands that modify the phases but do not take their origin in the computation of the geometrical delay. A good example is the `MODIFY DELAY` command that will apply a new (constant) delay to the current index. Some more specific commands, for example `MODIFY CABLE`, will correct faulty cable phase correction.

4.7.3 Frequency and velocity scales

NOEMA operates with Doppler tracking. When the user provides a setup, with a given reference rest frequency, F_{rest}^{ref}, and a source velocity, v, within some referential (usually LSR referential) on one side and an IF frequency, F_{IF}^{ref}, at which the rest frequency should appear on the other side. The Doppler tracking consists in modifying the LO1 frequency so that the two frequencies stay aligned to within one tenth of the smallest channel spacing of the spectral setup being observed.

The rest, F_{rest}, and topocentric frequencies, F_{topo}, are related through:

$$F_{topo} = F_{rest}\left(1 + \delta - \frac{v}{c}\right) \tag{40}$$

where δ is the Doppler factor between the chosen referential and the topocentric referential, and v is the source systemic velocity within this referential.

Since $F_{IF} = \pm(F_{topo} - F_{LO1})$ (+ for an USB conversion, - for a LSB conversion), we have:

$$F_{IF} = \pm\left(F_{rest}\left(1 + \delta - \frac{v}{c}\right) - F_{LO1}\right) \tag{41}$$

so by setting

$$F_{LO1} = F_{rest}^{ref}\left(1 + \delta - \frac{v}{c}\right) \mp F_{IF}^{ref} \tag{42}$$

Parameter	Freq	Frame	Notation	`SIC` variable
Reference rest frequency	RF	Rest	F_{rest}^{ref}	FREQUENCY
Sideband				ISB
Reference IF frequency	IF	Topo	F_{IF}^{ref}	FIF1
LO1 frequency		Topo	F_{LO1}	FLO1
Source referential				TYPE_VEL
Source velocity		Ref.	v	VELOCITY
Doppler factor			δ	DOPPLER

Table 4: Parameters for receiver tuning. For the source referential TYPE_VEL, 1 means LSR, 2 heliocentric, 3 geocentric, 4 no doppler tracking, 5 unknown.

Parameter	Freq	Frame	Notation	`SIC` variable
Number of channels			n_{ch}	N_CHANNELS
Channel number of (2)			i_{IF}	REF_NUM
Center frequency	IF	Topo	F_{IF}^0	LFCEN
Reference channel			i_{ref}	REF_CHANNEL
Rest frequency	RF	Rest	F_{rest}^0	F_OFFSET
Frequency spacing		Topo	δF_{rest}	LFRES
Frequency spacing		Rest	δF_{topo}	F_RESOLUTION

Table 5: Parameters for spectral windows and corresponding `SIC` variables

we ensure the Doppler tracking as defined above.

The frequency value of channel k from spectral window j are defined as:

$$F_{IF}(j,k) = (k - i_{IF}(j)) * \delta F_{topo} + F_{IF}^0(j) \quad (43)$$

$$F_{rest}(j,k) = (k - i_{rest}(j)) * \delta F_{rest} + F_{rest}^0(j) \quad (44)$$

where δF_{topo} is the channel spacing of the backend in the topocentric frame and $\delta F_{topo} = \delta F_{rest}\left(1 + \delta - \frac{v}{c}\right)$

4.7.4 Custom modifications

It is possible to modify any header or data header data using generic command `MODIFY HEADER`, `MODIFY DATA` and `MODIFY RECORD` that allow us to modify parameters of the observation header, spectral dumps or temporal dumps respectively.

Caution is to be exercised when using these commands as changes must be done coherently.

4.8 Atmosphere

Various commands relates to the atmosphere: the "atmospheric" calibration or chopper-wheel method, that is used to put the visibilities on a T_a^* scale (see 2.3.1), the water vapor radiometer (WVR) calibration that will derive atmospheric phase correction, and the total power phase correction that was used for the PdBI before the use of WVRs.

4.8.1 Atmosphere

Measurements Assume we have a system that measures the total power P received at the output terminal and that input power is measured in temperature scale T (see eq. 2) with an unknown gain (K_p) i.e. we have:

$$P = K_p T \tag{45}$$

Similarly, let's assume that the autocorrelations are on a power scale with a gain K_c, different from K_p, but the same for auto- and cross- correlations (this point is checked with measurement on a noise source, which is fully correlated for different antennas, so that autocorrelations match the crosscorrelation amplitudes). Then we have:

$$\widetilde{A_{ij}} = K_p T_{ij} \tag{46}$$

where T_{ij} is the source power at the input port.

In using the chopper wheel method, we place loads with known effective temperature in front of the receiver. For NOEMA, one uses a hot load made of absorber which is at the temperature of the receiver cabin and a cold load located inside the cryostat on the 15K stage ; regular observations are made on the sky:

$$\begin{aligned}
P_{hot} &= K_p \left(T_{hot} + T_{rec}\right) &(47)\\
P_{cold} &= K_p \left(T_{cold} + T_{rec}\right) &(48)\\
P_{sky} &= K_p \left(T_{sky} + T_{spill} + T_{rec} + T_a\right) &(49)\\
C_{ii} &= K_c \left(T_{sky} + T_{spill} + T_{rec} + T_a\right) &(50)\\
|C_{ij}| &= K_c T_a &(51)
\end{aligned}$$

The difference between the cross-correlation amplitudes $|C_{ij}|$ and the autocorrelations C_{ii} is that the "noise" (i.e. $T_{sky} + T_{spill} + T_{rec}$) is uncorrelated between different antennas and vanishes from the cross-products.

Receiver temperature By combining eq. 47 and 48, we can derive the receiver temperature T_{rec}:

$$T_{rec} = \frac{P_{cold} T_{hot} - P_{hot} T_{cold}}{P_{hot} - P_{cold}} \tag{52}$$

or equivalently with the autocorrelations.

System temperature We start by deriving the sky temperature with:

$$T_{sky} = \left(T_{hot} + T_{rec}\right) \frac{P_{sky}}{P_{hot}} - T_{rec} - T_{spill} \tag{53}$$

Estimating T_{spill} requires knowledge of the forward efficiency η_f. It is also used to compute the sky emission T_{emi}:

$$T_{emi} = \frac{T_{sky}}{\eta_f} \quad (54)$$

The water vapor content variable of an atmospheric model predicting sky brightness ($T^{atm}_{emi,s}$ and $T^{atm}_{emi,i}$) and opacity ($\tau_{atm,s}$ and $\tau_{atm,i}$) in the signal and image sideband is then varied in order to minimize the following quantity:

$$T_{emi} - \frac{T^{atm}_{emi,s} + g_{im} T^{atm}_{emi,i}}{1 + g_{im}} \quad (55)$$

The system temperatures for the signal $T_{sys,s}$ and image $T_{sys,i}$ sidebands are then computed as follows:

$$T_{sys,s} = \frac{e^{\tau_s} \left(T_{hot} - T_{sky} - T_{spill}\right)\left(1 + g_{im}\right)}{\eta_f} \frac{P_{sky}}{P_{hot} - P_{sky}} \quad (56)$$

$$T_{sys,i} = \frac{e^{\tau_i} \left(T_{hot} - T_{sky} - T_{spill}\right)\left(1 + \frac{1}{g_{im}}\right)}{\eta_f} \frac{P_{sky}}{P_{hot} - P_{sky}} \quad (57)$$

where:

$$T_{sky} + T_{spill} = (1 - \eta_f) \left(\frac{T^{atm}_{emi,s} + g_{im} T^{atm}_{emi,i}}{1 + g_{im}} \right) + \eta_f T_{ground} \quad (58)$$

Scaling of data The visibilities C_{ijk} out of the correlator are normalized in the following way to get observed visibilities on a temperature scale T_{ijk}:

$$T_{ijk} = \frac{C_{ijk}}{\sqrt{C_{iik} C_{jjk}}} \sqrt{T_{sys}(i) T_{sys}(j)} \quad (59)$$

In the left side of the right term, cross-correlations are normalized to the total power measured in autocorrelations (and the dependency on K_c disappears), so that a rate of correlation is measured. The right side corresponds to a conversion to T_a^* scale by multiplication by the baseline effective system temperature.

Command ATMOSPHERE This atmospheric calibration is normally applied online by the RDI program. However in some cases, one may want to update the atmospheric calibration because of an online problem at the time of the observations (i.e. a bug, a wrong value for an input parameter). Command `ATMOSPHERE` allows us to do this and will process all of the scans in the current index.

4.8.2 WVR

The water vapor radiometer operates around the water line at 22 GHz. By monitoring the amount of water vapor along the line of sight of each antenna, one can derive a corresponding atmospheric phase at the frequency of interest and correct the individual dumps from the correlator by this phase before averaging, hence mitigating atmospheric decorrelation (see also section 3.3.2).

This requires calibration of the data coming from the radiometer. A number of modes are available to derive the receiver gain, T_{cal}, and noise, T_{rec}, either from tabulated laboratory measurements or observations of loads of known brightness. The classical way of doing this for

NOEMA is to use T_{rec} derived from skydip measurements which are carried out regularly. The use of a hot load then allows us to derive the gain T_{cal}. With T_{rec} and T_{cal}, the sky antenna temperature, T_i, for the different channels can be computed.

The first generation of WVR used at NOEMA had 3 channels (centered at frequencies ν_1, ν_2 and ν_3), that were combined in a way that removed any ν^2 contribution (hence cloud emission):

$$T_{triple} = \frac{1 - \left(\frac{\nu_1}{\nu_2}\right)^2}{1 - \left(\frac{\nu_2}{\nu_3}\right)^2} \left(T_2 - T_3 \left(\frac{\nu_2}{\nu_3}\right)^2\right) - \left(T_1 - T_2 \left(\frac{\nu_1}{\nu_2}\right)^2\right) \tag{60}$$

As for the astronomical receiver calibration, the water vapor content of an atmospheric model is varied until a good match with the measured triple temperature is found. The derivative of the optical pathlength to the channel temperatures is then computed, in order that a scaling factor can be applied to the radiometer counts, so that their variation track atmospheric phases.

The offline version will do the same, but the spectral averaging was done online. So it is useful only to check calibration or do use an updated calibration for continuum records.

4.8.3 Monitor

The first atmospheric phase correction scheme was based on the total power measured in the 1mm band (when dual-frequency observing was available). The calibration scans are processed similarly to the regular astronomical calibration (see section 4.8.1), then the derivative of the path length over the emission temperature of the atmosphere at the atmospheric monitoring frequency is computed.

It is possible to fit a straight line within a time δt to remove drift of non-atmospheric origin (such as receiver gain variations), before computing the corrections.

As for the WVR, this correction was applied online and can only be recomputed for the continuum units.

4.9 (u,v) tables

The final goal of the calibration is to produce a set of calibrated visibilities that can be imaged or analysed in the (u,v) plane. In `GILDAS` , we write .uvt tables for that purpose. The .uvt file is a flavor of the more generic gildas data format (GDF).

4.9.1 GDF v1

The original GDF format contains visibilities consisting of:

- 7 data associated parameters, in a fixed order: `u, v, w, date, time, first antenna, second antenna`
- an array of complex visibility elements, that contain each a real part, an imaginary part and a weight

Note that in this original format, `u,v` and `w` are in meters, the `date` is a `CLASS` date, `time` is in seconds. The `w` column was often replaced by the scan number `scan` for flagging and editing purpose.

4.9.2 GDF v2

The original GDF data format had a number of limitations, including 32 bits addressing, which led to the development of a revised version, the so-called GDF v2.

GDF v2 addresses the previous limitations in size or number of elements and provides provisions for new modes, including:

- extra columns in (u,v) tables
- handling of polarization data
- an extra telescope section

The interested reader will find in "Preparing `GILDAS` for large datasets II - `GILDAS` Data Format Version 2" more details about GDF v2.

4.9.3 UVT versions

The analysis of (u,v) data needs to handle two frequency referentials: the topocentric frame that corresponds to the observed frequency and the source or rest frame. The former defines the angular resolution of the telescope, or the (u,v) coordinates that are expressed wavelength units, the latter is used for the identification of lines or in converting frequency shifts to velocity shifts. Both are linked through equation 40.

Historically (for GDF v1), the frequency axis was in the topocentric frame. The rest frequency was given separately. The spectral resolution did not distinguish between topocentric and source frame: it was only approximate

With GDF v2, UV table contains a UV Tables version stored in the table header. Version 2.0 corresponds to the historical GDF v1 implementation (see above). This version has both a lousy spectral axis definition and a lousy angular resolution. For narrow bands, it can still produce correct results, provided that the correct rest frequency is accounted for (option `/FREQUENCY` of command `TABLE`).

UV Table versions 2.1 and 2.2 provide a clear definition of the spectral axis: it is the rest frequency, in the source frame (at the source velocity in the selected system frame). The spectral resolution is in that same source frame. The doppler factor is provided to convert the source frame frequency to topocentric frame for computing the effective angular resolution from the `u,v` coordinates measured as a length in meters.

The difference between versions 2.1 and 2.2 is that in 2.1 the mean Doppler factor is provided where with version 2.2, a time dependent Doppler factor is stored as an extra column. Note that if the observatory section of the uv table is filled, the time dependent Doppler factors can be recomputed.

4.9.4 Command TABLE

Command `TABLE` will produce a UV table. See corresponding help for more information. Two options are very frequently used: the `/FREQUENCY` option that is used to recompute the frequency and velocity scales for a new rest frequency (see also section 4.7.3). The second useful option is `/RESAMPLE` that is used to resample the data with less channels, another spectral resolution, etc. One has to take care to not oversample the data.

UV tables can be read/edited as `SIC` variables using the command `DEFINE UVTABLE` (see associated help for more details).

UV tables can also be exported in UVFITS format using the `VECTOR\FITS` command (see corresponding `HELP`).

5 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.

5.1 Language

```
                        CLIC\ Command Language Summary

                Continuum and Line Interferometric Calibration

    ATMOSPHERE      : Perform atmospheric calibration.
    BLANK           : Blank some spectral channels
    COMPRESS        : Compress data.
    COPY            : Copy data.
    CURSOR          : Call the interactive graphic cursor.
    DROP            : Take a scan out of the current index.
    DUMP            : List some informations on the R spectrum.
    FILE            : Define the input/output files.
    FIND            : Search the input file for observations.
    FITS            : Write out spectra in FITS format (e.g. for CLASS).
    FLAG            : Flag data.
    GET             : Read a scan in the input file.
    HEADER          : Display some header information.
    IGNORE          : Ignore scans from the input file.
    LIST            : List header information about an ensemble of scans.
    MARK            : Force data to be treated as if flagged.
    MASK            : Cause some flags to be ignored.
    MINMAX          : compute extremal amplitudes in data
    MODIFY          : Edit and change the scan header (and data).
    MONITOR         : Process data for total power phase correction parameters.
    NEW_DATA        : Wait until new data present in input file.
    PLOT            : Plot data according to display options.
    PRINT           : Produces an output text file (PRINT BASELINE).
    RESIDUALS       : Plot residuals from last SOLVE operation.
    SET             : Enter a value for a parameter.
    SG_TABLE        : Create a UV data Table for mapping purposes.
    SHOW            : Show current value for a parameter.
    SOLVE           : Solve for calibration functions.
    STORE           : Store calibration functions.
    TABLE           : Create a UV data Table for mapping purposes.
    TAG             : Change the quality of scans in the output file.
    VARIABLES       : Enable/disable CLIC variables
    WVR             : Process data for WVR phase correction parameters.
```

5.2 ATMOSPHERE

```
CLIC\ATMOSPHERE [DETECTOR|CORRELATOR] [/COMPRESS] [/RESET]
[/NOWRITE] [/NOMONITOR]
```

Recompute the atmospheric (transparency) calibration from the data and the informations provided by the SET ATMOSPHERE command. All scans in the current index are processed:

- Atmospheric calibration scans (CALI): compute calibration temperature Tcal, using either the total power DETECTORs or the continuum CORRELATOR to measure the atmospheric emission. Default is DETECTOR. The data on the atmospheric monitor (the 1.3 mm) receiver will also be used to compute the phase correction factors (see also the MONITOR command).

- Apply the new model to the subsequent observations and write (update) the recalibrated data if option /NOWRITE is not present. This is done until a new calibration is found.

[/COMPRESS] Obsolete option.

[/RESET] ALL|AUTO|CAL Reset integrations time associated to ALL phases, SKY phase, or HOT/COLD cal phases.

[/NOWRITE] Do not update data on disk.

[/NOMONITOR] Do not compute and update monitoring section.

5.3 BLANK

```
CLIC\BLANK c1 c2 /SPW i [/RESET] [/EXTRAPOLATE] [/NOEXTRAPOLATE]
```

Blank channels c1 to c2 in spectral window i (mandatory argument). With option /reset, it will reset all ranges blanked in spectral window i. Current list can be obtained with command SHOW BLANK.

Options [/EXTRAPOLATE] and [/NOEXTRAPOLATE] control CLIC behaviour regarding blanked data. They will be either interpolated or blanked accordingly.

5.4 COMPRESS

```
CLIC\COMPRESS timemax uvmax [/TRIANGLE]
```

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.

[/TRIANGLE] add triangles to data. Not tested.

5.5 COPY

CLIC\COPY HEADERS|[NO]DATA [[NO]BASE] [[NO]ANTENNA] [NORF] [/EXTRACT]

Copy the content 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 or not.

COPY DATA selects the old mode, in which the data as well as the headers are copied in the output file.

COPY HEADERS selects the RECOMMENDED mode in which only the headers are copied in the output file. In this new so-called "header file", the data sections are not written but replaced by pointers to the original file. This way, the data file, originally written at Plateau de Bure, is later only used in a read-only mode. All further calibrations are stored in the (much smaller) header file. It is HIGHLY RECOMMENDED to use the extension ".hpb" for the new file containing the headers.

Example:

```
!
! Original file is "14-apr-1996-f081.ipb".
! Create a header file:
!
file in 14-apr-1996-f081.ipb
find
file out f081-b2.hpb new
copy headers
```

```
!
! Now open the f081-b2.hpb for input/output
!
file both f081-b2
find
solve phase /plot
store phase
!
! ... and so on as usual
!
```

When the header file is 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 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.

Most commands are available in this 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" file contents and the ".hpb" header file. The header file may refer to only part of the scans in the .ipb file (e.g. omit the IFPB or POINT scans), and it may refer to several .ipb files (e.g. data from two consecutive days).

Arguments [NO]BASE and [NO]ANTENNA control whether respectively the baseline and antenna-based calibration sections are written in the header file. Antenna-based calibration is now the default and omitting the baseline-based sections saves a lot of space. Do not forget to use COPY HEADERS BASE if you foresee you will need baseline-based calibration.

Argument [NORF] can be used to tell that one wishes to skip the passband calibration sections regardless of the ANTENNA or BASE arguments. It is used in view of storing RF bandpass solution as an extra scan with the STORE RF /SCAN option.

Option [/EXTRACT USB|LSB] will extract only the selected sideband.

5.6 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 on the result of a PLOT command.

After pressing any key, 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.

The following actions are possible:

- Press any key to get the coordinates of the selected point.

- Press 'H' to display some header information of the selected scan (as with LIST command).

- Press 'K' to delete the selected point from the current plot buffers (type PLOT SAME to replot the buffers). This may be very useful to remove corrupted points from the buffers e.g. before fitting calibration curves.

- Press 'N' to initiate a new range for Ignore, Tag, and Flag (see below). This works only with time-like plots, and is to be used preferrably with coordinates that are monotonous functions of time (scan number, observation number, time, ...)

- Press 'I' to ignore all scans in the current range (initiated by 'N'). This is equivalent to typing the IGNORE command for the same scans.

- 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 code in the range 0 to 9 (see TAG command). The quality codes are stored in the output file, which must be equal to the input file.

- Press 'F' to flag all records in the current range (initiated by 'N'). You will be prompted for a list of flags (see FLAG command). These flags will affect the baseline or antenna corresponding to the box you are pointing at. They will be stored in the output file, which must be equal to the input file.

- Press 'E' to exit the cursor mode.

5.7 DROP

```
CLIC\DROP observation [version]
```

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 in the current index. The observation will be ignored until the next FIND command. See also the IGNORE command.

5.8 DUMP

```
CLIC\DUMP arguments [/PLOT]
```

A debugging command that lists a certain number of informations on the last read observation.

- DUMP HEADER argument: lists a certain number of informations about the observation header. Argument may be ALL, HEADER, GENERAL, POSITION, INTERFEROMETER, FREQUENCY, ATMOSPHERE, MONITOR, CONTINNUM, LINE (with optional argument 'iband', dump only subband 'iband'), SCANNING, IC (Instrumental calibration), AIC (Antenna-based Instrumental calibration), PC (RF Passband calibration), APC (Antenna-based RF Passband calibration), DD (Data Descriptor), WVR (Water Vapor radiometer), PHASES.

- DUMP DATA: lists the data associated parameters.

- DUMP FILE: lists information about the input and output files.

- DUMP INDEX: lists information about the current index.

- DUMP VIRTUAL: gives the virtual memory and paging file quotas.

- DUMP SIZE: gives the values of a number of key variables that define the size of the problem.

- DUMP BUFFER: dumps levels for atmospheric calibration (for debugging).

- DUMP RF: dumps antennas used for RF calibration (for debugging),

- DUMP SBA: dumps the sideband average (for debugging).

- 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 DATA, DUMP CONTINUUM and DUMP LINE will return the phase-corrected or uncorrected data, depending on the last SET PHASE ATM or SET PHASE

NOATM command issued.

5.9 FILE

```
CLIC\FILE [type] [name] [NEW] [/WINDOW]
```

Selects the input and output files.

```
FILE IN Name            defines the input file.
FILE OUT Name [NEW]     defines the output file, and
                        initializes it if NEW is precised.
FILE BOTH Name          selects the same file for input and output.
```

The default filename extension is ".hpb". With FILE IN, the extension ".ipb" is also checked. This behaviour can be changed using the command SET EXTENSION. The character variable SHORT_FILE is available after a FILE IN: it contains the file name without directory or extension. 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.

```
CLIC\FILE RAW [project] [date] [/WINDOW] [/DIRECTORY]
```

FILE RAW [Project] [Date] will select the first file residing in the directories IPB_DATA:, IPB_DATA1:, ..., IPB_DATA9:, which matches the optionally given project name and date, following the standard name convention used at Plateau de Bure (jj-mmm-yyyy-proj.ipb, or YYMMJJPROJCODE.IPB in the archive). 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).

FILE RAW [Project] [Date] /WINDOW (if the windowing system is active) will create a panel window 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.

FILE RAW /DIRECTORY (if the windowing system is active) creates a panel window with a menu to edit the list of raw data file directories (logical names IPB_DATA:, IPB_DATA1:, ...)

5.10 FIND

```
CLIC\FIND [APPEND] [NEW_DATA] [UPDATE] [/LINE lname] [/NUMBER n1 n2]
[/SCAN s1 s2 [s3 s4 ...]] [/OFFSET o1 o2] [/PROCEDURE proc1 [...]]
[/QUALITY q] [/SOURCE s1 s2 ... sn] [/TELESCOPE tel] [/TYPE type]
[/RECEIVER number] [/MODE CORR|AUTO] [/LOAD HOT|COLD|SKY]
```

```
    [/SKIPAUTO] [/EXCLUDE proc1 [...]] [/POLAR]

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

/TYPE type           search by source type
/LINE lname          search by line name
/NUMBER n1 n2        search for the specified range of obs. numbers
/SCAN s1 s2 [s3 s4]  search for the specified range(s) of scan numbers
/OFFSET o1 p2        search for these offsets
/SOURCE s1 ... sn    search by source name
/PROCEDURE p1 .. pn  search by procedure name(s)
/QUALITY q           search for the data of quality better than q
/TELESCOPE tel       search for the specified telescope name
/RECEIVER number     search by receiver number
/MODE mode           search by correlation mode (auto/cross)
/LOAD load           search by load type (hot/cold/sky)
/SKIPAUTO            skip the autocorrelations in cross scans
/EXCLUDE             exclude from the search by procedure name(s)

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 sensi-
tive.

The current index is ordered by scan number or receiver number depending
on  the  last command SET SORT issued. However the scan ordering is done
modulo 9999 (i.e. the time order is respected if the  9999/0001  transi-
tion 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  in-
dex 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. The command IGNORE can be used to declare a list of observa-
tions to be ignored by the FIND command.

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 acquisi-
tion is done in CLIC format (Plateau de Bure) to use CLIC as an automat-
ed  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.
```

Argument UPDATE will perform a FIND using an updated input file, in case new observations were added since the last FILE IN.

Options /SOURCE, /PROCEDURE, /EXCLUDE and /SCAN have a maximum number of arguments (20 sources, 10 procedures kept or excluded and 100 scan ranges). Input list will be truncated with a warning if needs be.

5.10.1 FIND /POLAR

```
CLIC\FIND /POLAR argum
```

Find scan corresponding to a given state, where X and I indicate cross and direct switches for (physical) antenna i. Possible choices are: XXXXXX IIIIII XIXIXI IIXXII IXXIIX XXIIII XIIXIX IIIIXX IXIXXI

5.11 FITS

```
CLIC\FITS name
```

Create for each selected line subband a FITS file containing the spectral data. 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.

For autocorrelation data, the data from all antennas are averaged. For correlation data, the complex data from all baselines are averaged and the real part of the resulting visibility is used.

This command allows to easily write out spectra from point-like sources to be further analyzed in CLASS. Reading the data in CLASS and writing them in a CLASS-format file can be done with a procedure like:

```
FILE OUT myfile NEW
FITS READ name-l01.fits
WRITE next_obs
FITS READ name-l02.fits
WRITE next_obs
etc..
```

5.12 FLAG

```
CLIC\FLAG f1 f2 ... [/ANTENNA a1 [...]] [/BASELINE b1 [...]]
[/RESET]
```

```
Flag the current record (obtained by GET /RECORD) with flags f1 f2 ...

Flags  may be relative to antennas or baselines. One of the options /AN-
TENNA or /BASELINE, with lists of antenna numbers or baseline  names  as
arguments, must therefore be given. /ANTENNA ALL will flag all antennas,
/BASELINE ALL will flag all baselines.  These are the default.

Supported flag names are:

- C01 to C08 for bad individual continuum correlator subbands
- L01 to L08 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 (ant. based only)
- SATURATION for too high total power on a particular antenna
- TIME for time discontinuity
- DOPPLER for doppler discontinuity
- REDU for data reduction

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

FLAG with no argument lists the flags of the current record.

This command may be used in a MODIFY DATA or MODIFY RECORD loop, to flag
data.  If  more  than one record is to be flagged, command STORE FLAG is
HIGHLY RECOMMENDED.
```

5.13 GET

```
    CLIC\GET [n|FIRST|NEXT] [/RECORD r] [/HEADER] [/ATM]

GET loads the observation number n. If n is absent, the  previous  (last
read)  observation  is  recovered.  If  instead  of a number the keyword
"FIRST" is given, the first observation of the current index is  loaded.
With "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 contain by default the uncorrected data un-
less option /ATM is present, in which case the phase-corrected record is
loaded if it exists.

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.
```

5.14 HEADER

```
    CLIC\HEADER [/PLOT] [/LIST]

Displays some header information on the current observation.

     General information line
         Observation number
         Scan number
         Project Id
         Source name
         Source type (Object or Phase calibrator)
         Procedure name
         Interferometer configuration
         Date of observation
         UT of observation
         Hour angle

     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)
         Flux of the source

     Quality information line
         Quality code
         Flag
         Receiver number
         Number of dump
         Azimuth
         Elevation

     Spectral line information line
         Line name
         Rest frequency
         Sideband
         Doppler correction
         Source velocity

     Correlator information, for each subband
         Logical name
         Width (MHz)
         Central IF (MHz)
         Physical unit
```

```
        Quarter [for new receivers only]
        Polarization [for new receivers only]
        Narrow-band correlator input [for new receivers only]

    Interferometer status, for each antenna
        Antenna number
        Station
        Azimuth, Elevation, Focus corrections
        Receiver temperature (K)
        Image rejection (dB)
        Water (mm)
        System temperature (Tsys)
```

Argument /PLOT will produce an ASTRO like plot of the spectral setup.

Argument /LIST list the spectral windows and their rest frequencies.

5.15 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 can be given using the same format as with a FOR command (e.g. n1 n2 n3 TO n4 BY n5 n6 TO n7).

5.16 LIST

```
CLIC\LIST [key] [/BRIEF] [/LONG] [/OUTPUT file] [/SHORT]
[/PROJECT] [/SOURCE] [/VARIABLE var_list [/FORMAT format_list]]
[/OFFSET] [/FLAG [/MEMORY]] [/TELESCOPE] [/BANDPASS]
```

This command lists header information of an ensemble of observations. LIST is used for a quick look to observation headers, in a more or less detailed format. 'Key' specifies the file to be listed: IN or OUT; if 'Key' is not present, the current index (as determined by the last FIND command) is listed. The list will be ordered by scan numbers or by receiver number, depending on the command SET SORT SCAN|RECEIVER|NUM. For each observation, a medium-sized format is used by default. This can be modified using the options:

LIST /BRIEF

Brief format (observation numbers and version numbers only).

```
LIST /LONG

    Long format (not allowed for the output file). Several lines can  be
    listed for each scan, that can be selected using the SET FORMAT com-
    mand.

LIST /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.

The output of the LIST command can be written in an output file  instead
of  the terminal using the "/OUTPUT File" option.  LIST can also be used
to to list a number of specific parameters:

LIST /FLAG [/MEMORY]

    List data flags for current index. With option  /MEMORY,  will  list
    flags in memory (see STORE FLAG /MEMORY).

LIST /PROJECT

    List the observing projects in the current index. The number of dif-
    ferents offset positions is in variable N_OFFPOS, the offsets are in
    array OFF_POS[2,N_OFFPOS].

LIST /SOURCE

    List  the  observed sources in the current index. The number of dif-
    ferent source is in variable N_SOURCE, the source names in character
    array C_SOURCE[N_SOURCE].

LIST /TELESCOPE

    List  the  telescopes  in the current index. The number of different
    telescopes is in variable N_TELESCOPE, the telescope names in  char-
    acter array C_TELESCOPE[N_TELESCOPE].

LIST /OFFSET

    List the observed position offsets for the current index.

LIST /VARIABLE var_list

    List  the  value  of  the header variables given in var_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 IFCEN[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. These variables must have been previoulsy defined using VARIABLE RF and VARIABLE LINE.

LIST /BANDPASS

List the bandpass solutions stored as scan in the input file.

5.17 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 C136, L01 to L136), DATA, POINTING, SHADOW, TSYS, SATURATION and LOCK and REDU

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. See also STORE FLAG /MEMORY if you want to flag a subset of scans in memory.

5.18 MASK

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

```
    [/RESET] [/ALL] [/SPECTRAL]

This  command  causes some flags to be ignored by setting 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 rela-
tive  to antennas or baselines. One of the options /ANTENNA or /BASELINE
must therefore be given, with antenna numbers or baseline names as argu-
ments.

Supported flag names are:

- C001 to C136 for bad individual continuum correlator subbands
- L001 to L136 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 (ant. based only)
- SATURATION for too high total power on a particular antenna
- TIME for time discontinuity
- DOPPLER for doppler discontinuity
- REDU for data reduction

Option /ALL will mask all flags.

Option  /SPECTRAL  will mask the spectral flag (C001 to C136 and L001 to
L136)

Use option /RESET to remove flags from the mask works.

MASK with no arguments will list the mask words currently in use.
```

5.19 MINMAX

```
    CLIC\MINMAX

This command is used to compute extremal amplitudes on the  current  ob-
servation  (loaded  e.g.  with GET). It processes all continuum and line
data, USB and LSB.  Results for the continuum  subbands  are  stored  in
variables  C_MAXAMP_U,  C_MINAMP_U,  C_MAXAMP_L, C_MINAMP_L, and results
for the line subbanbds in variables L_*.

This command may be used in a MODIFY DATA  or  MODIFY  RECORD  loop,  to
search for bad data.
```

5.20 MONITOR

```
    CLIC\MONITOR delta_time
```

This command is used to prepare the atmospheric phase correction based on the total power monitor (normally done at 1.3 mm). It process all scans in the current index and performs two operations.

First, 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, i.e. using Receiver 2 data). These correction factors are then written in subsequent scans, until a new calibration is found.

Second, 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 (this is what is done in the correlator at the Plateau de Bure to compute the scan-averaged spectral and continuum quantities).

5.21 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, delay, etc. MODIFY applies to the current index. An output file must be opened (it may be equal to the input file).

Note the special behaviour of MODIFY HEADER, MODIFY DATA, and MODIFY RECORD, which execute an external script to modify the data and/or the header, hence giving to the user a large flexibility in the possible changes.

The MODIFY command is to be used with great caution, as it can directly affect the data. There's no telling what can happen if this command is wrongly used. So please consult an expert before any action.

5.21.1 MODIFY ANTENNA

```
CLIC\MODIFY ANTENNA a1 x1 y1 z1 [a2 x2 y2 z2 ...] [/OFFSET 89|96|99]
CLIC\MODIFY ANTENNA FITTED
```

Modify the vector coordinates for antenna a1 to be: x1, y1, z1 (meters), and the phases accordingly. Keyword FITTED will load the antenna coordinates the most recenty found by the SOLVE BASELINE command.

Option /OFFSET 86|96|99 allows to select to which version of the "standard" antenna coordinates the offset reffer.

5.21.2 MODIFY AXES_OFFSET

```
CLIC\MODIFY AXES_OFFSET 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 different 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.

5.21.3 MODIFY BASELINE

```
CLIC\MODIFY BASELINE b1 x1 y1 z1 [b2 x2 y2 z2 ...] [/OFFSET 89|96|99]
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.

Option /OFFSET 86|96|99 allows to select to which version of the "standard" antenna coordinates the offset reffer.

5.21.4 MODIFY BUG

```
CLIC\MODIFY BUG number
```

This command is reserved for the correction of nasty bugs in the data acquisition. 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.

2 Affecting data taken between 26-jan-2015 and 05-mar-2015. Bug in correl after change of commons to 7 antennas. Consequence is a phase offset between narrow band correlator units and widex units depending on elevation and baseline.

   MODIFY BUG 2 will correct the bug. Warning: this correction is an offset to the phases, so it should be applied only once. If the correction is done on data file (IPB), there is a check that this is the case, but header files (HPB) are not protected against correcting twice.

5.21.5 MODIFY CABLE

```
CLIC\MODIFY CABLE arguments
```

Modify the cable phase.

MODIFY CABLE a1 a2 a3 a4 a5 a6 corrects for a permutation of the cables to the phasemeters. Phasemeters 1 2 3 4 5 6 are assumed to be connected to the antennas a1 a2 a3 a4 a5 a6.

MODIFY CABLE CONTINUOUS corrects the cable phases to be continuous (should use only the correlations, without LOCK flag, for which the phases have a meaning).

MODIFY CABLE FACTOR f asssume the phase correction applied has to be multiplied by f (replaces the old MODIFY CABL2).

5.21.6 MODIFY DELAY

```
CLIC\MODIFY  DELAY a1 d1  [a2 d2 ...] [/OFFSET] [/IF if] [/BBAND ib]
[/ALL] [/INSTRUMENTAL] [/POLARISATION H|V|BOTH]
```

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 previous values.

Option /IF or /BBAND allow to modify the delay for a given IF or baseband. Option /ALL modify all spectral windows.

Option /INSTRUMENTAL allows to correct a delay that would have been introduced in the system after mixing with LO1, i.e. in IF1.

5.21.7 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.

5.21.8 MODIFY FLUX

```
CLIC\MODIFY FLUX value
```

Modify the flux of the source as stored in the header. In SET AMPLITUDE SCALED mode, the amplitude will be divided by this number before plotting.

5.21.9 MODIFY SPIDX

```
CLIC\MODIFY SPIDX value
```

Modify the spectral index of the source as stored in the header. In SET SPIDX ON mode, the amplitude be corrected by this spectral index with respect to reference frequency.

5.21.10 MODIFY FOCUS

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

Correct the phases for the offsets in focus, introduced to optimize efficiency. antenna1 is the antenna number, value1 the focus offset in mm, and so on. The phases are normally corrected in real time since 1996-nov-29. Between 1996-may-29 and 1996-nov-29, the focus corrections were logged in the data files. Before 1996-may-29 they are only in the log-obs files. Between 1996-nov-29 and 1998-apr-02, the correction had wrong sign for the few projects using HIGH LOCK.

So use MODIFY FOCUS with NO arguments for data more recent that 1996-nov-29: this should correct the HIGH LOCK problem. Between 1996-may-29 and 1996-nov-29, 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 (SOLVE PHASE /BREAK) just as you had done before.

5.21.11 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.

5.21.12 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.

5.21.13 MODIFY POSITION

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

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

5.21.14 MODIFY REFERENCE

```
CLIC\MODIFY REFERENCE UPPER|LOWER r1 r2 ...
```

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.

5.21.15 MODIFY SCALE

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

Multiply all data in the current index by this (complex) scale factor. To be used in case of emergency only!. Phase is interpreted according to the SET PHASE command (radians or degrees).

5.21.16 MODIFY TELESCOPE

```
CLIC\MODIFY TELESCOPE
```

Compute the telescope name (i.e. the configuration name) according to the new rules.

5.21.17 MODIFY TIME

```
CLIC\MODIFY TIME dut1
```

Modify the time constant DUT1 (in seconds) and recompute the phases accordingly. 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 seconds, if they are introduced asynchronously with the DUT1 constant...

5.21.18 MODIFY VELOCITY

```
CLIC\MODIFY VELOCITY New_vel
```

The source velocity is changed to New_vel. Use with caution: this command is actually changing the frequency and velocity scale of your data.

5.21.19 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. Especially, variables defined by the VARIABLE command can be modified...

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 encountered 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.

5.21.20 MODIFY DATA

```
CLIC\MODIFY DATA procedure [/BEFORE date] [/AFTER date] [/ATM]
```

This is a general command to edit the data headers of the scans in the current index. CLIC enters a loop in which for all scans in the current index, the data header of the average record is read. For each scan 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. Especially, variables defined by the VARIABLE command can be modified...

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.

The options /BEFORE and /AFTER allows to select data depending on their observing dates.

If present, the /ATM option allows to modify the data header of the phase corrected average record (will work only if such record is present in the data, so only on cross-correlations: CROSS, FLUX, POINT, GAIN ...)

5.21.21 MODIFY RECORD

CLIC\MODIFY RECORD procedure [/RECORD idump] [/BEFORE date] [/AFTER date]

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. In the case the option "/RECORD idump" is used, only the record number idump is read. 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. Especially, variables defined by the VARIABLE command can be modified...

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.

The options /BEFORE and /AFTER allows to select data depending on their observing dates.

5.22 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 (Plateau de Bure). 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).

5.23 PLOT

```
CLIC\PLOT keyword [/IDENTIFY [COLOUR]] [/NOFRAME [pen]] [/NODRAW]
[/RECORD list_of_records] [/RESET] [/APPEND] [/PHYSICAL]
[/BOXES nx ny]
```

Plot data from the current index according to options selected by the CLIC\SET command.

PLOT [ALL]

Erases the screen and plots all data in the current index (default).

PLOT FIRST

Erases the screen and plots data from the first observation in the current index.

PLOT NEXT

Plots data from the next observation in the current index. Does not clear the screen before plotting.

PLOT number

Plots data from the observation of the given number (must be in the current index). Does not clear the screen before plotting.

PLOT SAME

Plots again the last plotted buffers (with possibly new options, such as line type, limits, ...).

PLOT /NOFRAME [Pen]

Does not erase the screen, and plots data in the present boxes, optionally with a new pen. This is very useful for comparing data. It can also be used in conjunction with PLOT /APPEND.

PLOT /NODRAW

Does not produce the plot but read all data and update the X_DATA and Y_DATA buffers. This is very useful to e.g. modify these buffers in SIC before actual plotting (with PLOT SAME).

```
PLOT /RECORD list_of_records

    Plots only some records for the observation(s). "list_of_records" is
    of the format n1 to n2 n3 n4 to n5, as with the SIC\FOR command.

PLOT /IDENTIFY [COLOR]

    Plots  a different GREG symbol for each source (if SET PLOT POINT is
    currently active). Using optional argument COLOR will produce points
    also differing by color.

PLOT /PHYSICAL

    Plot labels use physical antenna number rather than logical numbers.

PLOT /BOX nx ny

    Plot  page  will be arranged with nx times ny boxes. Wildcard may be
    used.

PLOT /RESET

    Reset the time origin (and, by consequence, the  time-dependent  am-
    plitude and phase calibration curves) before plotting.

PLOT /APPEND

    Does  not  reset  the previous buffers before reading data and plot-
    ting.  This may be used at the Plateau  de  Bure  for  incrementally
    plotting new data just after it is written on disk.

After  the  plot,  the  arrays  X_DATA[N_DATA,N_BOXES]  and Y_DATA[N_DA-
TA,N_BOXES] contain the values of the points that have  been  displayed.
N_BOXES is the number of boxes that have been plotted, and N_DATA[N_BOX-
ES] is the number of data points  in  each  box.  W_DATA[N_DATA,N_BOXES]
contains the weights associated to each data point.
```

5.24 PRINT

```
    CLIC\PRINT Item

Prepares a procedure for further use.

PRINT BASELINE

    Prepares  a  procedure  to be used in OBS to enter the most recently
    fitted baseline parameters (SOLVE BASELINE command). This  procedure
```

also contains (but commented out) the CLIC\MODIFY command to edit previous data to the same fitted baseline parameters.

PRINT DELAY

Prepares a procedure to be used in OBS to enter the most recently fitted delay parameters (SOLVE DELAY command).

PRINT FLUXES

Prepares a procedure to be used in CLIC to re-enter the most recently determined source fluxes (SOLVE FLUX command).

5.25 RESIDUALS

```
CLIC\RESIDUALS item
```

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

5.26 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.

5.27 SET

```
CLIC\SET Keyword [Value1 [Value2 [...]]] [/DEFAULT]
```

This command is used to specify a value for a parameter used by CLIC. These values may be temporarily overridden by the options of some commands (e.g. FIND).

Each "SET Keyword" command has an equivalent "SHOW Keyword" command that display the current status. SET /DEFAULT restores all default values.

5.27.1 SET AMPLITUDE

```
CLIC\SET AMPLITUDE [ABSOLUTE|RELATIVE] [SCALED|UNSCALED]
[KELVIN|JANSKY] [ANTENNA|BASELINE] [RAW] [SIZED|UNSIZED]
[SPIDX|NOSPIDX]
```

This command controls which scaling factor is applied to the data for plotting and writing in the output 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; SCALED is only used for the command SOLVE AMPLITUDE.

- KELVIN|JANSKY indicates the unit in which the amplitude are displayed: either Kelvins (in main-beam brightness temperature) or Janskys.

SET AMPLITUDE ABSOLUTE forces SET AMPLITUDE KELVIN since the uncalibrated data are measured in Kelvins. With SET AMPLITUDE RELATIVE, the amplitudes are in Janskys, since a calibrator of known flux has been used for reference. If the default is overridden (SET AMPLITUDE ABSOLUTE JANSKY or SET AMPLITUDE RELATIVE KELVIN), conversion factors (=antenna efficiencies) are taken from the scan headers; these factors may be determined by SOLVE FLUX and stored by STORE FLUX.

SET AMPLITUDE 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 storing operation), and SET AMPLITUDE RELATIVE (application). Both baseline-based and antenna-based calibration curves may be stored alongside in the data header, independently of each other. Using SET AMPLITUDE ANTENNA is recommended.

SET AMPLITUDE RAW allows to plot the amplitude as correlation coefficient by dividing the amplitudes by the geometrical average of system temperatures of the antennas consisting the considered baseline.

SET AMPLITUDE SIZED|UNSIZED switches on and off a correction of the amplitude for source size (sources with known size are W3OH and MWC349).

SET AMPLITUDE SPIDX|NOSPIDX switches on and off a correction of the amplitude for the source spectral index (w.r.t. the reference frequency).

5.27.2 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 SECOND. The ANGLE unit is also used to display Continuum drifts.

5.27.3 SET ANTENNAS

```
CLIC\SET ANTENNAS [a1 a2 ...]
CLIC\SET ANTENNAS [ALL] [PHYSICAL]|[LOGICAL]
```

Selects the antennas for which data will be displayed by command PLOT. 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 arguments selects all antennas present in 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 the default.

Note that SET ANTENNA also allows to select the antenna to be processed by the SOLVE HOLOGRAPHY command (if several antennas are selected, the first one in the list is processed).

SET ANTENNA PHYSICAL|LOGICAL allows to select if the antenna numbers are to be interpreted as physical (i.e. antenna ID) or logical (rank of the antenna in the ordered list of antenna physical number available in the observation). The antenna numbering in the header of boxes in the PLOT will change according to this switch.

5.27.4 SET APC

```
CLIC\SET APC status
```

*** THIS COMMAND IS OBSOLETE ***

5.27.5 SET AVERAGING

```
CLIC\SET AVERAGING mode
```

Selects time averaging of data plotted (the data in the file is unaffected). 'mode' may be :

- NONE : all data points are plotted.
- SCAN : the scan-averaged data is used and only one point is thus plotted per scan.
- TIME dt : data is averaged in time intervals of length dt (seconds). Data of consecutive scans is NOT averaged together.
- METHOD VECTOR : complex visibilities are averaged as complex numbers.
- METHOD SCALAR : amplitude and phases of visibilities are averaged separately.
- CONT : sideband averages are computed on continuum subbands.
- LINE : sideband averages are computed on line subbands. Baseband averages are derived from the IF averages.

This command obviously does not affect the spectral data. See also SET BINNING for another way of averaging data.

5.27.6 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 sidebands selected), the plot page will be partitioned in order to:

- AUTO mode: approach this aspect ratio for each box while filling the whole page.
- EXACT mode: use this aspect ratio for each box (part of the plot

page will be left blank).

The default is 2.0 AUTO.

5.27.7 SET ATMOSPHERE

```
CLIC\SET ATMOSPHERE Argument Value /ANTENNA a1 [a2 ...]
```

Selects the way atmospheric calibration is done by command ATMOSPHERE, Argument may be FILE, AUTO, TREC, or MANUAL. This will affect the antennas given in argument to the option /ANTENNA (/ANTENNA ALL selects all antennas). Argument may also be NEW, 2009, 2003, OLD, 1985, to switch between atmospheric model versions or INTERPOLATE to use tabulated atmospheric model (defined to be GAG_ATMOSPHERE) ; option /ANTENNA is not required in that case.

- 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.

- OLD or 1985 select the old ATM model, in use at IRAM since circa 1985.

- 2003 select the 2003 version of the ATM model,developed by Juan Pardo in ISM in Madrid. For this, the new ATM library must be available. If not the old ATM will be used.

- NEW or 2009 (the default) select the 2009 ATM model,developed by Juan Pardo in ISM in Madrid. For this, the ATM library must be available. If not the old ATM will be used.

```
- INTERPOLATE will use a tabulated file produced  by  ASTRO\ATMOSPHERE
  MAKE.  This  option should not be used, as the use of tabulated file
  is only used to speed up calculations at Bure.
```

5.27.8 SET BANDS

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

Selects the sidebands for which data will be displayed by command  PLOT.
Valid  codes are "UPPER" or "USB", "LOWER" or "LSB", "AVERAGE" or "DSB",
"DIFFERENCE", and "RATIO".

In "AVERAGE", "DIFFERENCE" or "RATIO" modes, the sidebands  visibilities
are  corrected  before  combination for their relative phases, as deter-
mined 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).
```

5.27.9 SET BASELINES

```
    CLIC\SET BASELINES [b1 b2 ...]
    CLIC\SET BASELINES [ALL]  [PHYSICAL]|[LOGICAL]

Selects  the baselines for which data will be displayed by command PLOT.
Valid codes are pairs  of  antennas,  e.g.  "01-02",  "01-03",  "09-10",
etc...  This  command  is  exclusive with commands SET ANTENNAS and SET
TRIANGLES.

SET BASELINE with no argument selects all baselines connecting  the  an-
tennas previously in use. SET BASELINE ALL will select all the baselines
available in the first scan of the current index, for each  command  ac-
cessing the data (e.g. PLOT).  This is the default.

SET  BASELINE  PHYSICAL|LOGICAL allows to select if the baseline numbers
are to be interpreted as physical (i.e. antenna ID) or logical (rank  of
the  antenna in the ordered list of antenna physical number available in
the observation). The baseline numbering in the header of boxes  in  the
PLOT will change according to this switch.
```

5.27.10 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; default is 0). SET BINNING OFF will turn this mode off. Note that this averaging in bins occurs AFTER the averaging selected by SET AVERAGING.

SET BINNING is particularly useful for averaging spectra along the frequency axis and 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.

5.27.11 SET BPC

```
CLIC\SET BPC status
```

FIND will select observations according to the status of RF Bandpass Calibration (BPC). 'status' may be YES to select observations already calibrated, NO to select still uncalibrated observations, * to disregard this selection criterion. This command is very seldom used.

5.27.12 SET CLOSURE

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

*** THIS COMMAND IS OBSOLETE ***

Select weights to be used for each baseline when computing 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.

5.27.13 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). Use SHOW CRITERIA to list the current criteria.

SET /DEFAULT will set default values for all parameters (not only selection criteria).

5.27.14 SET DATA

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

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

5.27.15 SET DEFAULT

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

Reset all the SET parameters to their default values.

5.27.16 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.

5.27.17 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; this is the default.
- with ATMOSPHERE the rms phase fluctuations as measured when compressing the data, are included in the error bars.

5.27.18 SET EXTENSION

```
CLIC\SET EXTENSION string
```

Use 'string' as the list of the default extensions for the FILE IN command. The default is ".hpb .ipb" (in this order).

Not all extensions are accepted by CLIC: other possible values are ".ipb-raw", ".ipb-comp", ".ipb-cal", ".ipb-data".

5.27.19 SET FLUX

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

Enters ‘value’ as the flux (in Janskys) of source ‘name’.

The flux of one or several reference sources must be given to CLIC as an input to command SOLVE FLUX (which derives the antenna efficiencies and the fluxes of the other objects). If the flux of a source is entered by SET FLUX, this source will be a reference source. After "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. The reference sources are listed with a "FIXED" keyword (their flux is fixed), while the flux determined by SOLVE FLUX are listed as "FREE".

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

5.27.20 SET SPIDX

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

Enters ‘value’ as the spectral index of source ‘name’.

The flux of one or several reference sources must be given to CLIC as an input to command SOLVE SPIDX (which derives the antenna efficiencies and the spectral indexes of the other objects). If the spectral index of a source is entered by SET SPIDX, this source will be a reference source. After "SET SPIDX name *", source ‘name’ will not be a reference source any more. Its spectral index may then be re-determined by a subsequent SOLVE SPIDX command.

Use command SHOW SPIDX to list the spectral indexes known to the current CLIC session. The reference sources are listed with a "FIXED" keyword (their spectral index is fixed), while the flux determined by SOLVE SPIDX are listed as "FREE".

One may optionally enter a frequency (in GHz) and a date (jj-mmm-yyyy). The frequencies and dates are checked in that case by SOLVE SPIDX and

```
STORE SPIDX. 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 SPIDX ALL /RESET will empty the  spectral  index
list.
```

5.27.21 SET FORMAT

```
    CLIC\SET FORMAT Keyword [ON] [OFF]

Set the format of the header information listed with the LIST /LONG com-
mand. Each keyword indicate whether certain informations are to be writ-
ten  (ON) or not (OFF). If all Keyword are ON, then the same list of in-
formation as with the command HEADER is obtained.

    General information line  (always written)
         Observation number
         Scan number
         Project Id
         Source name
         Source type
         Procedure name
         Interferometer configuration
         Date of observation
         UT of observation
         Hour angle

     Position information line  (keyword POSITION)
         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)
         Flux of the source

     Quality information line (keyword QUALITY)
         Quality code
         Flag
         Receiver number
         Number of dump
         Azimuth
         Elevation

     Spectral line information line (keyword STATUS)
         Line name
         Rest frequency
```

```
        eideband
        Doppler correction
        Source velocity
        Quarter [for new receivers only]
        Polarization [for new receivers only]
        Narrow-band correlator input [for new receivers only]

    Correlator information, for each subband (keyword SPECTRAL)
        Logical name
        Width (MHz)
        Central IF (MHz)
        Physical unit

    Interferometer status, for each antenna (keyword INTERFERO)
        Antenna number
        Station

    Pointing & Focus correction, for each antenna (keywrod POINTING)
        Azimuth correction
        Elevation correction
        Focus correction

    Calibration information, for each antenna (keyword CALIBRATION)
        Receiver temperature (K)
        Image rejection (dB)
        Water (mm)
        System temperature (Tsys)
```

5.27.22 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, for the given sub-band and sideband, by the commands MODIFY FREQUENCY and MODIFY DOPPLER.

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 subband.

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

5.27.23 SET GAIN_IMAGE

```
CLIC\SET GAIN_IMAGE value /ANTENNA i|ALL
```

```
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.
```

5.27.24 SET GAIN_METHOD

```
CLIC\SET GAIN_METHOD OLD|NEW
```

```
Selects  the  method used to compute antenna-based gains from baselines-
based measured  quantities.  Default  is  OLD  (older  but  more  robust
method).

OLD  method: 'gain' for a antenna i is computed from three baselines (Gi
= Gij.Gik/Gjk). All possible "triangular ratios" including the antenna i
are  computed  and averaged (for the phase, only triangles including the
reference antenna are considered).

NEW method: 'ALMA' like method. Solves the linear  system  of  equations
(for the amplitudes, solves the logarithms).
```

5.27.25 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  juxtaposi-
tion  of  both sidebands of a common 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 the case for the 320  MHz  bands
at  the  Plateau de Bure correlator, as well as the 160 and 80 MHz bands
in some modes.

The GIBBS number is used by further PLOT and TABLE commands. The default
is 0, which is relevant for line sources with no continuum emission.
```

5.27.26 SET HOUR_ANGLE

```
CLIC\SET HOUR_ANGLE begin end
```

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

5.27.27 SET IC

```
CLIC\SET IC status
```

```
FIND will select observations according to the  status  of  Instrumental
(Phase+Amplitude)  Calibration  (IC).  'status' may be YES to select ob-
servations already calibrated, NO to select still uncalibrated  observa-
tions,  *  to  disregard  this selection criterion. This command is very
seldom used.
```

5.27.28 SET LEVEL

```
CLIC\SET LEVEL number
```

```
Set the threshold severity level (0-8) for messages to be output on  the
terminal. The default value is 4.

With SET LEVEL 1, all messages will be displayed. With SET LEVEL 8, only
key messages will be displayed (this is useful during pipeline  process-
ing).
```

5.27.29 SET LINE

```
CLIC\SET LINE name
```

```
FIND  will  select all observations according to the specified line name
(not case sensitive). Default is *.  A syntax like NAM* can be  used  to
find observations with line names beginning by NAM.
```

5.27.30 SET MODE

```
CLIC\SET MODE type
```

```
*** THIS COMMAND IS OBSOLETE ***

Selects  which  kind of data are displayed.  "type" stands  for  TIME or
SPECTRAL.  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.

This command is now obsolete. Please just select the  parameters  to  be
plotted using the SET X and SET Y commands.
```

5.27.31 SET NARROW_INPUT

```
    CLIC\SET NARROW_INPUT 0|1|2

*** THIS COMMAND IS OBSOLETE ***

Selects  the narrow-band correlator input.  The command is now obsolete.
Use SET BBANDS instead.
```

5.27.32 SET NUMBER

```
    CLIC\SET NUMBER n1 n2

FIND will select all Observations with numbers between n1 and  n2.   De-
fault is * *.
```

5.27.33 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' in-
ternal format and is available after the command VARIABLE GENERAL ON has
been issued).
```

5.27.34 SET OFFSETS

```
    CLIC\SET OFFSETS o1 o2

FIND  will select all observations with offsets o1 and o2.  Default is *
*. This is very useful in case of mosaic osbervations, in order  to  se-
lect a specific field (and e.g. create a UV table). See also SET RANGE.
```

5.27.35 SET PHASE

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

```
CLIC\SET PHASE ABSOLUTE|RELATIVE

    This command decides whether the phase calibration is applied or not
    to the data for plotting and writing the final UV table,  in  subse-
    quent  PLOT  and TABLE commands. ABSOLUTE means do not use the phase
    calibration determined by the SOLVE PHASE  command,  RELATIVE  means
    apply it.

CLIC\SET PHASE INTERNAL|EXTERNAL

    Switch between two modes of phase calibration.

    INTERNAL  is  the  standard  mode.  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, deter-
    mined on top of the phase curve Rec. 1, by  using  SOLVE  PHASE  and
    STORE PHASE with SET PHASE EXTERNAL in effect.

    SET PHASE INTERNAL  is recommended for Receiver 1,  SET PHASE EXTER-
    NAL for Receiver 2.

CLIC\SET PHASE ANTENNA|BASELINE

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

CLIC\SET PHASE ATMOSPHERE|NOATMOSPHERE

    Force CLIC to use or not the real-time atmospheric phase correction.
    The atmospheric phase correction is based on monitoring  the  atmos-
    phere  water vapor emission using either the total power measured by
```

```
    the 1.3 mm receivers or the 22 GHz water vapor  radiometers.  It  is
    applied in real-time to each dump before computing the scan-averaged
    quantities (spectra and continuum); these are further corrected  for
    the  average  atmospheric phase, hence leading to phases essentially
    not modified, but to improved amplitudes (correction of the decorre-
    lation).  This  phase-corrected  scan-averaged  dump will be used by
    CLIC after SET PHASE ATM has been issued.

    The phase correction will NOT be used if it has  been  declared  in-
    valid  for  a given scan, using the command STORE CORRECTION, except
    if SET PHASE NOFILE is in effect. See these commands.

    Note that the continuum 1 sec dumps are not corrected in  real-time,
    and  are  therefore  not  affected  by the SET PHASE ATM command. To
    avoid any confusion, SET PHASE ATM forces SET AVER SCAN.

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 will be used, and the
    phase correction will thsu 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 WVR|NOWVR

    Switch ON or OFF the off-line atmospheric phase correction based  on
    the  WVR  data. All data (individual as well as scan-averaged dumps)
    are affected. It is necessary to have run the  WVR  command  before.
    SET PHASE WVR forces SET PHASE NOTOTAL.

CLIC\SET PHASE TOTAL|NOTOTAL

    Switch  ON or OFF the off-line atmospheric phase correction based on
    the 1.3 mm total power monitoring. All data (individual as  well  as
    scan-averaged  dumps)  are affected. It is necessary to have run the
    MONITOR command before. SET PHASE TOTAL forces SET PHASE NOWVR.

CLIC\SET PHASE DEGREE|RADIANS

    Select the unit in which the phases are plotted.

CLIC\SET PHASE JUMPY|CONTINUOUS n
```

```
Selects the way phases are determined.  With argument JUMPY  no  at-
tempt  is  made  to  suppress 2pi jumps: the determination is always
[-pi,pi].  With argument "CONTINUOUS n", the phase jumps are limited
to  +/-  pi, that is the phase is always chosen in the range [previ-
ous-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).
```

5.27.36 SET PLANET

```
    CLIC\SET PLANET *|PRIMARY|FILE [filename]

Planet model to be used by the SOLVE FLUX command.

    * = default (elliptical disc)

    PRIMARY = same with primary beam attenuation

    FILE filename : use data in file filename (must be cubic splines).
```

5.27.37 SET PLOT

```
    CLIC\SET PLOT LINE|POINTS|HISTOGRAM|BARS
    CLIC\SET PLOT PHYSICAL|LOGICAL HEADER|IPB

Selects the way the data are displayed.  "type" stands for LINE, POINTS,
HISTOGRAM,  or BARS. With POINTS, the current GreG marker, as defined by
the GREG\SET MARKER command, is used.  With BARS  (valid  only  for  the
visibility data, i.e. amplitude, phase, real, or imaginary), 1-sigma er-
ror bars are drawn.

Can also force plotting physical antenna wiht SET PLOT PHYSICAL (can  be
reverted with SET PLOT LOGICAL).

Normally,  with  SET PLOT IPB (default), CLIC looks for the data headers
(stored in the IPB file) even if one plots parameters in the observation
(which  is  contained  also contained in the .hpb file). SET PLOT HEADER
allows to bypass this check, but flags can be lost.
```

5.27.38 SET POLARIZATION

```
    CLIC\SET POLARIZATION NO|HOR|VER|BOTH|EACH

Selects the polarization of the new receivers. HOR and VER refers to the
```

two polarization channels (but the 'horizontal' or 'vertical' definition is arbitrary). BOTH means that both polarization must be used and averaged when applicable (eg time variation of the phase or amplitude). EACH will plot H and V polarization separately but at the same time (e.g. useful to SOLVE DELAY).

SET POLARIZATION NO makes CLIC forget anything about polarization. This is the mode to use to reduce data from the old receivers (<2007).

5.27.39 SET PROCEDURE

```
CLIC\SET PROCEDURE proc
```

FIND will select observations done under procedure 'proc'. Known procedures are: CORRELATION, AUTOCORR, GAIN, DELAY, FOCUS, POINTING, CALIBRATE, IFPB, ONOFF, HOLOGRAPHY, FIVE_POINT, PSEUDO_CONT, FLUX, STABILITY, CWVR, VLBI, VLBG, OTF, BANDPASS, SKYDIP.

SET PROCEDURE * will disable procedure as a selection criterion.

5.27.40 SET PROJECT

```
CLIC\SET PROJECT projId
```

FIND will select observations done for the observing project projId. SET PROJECT * will disable project number as a selection criterion.

5.27.41 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.

5.27.42 SET RANGE

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

FIND will select all observations with offsets in the specified range. Default is * * * *. See also SET OFFSET command.

5.27.43 SET RECEIVER

```
CLIC\SET RECEIVER number
```

```
Use  the receiver number as a selection criterion. With the OLD receiver
system at Plateau de Bure (<2007), Receiver 1  is  the  3  mm  receiver,
while  Receiver  2  is the 1.3 mm receiver. With the NEW receiver system
(>2007), 4 receiver bands are available:

  - receiver band 1: 80-117 GHz (3mm band) -- AVAILABLE

  - receiver band 2: 129-174 GHz (2mm band)

  - receiver band 3: 200-257 GHz (1.3mm band) -- AVAILABLE

  - receiver band 4: 277-371 GHz (1mm band)

The default is SET RECEIVER * : observations with all receivers will  be
selected.

For OLD receiver data, SET RECEIVER 1 does automatically a SET PHASE IN-
TERNAL, while SET RECEIVER 2 does SET PHASE EXTERNAL. See the SET  PHASE
command  help.  For NEW receiver data, SET PHASE INTERNAL is the default
for all bands.
```

5.27.44 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.
```

5.27.45 SET REDUCED

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

```
FIND will select all observations with reduction dates  between  d1  and
d2 (format jj-mmm-yyyy). Default is * *.
```

5.27.46 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).  The phase
```

for this antenna is set to zero. Default is Antenna 1.

5.27.47 SET RF_PASSBAND

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

This command controls the behaviour of CLIC regarding the RF passband calibration.

SET RF_PASSBAND ON|OFF

Switch ON or OFF the application of RF passband calibration curve in plotting the data. The RF passband calibration curve is computed 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 ON|OFF.

SET RF_PASSBAND 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, while the frequency-dependent passband curve is determined by using SOLVE RF_PASSBAND on all subbands together (Note: this will not work for data taken before July 14th 1990). SET RF_PASSBAND FREQUENCY is recommended.

SET RF_PASSBAND MEMORY|FILE

Use either the passband curves just determined by SOLVE RF_PASSBAND, and still present in the program memory, or the passband curves previously stored in the data headers of the input file by a command STORE RF_PASSBAND.

SET RF_PASSBAND ANTENNA|BASELINE

Switch between Antenna-based and Baseline-based RF passband calibrations. This switch will be active for SOLVE RF_PASSBAND (passband determination), STORE RF_PASSBAND (passband storing operation), and SET RF_PASSBAND ON (fpassband application). Both baseline-based and antenna-based calibration curves may be stored alongside in the data header, independently of each other. SET RF_PASSBAND ANTENNA is recommended.

SET RF_PASSBAND SPECTRUM

In the MEMORY mode, will look for a SPECTRUM solution in memory (obtained after a SOLVE RF /SPECTRUM command). In FILE mode, this will look for a scan stored in the hpb file. In several file are present they can be selected with SET RF FILE #i. Solutions can be listed with LIST /BANDPASS option.

5.27.48 SET SKIP

```
SET SKIP YES|NO
```

Controls behaviour of FIND command. If set to YES, FIND will skip auto-correlations that are stored together with cross-correlations, while keeping the genuine autocorrelations (e.g. AUTO, CAL).

5.27.49 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 * *.

5.27.50 SET SELECTION

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

Choose the type of data selection to be done by command TABLE (to create an output UV table).

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

- The second argument is the sideband to be used: UPPER (or USB), LOWER (or LSB), AVERAGE (or DSB), AUTO or SSB. 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. AUTO will determine for each narrow input whether the receiver tuning is DSB or SSB and accordingly select DSB (write a visibility for each sideband) or the signal sideband if SSB. SSB will write one visibility for the signal side band (automatically determined). This last two options are useful for continuum only. For LINE, they will just select the matching side band as does DSB.

- The third argument is a subband list.In CONTINUUM mode, subbands are averaged, in spectral mode they are combined to produce a single spectrum. The subband list is given with the same syntax as in the SET SUBBAND command, e.g. "n1 to n3" or "n1 to n3 and n5".

Example: SET SELECTION CONTINUUM USB C01 AND C03 AND C05 selects continuum data, USB, and the subbands C01, C03, and C05.

Arguments "FREQUENCY 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 is 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....

5.27.51 SET SOURCE

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

FIND will select all scans according to the specified source names (matching is not case-sensitive). Up to 10 source names can be given. Syntax like NAM* can be used to find all observations with source name beginning by NAM. Default is *.

5.27.52 SET SORT

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

The output of LIST and LIST /SHORT may be sorted primarily be receiver number or scan number or observation number. Use SET SORT to switch between the three modes. Default is RECEIVER mode.

5.27.53 SET SPECTRUM

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

*** THIS COMMAND IS OBSOLETE ***

5.27.54 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).

5.27.55 SET SUBBANDS

```
CLIC\SET SUBBANDS n1 n2 ...  [/WINDOW f1 l1 f2 l2 ...]
CLIC\SET SUBBANDS LINE|CONT
CLIC\SET SUBBANDS ALL
CLIC\SET SUBBANDS EACH
CLIC\SET SUBBANDS HOR|VER
CLIC\SET SUBBANDS Q1|Q2|Q3|Q4
CLIC\SET SUBBANDS NBC1|NBC2
```

*** THIS COMMAND IS OBSOLETE ***

Selects the subbands for which data will be displayed by command PLOT. Valid codes are continuum subbands numbers (C01, C02, ... C08) or line subbands numbers (L01, L02, ... L08). These are logical numbers, so one should select e.g. L01 to L04 if four correlator units were used, independentely from the physical units actually used. This is a classical trap, especially with the old receiver system (<2007): if e.g. units 1 to 5 were used on Receiver 1 and units 6 to 8 on Receiver 2, the corresponding subbands will be L01 to L05 for the Receiver 1 scan, and L01 to L03 for the Receiver 2 scan.

Subbands may be grouped by typing e.g. "SET SUBBANDS n1 to n2 and n3 n4". Here, two quantities will be plotted. The first one is either the average of 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 quantity plotted is subband n4.

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 SUBBANDS CONT. Done by SET X I_F

A number of usefule shortenings are available:

- SET SUBBANDS ALL will automatically select all the subbands in the first scan of the current index, for each command accessing the da-

```
ta. The subbands are concatenated (equivalent to e.g.  SET  SUBBANDS
L01 to L06).

-  SET SUBBANDS EACH will automatically select all the subbands in the
  first scan of the current index, for each command accessing the  da-
  ta.  The  subband are NOT concatenated (equivalent to e.g.  SET SUB-
  BANDS L01 L02 L03 L04 L05 L06).

- SET SUBBANDS HOR|VER will automatically select (in the first scan of
  the  current index) the subbands connected to the horizontal or ver-
  tical polarization channel (if any). The subbands are concatenated.

- SET SUBBANDS Q1|Q2|Q3|Q4 will automatically  select  (in  the  first
  scan  of  the  current index) the subbands connected to the selected
  quarter (if any). The subbands are concatenated.

- SET SUBBANDS NBC1|NBC2 will automatically select (in the first  scan
  of the current index) the subbands connected to the selected narrow-
  band correlator input (if any). The subbands are concatenated.


CLIC\SET SUBBANDS n1 n2 ...  /WINDOW first1 last1 first2 last2 ...

The /WINDOW option select the first and last channels to be used for
the  LINE subbands. There should be one couple of parameter for each
group of subbands.

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 10 64

    will  avoid plotting channels 1 to 9 of each of the two subbands
L01 and L02 (which are here combined to a single spectrum). This may
be  useful  to flag meaningless channels at the low-frequency and at
the high frequency ends of each spectral correlator. Note:  this  is
now done automatically, see SET DROP command.

In  time mode, the window limits select the data to be integrated to
compute a single point.For example
    SET SUBBANDS L01 L02 /WINDOW 1 10 1 10 will plot data integrated
from  the  first  ten channels of the first line subband, as a first
quantity, and data integrated from the first 10 channels of the sec-
ond line subband, as a second quantity.

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).
This command is now obsolete. Use SET SPW instead.

5.27.56 SET SPW

CLIC\SET SPW CLIC\SET SPW n1 n2 ... [/WINDOW f1 l1 f2 l2 ...] [/NOSELECT]
CLIC\SET SPW LINE|CONT
CLIC\SET SPW ALL
Selects the spectral windows for which data will be displayed by command PLOT. Valid codes are continuum spw numbers (C001, C002, ... C008) or line spw numbers (L001, L002, ... L008). These are logical numbers, so one should select e.g. L01 to L04 if four correlator units were used, independentely from the physical units actually used. This is a classical trap, especially with the old receiver system (<2007): if e.g. units 1 to 5 were used on Receiver 1 and units 6 to 8 on Receiver 2, the corresponding spw will be L01 to L05 for the Receiver 1 scan, and L01 to L03 for the Receiver 2 scan.

Spectral windows may be grouped by typing e.g. "SET SPW n1 to n2 and n3 n4". Here, two quantities will be plotted. The first one is either the average of spw n1 to n2 and n3 (in time mode), or the concatenation of spectral data from spw n1 to n2 and n3 (in spectral mode). The second quantity plotted is spw n4.

SET SPW LINE|CONT will switch all spw to their line/continuum counterpart, e.g. L01 to L04 will be changed to C01 to C04 by SET SPW CONT. Done by SET X I_F

SET SPW n1 /NOSELECT will select spectral window n1 while keeping previous selection mode (i.e. BB or IF selection) which allows to select a high-spectral resolution spectral window for delay determination (that needs BB or IF selection). This will update the baseband or IF value if necessary.

A number of useful shortenings are available:

- SET SPW ALL will automatically select all the subbands in the first scan of the current index, for each command accessing the data. The subbands are concatenated (equivalent to e.g. SET SPW L01 to L06).

5.27.57 SET TELESCOPE

```
CLIC\SET TELESCOPE name
```

```
FIND  will  select  all scans according to the specified telescope (i.e.
interferometer configuration) name.  Default is *.  Syntax like NAM* can
be used to find all observations with telescope name beginning by NAM.
```

5.27.58 SET TIME_ORIGIN

```
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.
01-AUG-2004). "SET TIME_ORIGIN *" resets the default (automatic)  behav-
iour.
```

5.27.59 SET TOTAL_POWER

```
CLIC\SET TOTAL_POWER RAW|PHYSICAL
```

```
For  new receivers, switch between total power as measured by the corre-
lator (raw) in units of (sigma/v)^2 and "physical" temperature scale (in
K).
```

5.27.60 SET TREC

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

```
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.
```

5.27.61 SET TRIANGLE

```
CLIC\SET TRIANGLE t1 t2 ... PHYSICAL|LOGICAL
```

```
Selects the triangle products for which data will be  displayed  by com-
mand  PLOT.  Valid  triangles are codes as e.g. "123"  or  "345".  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.

5.27.62 SET TYPE

```
CLIC\SET TYPE par
```

FIND will select observations of specified type 'par'. This may be OBJECT, PHASE (i.e. calibrators), or RF (i.e. RF passband calibrator; this is obsolete). Use argument "*" to disable selection by source type.

5.27.63 SET UV_RANGE

```
CLIC\SET UV_RANGE UVmin UVmax
```

This command will force all further PLOT commands to use only the points that are within this range in the UV plane, i.e. those for which UVmin < sqrt(U**2+V**2) < UVmax.

5.27.64 SET VIRTUAL

```
CLIC\SET VIRTUAL
```

*** THIS COMMAND IS OBSOLETE ***

5.27.65 SET WATER

```
CLIC\SET WATER value
```

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.

5.27.66 SET WEIGHTS

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

Selects the way the weights written in the output file by the command TABLE are computed.

Weights are always proportional to observing time.

With TSYS ON, data is also 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 calibration.

Default is TSYS ON and CALIBRATION ON, which results in weights equal to 1/sigma^2, where sigma is the thermal noise in the data.

5.27.67 SET X

```
CLIC\SET X param1 [param2 ...] [/LIMITS min1 max1 [min2 max2 ...]]
```

Choose the parameters to be plotted along X-axes by command PLOT.

Parameters valid in both TIME mode and SPECTRAL mode:

AMPLITUDE, PHASE, REAL, or IMAGINARY: referring to the visibility in the spectral window(s) or baseband(s) or IF(s), sideband(s), baseline(s) (or antenna(s)) selected by SET SPW, SET BBAND, SET IF, 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 SPW (or SET BB) 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 intermediate frequency in the data.

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

IF1 : the frequency in the first IF frequency

IF2 : the frequency in the second IF frequency

IF3 : the frequency in the third IF frequency

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).

LO1_FREQ: LO1 frequency

LO1_REF: LO1 ref frequency

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

CABLE_ALTERNATE: idem for the unused reference

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.

TOT_SCALE: scaling factor to go from cts to K for total power

DH_ACTP[1-8]: the total power measured in the autocorrelation (NB correlator)

DH_ANTTP: the total power measured in the warm IF cartridge

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 ... T09 : general test parameters (in data headers)

T10 ... T29 : 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_DIR_AV, 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  mea-
  sured 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 tem-
  perature.

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.

WVRTAMB, WVRTPEL: The temperature of the water vapor radiometer (WVR) ambient load and peltier cooler.

WVRTCAL1, WVRTCAL2, WVRTCAL3 : The channel gains for the 3 frequency bands.

WVRREF1, WVRREF2, WVRREF3 : The average counts on reference observation

WVRAVER1, WVRAVER2, WVRAVER3 : The average counts on current observation

WVRAMB1, WVRAMB2, WVRAMB3 : The average counts on last ambient measurement

WVRTREC1, WVRTREC2, WVRTREC3 : The receiver temperatures

WVRFEFF1, WVRFEFF2, WVRFEFF3 : The coupling factors to sky

WVRMODE : The calibration mode

WVRH2O, WVRPATH : The precipitable water vapor and corresponding pathlength

WVRTSYS1, WVRTSYS2, WVRTSYS3 : The system temperatures

WVRDPATH1, WVRDPATH1, WVRDPATH3 : The Kelvin to water vapor pathlength (model)

WVRFPATH1, WVRFPATH2, WVRFPATH3 : The Kelvin to water vapor pathlength (empirical)

WVRLIQ1, WVRLIQ2, WVRLIQ3 : The Kelvin to liquid water emission

WVRDCLOUD1, WVRDCLOUD2, WVRDCLOUD3 : The Kelvin to liquid water pathlength (model)

WVRTATM : The temperature of atmosphere

WVRQUAL : The quality code

DH_WVR1, DH_WVR2, DH_WVR3 : counts of each WVR channel

DH_WVRSTAT : status word

WVR_PHA_M : The WVR phase value (model)

WVR_PHA_E : The WVR phase value (empirical)

WVR_PHA_C : The WVR phase value due to Cloud (Model)

tatm_s, tatm_i : The temperature of the atmosphere in the signal and image band

REFC1, REFC2, REFC2: refraction coefficients.

REFRACTION: refraction correction.

ATTENUATION: attenuation in the warm IF cartridge

LILEVL[01\-12]: tweak level (LSB for DSB correlator)

LILEVU[01\-12]: tweak level (USB for DSB correlator)

TIM[01\-04]: timing parameters

LASER_LEVEL : optical power in the fiber optic Rx

HIQ_ATTEN[1-2]: high-Q cable attenuation

WIDEX_TEMP[1-4]: WIDEX unit temperatures

INCLIX, INCLIY: station inclination (/X,/Y)

INCLI_TEMP: inclinometer temperature

The available parameters are the same as with the SET Y command. Default is SET X TIME.

The /LIMITS option is used to specify fixed limits, e.g.: "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 = =".

5.27.68 SET Y

```
CLIC\SET Y param1 [param2 ...] [/LIMITS min1 max1 [min2 max2 ...]]
```

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

Parameters valid in both TIME mode and SPECTRAL mode:

AMPLITUDE, PHASE, REAL, or IMAGINARY: referring to the visibility in the spectral window(s) or baseband(s) or IF(s), sideband(s), baseline(s) (or antenna(s)) selected by SET SPW, SET BBAND, SET IF, 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 SPW (or SET BB) 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 intermediate frequency in the data.

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

IF1 : the frequency in the first IF frequency

IF2 : the frequency in the second IF frequency

IF3 : the frequency in the third IF frequency

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).

LO1_FREQ: LO1 frequency

LO1_REF: LO1 ref frequency

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

CABLE_ALTERNATE: idem for the unused reference

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.

TOT_SCALE: scaling factor to go from cts to K for total power

DH_ACTP[1-8]: the total power measured in the autocorrelation (NB correlator)

DH_ANTTP: the total power measured in the warm IF cartridge

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 ... T09 : general test parameters (in data headers)

T10 ... T29 : 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_DIR_AV, 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.

WVRTAMB, WVRTPEL: The temperature of the water vapor radiometer (WVR) ambient load and peltier cooler.

WVRTCAL1, WVRTCAL2, WVRTCAL3 : The channel gains for the 3 frequency bands.

WVRREF1, WVRREF2, WVRREF3 : The average counts on reference observation

WVRAVER1, WVRAVER2, WVRAVER3 : The average counts on current observation

WVRAMB1, WVRAMB2, WVRAMB3 : The average counts on last ambient measurement

WVRTREC1, WVRTREC2, WVRTREC3 : The receiver temperatures

WVRFEFF1, WVRFEFF2, WVRFEFF3 : The coupling factors to sky

WVRMODE : The calibration mode

WVRH2O, WVRPATH : The precipitable water vapor and corresponding pathlength

WVRTSYS1, WVRTSYS2, WVRTSYS3 : The system temperatures

WVRDPATH1, WVRDPATH1, WVRDPATH3 : The Kelvin to water vapor pathlength (model)

WVRFPATH1, WVRFPATH2, WVRFPATH3 : The Kelvin to water vapor pathlength (empirical)

WVRLIQ1, WVRLIQ2, WVRLIQ3 : The Kelvin to liquid water emission

WVRDCLOUD1, WVRDCLOUD2, WVRDCLOUD3 : The Kelvin to liquid water pathlength (model)

WVRTATM : The temperature of atmosphere

WVRQUAL : The quality code

DH_WVR1, DH_WVR2, DH_WVR3 : counts of each WVR channel

DH_WVRSTAT : status word

WVR_PHA_M : The WVR phase value (model)

WVR_PHA_E : The WVR phase value (empirical)

WVR_PHA_C : The WVR phase value due to Cloud (Model)

tatm_s, tatm_i : The temperature of the atmosphere in the signal and

```
    image band

  REFC1, REFC2, REFC2: refraction coefficients.

  REFRACTION: refraction correction.

  ATTENUATION: attenuation in the warm IF cartridge

  LILEVL[01\-12]: tweak level (LSB for DSB correlator)

  LILEVU[01\-12]: tweak level (USB for DSB correlator)

  TIM[01\-04]: timing parameters

  LASER_LEVEL : optical power in the fiber optic Rx

  HIQ_ATTEN[1-2]: high-Q cable attenuation

  WIDEX_TEMP[1-4]: WIDEX unit temperatures

  INCLIX, INCLIY: station inclination (/X,/Y)

  INCLI_TEMP: inclinometer temperature
```

```
The  available  parameters  are the same as with the SET Y command.  De-
fault is SET Y AMPLITUDE PHASE.

The /LIMITS option is used to specify fixed limits, e.g.: "SET Y  AMPLI-
TUDE  /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 * * * if SET
PHASE  CONTINUOUS  is  effective, 0 * -180 180 if SET PHASE JUMPY DEGREE
(with corresponding values if SET PHASE RADIANS).
```

5.28 SHOW

```
    CLIC\SHOW Argument
```

```
Display the parameters defined by SET. Each "SET Argument"  command  has
an equivalent "SHOW Argument".

In  addtion,  "SHOW  ALL"  will display all parameters specified by SET.
"SHOW CRITERIA" will display only selection  criteria  for  the  command
```

FIND, "SHOW DISPLAY" will give only the parameters relevant to command PLOT, and "SHOW GENERAL" will give the rest of the parameters.

5.29 SOLVE

```
CLIC\SOLVE Item
```

This is a command to determine interferometer parameters from measured data. SOLVE is processing the current index.

5.29.1 SOLVE AMPLITUDE

```
CLIC\SOLVE AMPLITUDE  [/PLOT] [/BREAK kind time [kind time ...]
[/POLYNOMIAL [degree]] [/WEIGHT] [/RESET]
```

This command fits 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 AMPLITUDE 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 AMPLITUDE internally and temporarily resets SET AMPLITUDE to SCALED.

In antenna mode (selected by SET AMPLITUDE ANTENNA), 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. Option /RESET will reset the calibration curve in memory.

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 ...]" which introduces a break 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.

5.29.2 SOLVE BASELINE

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

This uses a linear method to determine baselines. 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. With SET ANTENNA in action the antenna position offsets are directly fitted to the antenna phases, ensuring baseline closure.

The fitting should work only if the starting values are within half a wavelength in any direction of the true values. 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 arguments range and interval are 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.

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.

The /RESET option resets the solutions in memory.

The /PLOT option allows to plot the data used for fitting.

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

If 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.

5.29.3 SOLVE DELAY

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

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 /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.

The results are given in nanoseconds. Use option /PRINT or command PRINT DELAY to create a procedure file (INTER_OBS: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 will be plotted over the data. One needs to select an IF or a baseband beforehand (set SET IF or SET BB).

5.29.4 SOLVE FLUX

```
    CLIC\SOLVE FLUX [NOREFERENCE]  [BEST  n]  [REAL]  [/RESET]  [/OUTPUT
file]

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

It  should be used before computing any amplitude calibration, on an in-
dex covering a reasonably short time interval to  avoid  possible  effi-
ciency variations.

The commands should be used in the following way:

  -  The  command SET FLUX is 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.

  -  Then the command SOLVE FLUX will use the sources of known flux (op-
    tionally with matching frequencies and dates) to determine the effi-
    ciencies  for  all  antennas. SOLVE FLUX now gives the decorrelation
    factor relative to the efficiencies logged in the scan headers  (as-
    sumed to be the standard single-dish efficiencies).

  - SOLVE FLUX then uses these antenna efficiences to compute the fluxes
    of all other sources. IF the keyword "BEST n" is present, the n  an-
    tennas  giving the highest fluxes will be used for averaging (n is 1
    to the number of available antennas). Default is n=3.

  - The command SHOW FLUX will give the current flux list. The reference
    sources  are  listed with a "FIXED" keyword, while the fluxes deter-
    mined by SOLVE FLUX are listed as "FREE".

  - SOLVE FLUX /RESET can be used to reset the flux  list  (i.e.  remove
    from  the  list all sources whose flux is not fixed) before process-
    ing.

  - SOLVE FLUX /OUTPUT file [NEW] will produce an output file  with  the
    results  printed  for  each  antenna.  Use keyword NEW to open a new
    file.

  - The command PRINT FLUX will create a procedure that may be used lat-
    er 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.

If no reference sources are available, the keyword NOREFERENCE should be given, and the default efficiencies stored in the data header will be used (step 2 in the above list is bypassed).

The keyword REAL forces SOLVE FLUX to use the real part of the visibilities instead of the amplitude to derive the antenna efficiencies and source fluxes. This is only for test purposes and must not be used without asking an expert.

5.29.5 SOLVE SPIDX

CLIC\SOLVE SPIDX [NOREFERENCE] [BEST n] [REAL] [/RESET] [/OUTPUT file]

Calculate the spectral indexes of the sources in the current index or the antenna efficiencies (Jansky to Kelvin) if the source spectral index is known. The command can also be used to bootstrap source spectral indexes 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 SPIDX is used to define the spectral index of one, or several of the sources in the current index for which the spectral index is known. Frequencies and dates may be specified.

- Then the command SOLVE SPIDX will use the sources of known spectral index (optionally with matching frequencies and dates) to determine the efficiencies for all antennas. SOLVE SPIDX now gives the decorrelation factor relative to the efficiencies logged in the scan headers (assumed to be the standard single-dish efficiencies).

- SOLVE SPIDX then uses these antenna efficiences to compute the spectral indexes of all other sources. IF the keyword "BEST n" is present, the n antennas giving the highest fluxes will be used for averaging (n is 1 to the number of available antennas). Default is n=3.

- The command SHOW SPIDX will give the current spectral index list. The reference sources are listed with a "FIXED" keyword, while the spectral indexes determined by SOLVE SPIDX are listed as "FREE".

- SOLVE SPIDX /RESET can be used to reset the spectral index list (i.e. remove from the list all sources whose spectral index is not fixed) before processing.

- SOLVE SPIDX /OUTPUT file [NEW] will produce an output file with the results printed for each antenna. Use keyword NEW to open a new file.

- The command STORE SPIDX will store the spectral indexes and efficiencies in the headers of the observations in the current index.

If no reference sources are available, the keyword NOREFERENCE should be given, and the default efficiencies stored in the data header will be used (step 2 in the above list is bypassed).

The keyword REAL forces SOLVE SPIDX to use the real part of the visibilities instead of the amplitude to derive the antenna efficiencies and source spectral indexes. This is only for test purposes and must not be used without asking an expert.

5.29.6 SOLVE FIVE

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

Find pointing corrections from FIVE point scans. All five-point scans in the current index are processed by a gaussian fit. Its width can be fixed if the argument 'beam' is given (in arcsec). All continuum subbands and both side bands are averaged. The fits may be displayed with option /PLOT.

The presence of option /PRINT produces a procedure file (INTER_OBS:pointing.obs), to be used in OBS for introducing the fitted pointing offset.

The results may also be written on an output ASCII 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). With argument TPOINT, the output is written in a format suitable for processing by the TPOINT program.

5.29.7 SOLVE FOCUS

```
CLIC\SOLVE FOCUS [/PLOT] [/COMPRESS time_max] [/PRINT]
[/OUTPUT filename [NEW][OLD]] [/TOTAL] [/FIX par1 [value] ...]
```

Find focus corrections from a FOCUS scan using a parabolic fit. All focus scans in the current index are processed. SET AVERAGE 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 5 seconds.

The presence of option /PRINT produces a procedure file (INTER_OBS:focus.obs), to be used in OBS for introducing the fitted focus offset. With option /OUTPUT, results of the fit, together with elevation and azimuth, are written in an output ASCII file, for further examination.

With option /TOTAL, SOLVE FOCUS uses the total power to solve for axial focus errors. In that case, option /FIX may be used to fix one parameter. Possible parameters are:

```
FOCUS: the axial focus error (mm)
PEAK: the peak amplitude, in total power units
WIDTH: the HPW of focus curve  (mm)
ZERO: the off-source zero level, in total power units
```

With /TOTAL, /COMPRESS does the ON-OFF combination if in beam switching mode. In that case ZERO is preferrably fixed to zero (e.g. SOLVE FOCUS /TOTAL /COMPRESS /PLOT /FIX ZERO 0).

5.29.8 SOLVE GAIN

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

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 (DSB receiver up to 2006), or the relative phases between basebands (SSB dual-polarisation receivers).

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 produces a procedure INTER_OBS:gain.obs to set the gains (and phases) in OBS.

Option /OFFSET allow to only compute the phases, not the gain ratio.

5.29.9 SOLVE HOLOGRAPHY

```
CLIC\SOLVE HOLOGRAPHY [NPOINTS npix]
[FREE [RINGS r1 r2] [SECTOR s1 s2]]
[MODES nmodes]
[ITER niter gain]
[MASK npanels p1 p2 p3 ...]
[BASELINES b1 b2 b3 ... ]
[POINTING x1 y1]
[REFERENCE a1]
[DISTANCE dist]
[DIAMETER diam]
[DEFOCUS df]
[TAPER t]
[FOCUS df]
[TYPE ASDM|VERTEX|AEC|MELCO12_1|MELCO12_2|MELCO12_3|BURE|IRAM30]
[TEST testFile]
[FRESNEL]
[NOFOCUS]
[NOXYFOCUS]
[ASTIGMATISM [ANGLE astangle]]
[APODIZE]
[NOFEED]
[BEAM SIGNAL|REFERENCE]
[RIGGING e1 e2]
[TEMP_BIAS t]
[FIXSPACING s]
[/PLOT [AMP amin amax astep] [PHA pmin pmax pstep]
[ERRORS emin emax estep]  [NUMBER]]
[/OFFSET x y z]
```

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.

SOLVING FOR ANTENNA PARAMETERS

The amplitude and phase maps are obtained by FFT 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 displayed (in decibels), from -15 to 0 dB, with contours in steps of 3db (these may be changed using "/PLOT AMP amin, amax and astep").

A least square fit is used to correct the phases from a remaining phase offset, pointing errors, and focus offsets. The panel rings following the keyword 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 "/PLOT ERRORS 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.

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.

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).

SOLVING FOR PANEL DISPLACEMENTS

Finally, if "PLOT MODE nmodes" is entered with nmodes larger than 0, a listing of panels displacements is computed. This uses the parameter nmodes which is the number of modes used for each panel: 1 is the translation mode only (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).

The results of this computation is written in  a  file  "panels-an1.dat"
(or similar name for other antennas). In this file, a line for each pan-
el 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.

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 or-
der 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 (ITER niter gain); their default values are 5 and  1.0  .  Use
ITER 0 for no iterative procedure at all. At each step the phase residu-
al rms and the rms of panel deformations fitted are given  (weighted  by
the  fitted  amplitude  illumination  and counted perpendicularly to the
surface).

Variables containing antenna parameters are available:
  -TAPER_X, TAPER_Y: illumination tapers.
  -OFFSET_X, OFFSET_Y: illumination offsets.
  -RMS_PHA_U, RMS_PHA_W: phase r.m.s (unweigthed or weighted by  illumi-
    nation).
  -ETA,  ETA_230,  ETA_345:  aperture efficiency at observing frequency,
    230 and 345 GHz.
  -ETA_I, ETA_S: illumination and feed taper efficiency.
  -RUZE, RUZE_230, RUZE_345: ruze factor at observing frequency, 230 and
    345 GHZ
  -JYKEL, JYKEL_230, JYKEL_345: antenna efficiency at observing frequen-
    cy, 230 and 345 GHz.
  -HOLO_FOCUS: focus position.
  -HOLO_RMS: surface r.m.s. (unweighted or weighted by illumination).
  -HOLO_RING: rings r.m.s

SOLVE HOLOGRAPHY options

SOLVE HOLOGRAPHY NPOINTS npix

    Gives the number of pixels of the amplitude and phase maps.  Default
    is 64.

SOLVE HOLOGRAPHY MODE nmodes
```

```
    Force  CLIC  to compute the panel displacements (see above).  nmodes
    is 1 to 5.

SOLVE HOLOGRAPHY ITER niter gain

    Select the number of iteration and gain to be  used  for  the  panel
    displacement determination (see above). Does make sense only if used
    in conjonction with the MODES keyword.

SOLVE HOLOGRAPHY BASELINES b1 b2 b3 ...

    By default, all baselines connecting the antenna to be studied  (se-
    lected  by  SET  ANTENNA)  to  a fixed antenna are used. The keyword
    BASELINES allows to specifically select the baselines to be used.

SOLVE HOLOGRAPHY MASK npanels p1 p2 p3 ...

    Allows to mask some panels.

SOLVE HOLOGRAPHY REFERENCE a1

    Allow to select a reference baseline (ALMA specific)

SOLVE HOLOGRAPHY FREE [RINGS r1 r2] [SECTOR s1 s2]

    With keyword RINGS, indicates the ring NOT to be used for paraboloid
    fit.  With keyword SECTORS, indicates the sectors NOT to be used for
    paraboloid fit.

SOLVE HOLOGRAPHY ASTIGMATISM [ANGLE astAngle]

    Options for fitting. With keyword ANGLE, SOLVE  HOLOGRAPHY  ASTIGMA-
    TISM uses a forced astAngle (in degrees) for astigmatism orientation
    and fits only astigmatism r.m.s.

SOLVE HOLOGRAPHY NOFOCUS NOXYFOCUS

    Options for fitting. With keyword NOFOCUS, no attempt is made to fit
    the  focus. With keyword NOXYFOCUS, only the z component of focus is
    fitted.

SOLVE HOLOGRAPHY FOCUS f

    Allows to speficy value of focus (in m).

SOLVE HOLOGRAPHY POINTING p1 p2
```

```
    Allow to add pointing corrections in case the coordinates stored  in
    the data file are wrong.

SOLVE HOLOGRAPHY DEFOCUS df

    Allow  to  introduce  known  defocus (useful for near-field measure-
    ments).

SOLVE HOLOGRAPHY TAPER t

    Allow to set the value of the illumination taper at the edge of  the
    primary (power).

SOLVE HOLOGRAPHY DIAMETER d

    Sets antenna diameter to d.

SOLVE HOLOGRAPHY TEST testFile

    Use  a  test  beam file instead of real data from the CLIC data file
    (must be a gdf .beam file).

SOLVE HOLOGRAPHY DISTANCE dist

    Gives distance of the source, in meters. Not relevant for astronomi-
    cal sources, of course. Any distance larger than than 1000 km (which
    is the default) forces the FRESNEL approximation.

SOLVE HOLOGRAPHY FRESNEL


    Use Fresnel approximation (use only the Fourier  transform,  neglect
    the  additional  terms in the complex exponential argument). This is
    the default mode for long distance (e.g. astronomical) sources,  but
    must be indicated if a DISTANCE has been entered.

SOLVE HOLOGRAPHY TYPE BURE|IRAM30

    Allow to force an antenna type.

SOLVE HOLOGRAPHY APODIZE

    Do  an  apodization  of the beam map (quadratic, down to zero on map
    edges).

SOLVE HOLOGRAPHY BEAM REFERENCE
```

Allows to do just the gridding of a reference beam (exits before FFT). This is useful for special holography receivers that have a signal and reference beam.

SOLVE HOLOGRAPHY /OFFSET x y z

Introduce a focus offset (in m) around which the solution will be searched.

SOLVE HOLOGRAPHY RIGGING [e1 e2]

Correct for gravitational deformations from the average of the two elevations e1 and e2 (default 20 and 90 degrees).

SOLVE HOLOGRAPHY TEMP_BIAS t

Correct for the thermal deformations between ambiant temperature and bias temperature t.

SOLVE HOLOGRAPHY FIXSPACING s

Set the spacing used for gridding.

SOLVE HOLOGRAPHY /PLOT [AMP amin amax astep] [PHA pmin pmax pstep] [ERRORS emin emax estep] [NUMBER]

With /PLOT, SOLVE HOLOGRAPHY will plots the results: two maps are displayed, which by default are the amplitude illumination pattern (default plot limits are -15dB to 0dB by step of 3dB) and the antenna normal surface errors (from -500 to 500 mum, with contours in steps of 100 mum). The min., max., and steps can be changed with "/PLOT AMP amin amax astep" and "/PLOT ERRORS emin emax estep". With "/PLOT PHASE", the phase residuals are plotted instead of the surface errors. Default are from -pi to +pi by step of 0.2 radians.

If NUMBER is given as a /PLOT argument, the panels numbers are drawn.

5.29.10 SOLVE PHASE

```
CLIC\SOLVE PHASE [/PLOT] [/BREAK kind time [kind time ...]]
[/POLYNOMIAL degree] [/WEIGHT] [/RESET]
```

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 (SET PHASE 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.

In antenna mode (selected by SET PHASE ANTENNA), 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%.

Option /PLOT will plot the fitted curve over the data. Option /RESET will reset the calibration curve in memory.

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 ...]" which introduces a break 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.

5.29.11 SOLVE POINTING

```
CLIC\SOLVE POINTING [beam] [/PLOT] [/COMPRESS [time_max]] [/PRINT]
[/OUTPUT filename [NEW|APPEND] [FLUX] [TPOINT]]
[/TOTAL] [/FIX param1 [value1] param2 [value2] ... ]
```

Find pointing corrections from POINTING scans. All pointing scans in the current index are processed by a gaussian fit. Its width can be fixed if the argument 'beam' is given (in arcsec). All continuum subbands and both side bands are averaged. SET AVERAGE 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 (INTER_OBS:pointing.obs), to be used in OBS for introducing the fitted pointing offset.

The results may also be written on an output ASCII 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). With argument TPOINT, the output is written in a format suitable for processing by the TPOINT program.

With option /TOTAL, SOLVE POINTING uses the total power to solve for pointing errors. In that case, option /FIX may be used to fix one parameter. Possible parameters are:

```
AZ: the azimuth collimation error (arc sec.)
EL: the elevation collimation error (arc sec.)
PEAK: the peak amplitude, in total power units
WIDTH: the HPBW (arc sec.)
ZERO: the off-source zero level, in total power units
```

With /TOTAL, /COMPRESS does the ON-OFF combination if in beam switching mode. In that case ZERO is preferrably fixed to zero (e.g. SOLVE POINTING /TOTAL /COMPRESS /PLOT /FIX ZERO 0).

5.29.12 SOLVE RF_PASSBAND

```
CLIC\SOLVE RF_PASSBAND [da] [dp] [/PLOT] [/SPECTRUM] [/RESET]
CLIC\SOLVE RF_PASSBAND [/IGNORE a1 a2 ...]
```

Solve for passband calibration curves, by fitting it to the amplitudes and phases. The current index should contain calibration observations of strong continuum sources (RF passband calibrator). The behaviour of this command depends on the current mode of RF passband calibration (Frequency, Channel -- deprecated, or Spectrum). A baseband should have been selected beforehand (see SET BBAND).

- For frequency-dependent RF passabnd calibration (SET RF_PASSBAND FREQUENCY, recommended): the resolution is normally done using all the spectral subbands plotted together, as a function of intermediate frequency. It should be done separately for each baseband and sideband (if applicable). A single frequency-dependent polynomial is fitted, a high degree might be necessary for the phase, if band edges are used (up to 50 is feasible).

- For channel dependent RF passband calibration (SET RF_PASSBAND CHANNEL)

  (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). Command STORE should be used next to store the fitted function in the header of source observations. Both channel dependent and frequency dependent curves can be stored; Use command SET RF_PASSBAND FREQUENCY|CHANNEL to apply one or the other.

Option /SPECTRUM supersedes any polynomial given and does use the data points plotted to derive a bandpass solution. It will factorize the gains per antenna if SET RF ANTENNA is selected. The bandpass solution will then be computed by linear interpolation of these data points.

Option /PLOT will plot the polynomial fits over the data. Option /RESET will reset polynoms in memory.

Option /IGNORE works only in ANTENNA mode. Antennas selected after option will be ignored in the factorization. This is useful for basebands of the narrow-correlator when more than 6 antennas were used (with WIDEX).

5.29.13 SOLVE SKYDIP

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

Compute receiver temperature TREC or antenna forward efficiency EFF from skydip scan. Default is EFF. All skydip scans in the current index are solved. A graphic display of the solution can be plotted using the /PLOT option. "SET Y TOTAL" must have been entered before solving the skydip, to force the software to use the total power measurements (otherwise, autocorrelations will be used). One should select a baseband first (see SET BBAND).

The resulting receiver temperatures and forwad efficiencies are available in the variables T_REC and FORWARD_EFF, providing the command "VARIABLE ATMOSPHERE ON" has been issued.

5.29.14 SOLVE TOTAL

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

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 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 temporarily disabled ***

The presence of option /PRINT produces a procedure file (INTER_OBS:pointing.obs), to be used in OBS for introducing the fitted pointing offset.

The results may also be written on an output ASCII 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). With argument TPOINT, the output is written in a format suitable for processing by the TPOINT program.

5.30 STORE

```
CLIC\STORE Keyword
```

Writes calibration (or edition) data in the output file. All scans in the current index are processed.

5.30.1 STORE AMPLITUDE

```
CLIC\STORE AMPLITUDE [/BAND LSB|USB|DSB] [/SELF]
                [/POLAR HORIZONTAL|VERTICAL|BOTH]
```

Store the amplitude calibration determined by the last SOLVE AMPLITUDE.

One calibration curve is stored for each sideband. With option "/BAND

```
code", one may use the calibration curve  determined  with  one  of  the
sidebands  (‘code’ is UPPER or USB, LOWER or LSB, or AVERAGE or DSB), to
calibrate both sidebands. With option /POLAR, one may use  the  calibra-
tion curve determined with one of the polarizations.

With  option "/SELF", the calibration stored will not be the calibration
curve (as determined from the last SOLVE  AMPLITUDE  command)  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  cali-
brate  the same side band. This provide a simple, easy way to self-cali-
brate data taken on strong continuum sources (quasars).

STORE AMPLITUDE and STORE PHASE can be  performed  simultaneously  using
STORE  AMPLITUDE  PHASE  [/BAND code] [/SELF] [/RECEIVER irec] (the /RE-
CEIVER option has no meaning for amplitudes).
```

5.30.2 STORE CORRECTION

```
    CLIC\STORE CORRECTION [GOOD|BAD|AUTO|SELF [tmin]]  [/RECEIVER  irec]
[/ANTENNA a1 ...] [/FRACTION fraction]

Store  in the header of each scan (of the current index) the information
whether the atmospheric phase correction is or not declared  valid,  and
should  be  actually  applied when SET PHASE ATM is selected. This is an
antenna-based flag.

  - GOOD: the atmospheric phase correction is to be used.

  - BAD: the atmospheric phase correction is not to be used.

  - AUTO [tmin]: that information is determined on the phase calibrators
    (type  PHASE),  by  comparing  the scan-averaged 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’ defaults to 15 minutes.

  - SELF: that information is determined on  the  source,  whatever  its
    type may be, by comparing its amplitude with and without the correc-
    tion. This will produce random result if the source has no continuum
    emission.

  -  STORE  CORRECTION  /RECEIVER  irec: the validity  of the correction
    from Receiver ’irec’ is used (useful to transfer the correction  va-
    lidity from one frequency to the other).

With  option /ANTENNA a1 a2 ..., only the specified antennas are consid-
ered. The correction validity for other antennas is not modified.
```

With option /FRACTION fraction, fraction of amplitude will replace the noise in estimating if uncorrected is better than corrected.

5.30.3 STORE FLAG

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

Flag all data in the current index according to the parameters and option specified.

Supported flag names are:

- C001 to C136 for bad individual continuum correlator subbands
- L001 to L136 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 (ant. based only)
- SATURATION for too high total power on a particular antenna
- TIME for time discontinuity
- DOPPLER for doppler discontinuity
- REDU for data reduction

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

Use option /MEMORY to store flags in memory (not in data). They are lost when the session is over.

"STORE FLAG" is equivalent to "MODIFY DATA proc.clic", where the "proc.clic" procedure contains:

```
      FLAG f1 f2 ... [/ANTENNA a1 a2 ...] [/BASELINE b1 b2 ...] [/RESET]
      GO WRITE
```

but it is simpler and faster. All the data records will be flagged.

5.30.4 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. See the SOLVE FLUX and SET FLUX commands.

5.30.5 STORE SPIDX

```
CLIC\STORE SPIDX
```

Store the source spectral indexes determined from a previous SOLVE SPIDX command. Source names, frequencies (within 1GHz) and dates (within a week) must match. See the SOLVE SPIDX and SET SPIDX commands.

5.30.6 STORE PHASE

```
CLIC\STORE PHASE [/BAND LSB|USB|DSB] [/SELF] [/RECEIVER irec]
                     [/POLAR HORIZONTAL|VERTICAL|BOTH]
```

Store the phase calibration determined by the last SOLVE PHASE command.

One calibration curve is stored for each sideband. With option "/BAND code", one may use the calibration curve determined with one of the sidebands ('code' is UPPER or USB, LOWER or LSB, or AVERAGE or DSB), to calibrate both sidebands. With option /POLAR, one may use the calibration curve determined with one of the polarizations.

With option "/SELF", the calibration stored will not be the calibration curve (as determined from the last SOLVE PHASE command) 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 self-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). In practice, this is used for Receiver 2 data, for which the calibration curve determined with Receiver 1 is stored. /BAND may be used in conjunction with /RECEIVER.

STORE PHASE and STORE AMPLITUDE can be performed simultaneously using STORE AMPLITUDE PHASE [/BAND code] [/SELF] [/RECEIVER irec] (the /RECEIVER option has no meaning for amplitudes).

5.30.7 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 directly the corresponding quality word:

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

5.30.8 STORE RF_PASSBAND

```
CLIC\STORE RF_PASSBAND [/SCAN [/MULTIPLE] [/OVER]]
```

Store the RF passband calibration curves. Channel dependent and frequency dependent curves will be simultaneously stored if available. Caution: RF passbands should be stored only for consistent spectral correlator configurations.

Option /SCAN allows to store directly the computed passband as an extra observation in the hpb file (a file out must be opened). By default, CLIC will complain if the file already contains a BANDPASS scan, unless the /MULTIPLE option is invoked. Up to 10 solutions can be stored in this case. Note that any type of bandpass (frequency or spectrum) can be saved in such a way. Option /OVER allows to overwrite the latest bandpass solution instead of writing a new scan.

5.31 SG_TABLE

```
CLIC\SG_TABLE Name [OLD|NEW]
[/RESAMPLE nc ref val inc code shape width]  [/FFT]
[/FREQUENCY name rest-freq] [/DROP  n1 n2]
[/NOCHECK [SOURCE|POINTING|PHASE|EPOCH]]
[/ADD Item[s]]
[/POLARIZATION SPLIT|AVERAGE|JOINT]
```

Prepare a UV Table, in spectral line mode only, but with added flexibility to store more information compared with the TABLE command. Polarization is handled in 3 possible ways, the default being AVERAGE.

Option /POLARIZATION and /ADD control the details of the polarization handling and of the extra information written.

```
See Command TABLE for the other options.
```

5.31.1 SG_TABLE /POLARIZATION

```
  SPLIT:         A different visibility for each polarization
  AVERAGE: averaged polarizations before writing
  JOINT:   All channels Polar 1, then All channels polar 2 in visibility
```

5.31.2 SG_TABLE /ADD

```
    CLIC\SG_TABLE Name [OLD|NEW] /ADD Item [Item [...]]

Add some more information columns.  Possible items are

 U V W DATE TIME IANT JANT
 which  are in principle already present in elements 1 to 7 of the visi-
bilities.

 L_PHASE_OFF M_PHASE_OFF X_POINT_OFF  Y_POINT_OFF
 which indicate the Phase and Pointing offsets (e.g. for mosaics)

 ELEVATION HOUR_ANGLE PARA_ANGLE
 which can be useful for full polarization measurements

 SCAN ON_TIME WEIGHT
 for bookkeeping

 X_POINT_IANT Y_POINT_IANT X_POINT_JANT Y_POINT_JANT
 the antenna pointing errors (used mostly for simulations...)

 RA  DEC  FREQUENCY
 the Source coordinates and Observing frequency (in Real*8, used for
 multisource UV tables, still very experimental)

 STOKES is also a recognized item, but it is handled by  the  /POLARIZA-
TION option
```

5.32 TABLE

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

```
    [/NOCHECK [SOURCE|POINTING|PHASE|EPOCH]]

This  command  will  create an UV data Table from the current index.  is
not given, the most recently created table will be extended.  Next argu-
ment  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 must have been given by the command SET  SE-
LECTION. The weighting mode can be modified by the command SET WEIGHTS.

TABLE /RESAMPLE nc ref val inc code [shape width /FFT]

    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 cor-
    relator (due to on-line apodization), and followed by  reconvolution
    to  produce frequency channels of the given 'shape' and 'width'. Al-
    lowed shapes are:
      TBox = a box in delay space (unapodized correlator)
      Ppar = a parabola in delay space (apodized  correlator)  (the  de-
        fault)
      FBox = a box in frequency space (square filter)
      FTri = a triangle in frequency space (Hanning smoothed square fil-
        ter)
    The width is the channel width in units of channel  separation  (de-
    fault 1).

    Option  /FFT  is  not recommended when joining together several sub-
    bands 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.

TABLE /FREQUENCY  name rest-freq

    Option /FREQUENCY is used to redefine the rest  frequency  (in  MHz)
```

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.

TABLE /NOCHECK [SOURCE|POINTING|PHASE|EPOCH]

When processing each scan, CLIC checks whether a number of position parameters are consistent with those defined in the table header. Option /NOCHECK allows to switch off this checking. Arguments can be given to switch off only part of the parameters (SOURCE name, POINTING direction, PHASE center, EPOCH of coordinates). This option is intended for building tables with inconsistent parameters (typical exemple is a different source name...). It is potentially dangerous and is to be used with caution.

TABLE /DROP n1 n2 --- THIS OPTION IS OBSOLETE

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.

TABLE /COMPRESS tmax uvmax

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

5.32.1 TABLE UVTABLE

UV Table format

A UV 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 CLIC 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)
11. Same for second frequency point, and so on.

See the SET WEIGHT command to select the weighting mode . The first dimension is then the 3 * Nchan + 7, for Nchan frequency channels. The second dimension is the number of UV points measured.

5.33 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.

5.34 VARIABLES

```
CLIC\VARIABLES group ON|OFF
```

This command is used to create/delete CLIC variables corresponding to header information. Several 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 scanning information (Record based)
```

```
ATMOSPHERE     Atm. calibration parameters and results (Scan based)
MONITOR        Total power monitor information (Scan based)
WVR            Water Vapor Radiometer information (Scan based)
DESCRIPTOR     Data descriptor information (Scan based)
DATA_HEADER    Data header information (Record based)
DATA_RECORD    Data values (Record based)
INDEX          Current index variables
ALMA           ALMA specific information
AIC            Antenna Instrumental Calibration (Scan based)
SIZE           Dimensioning parameters
INSTRUMENT     Instrumental parameters
SPW            Spectral windows parameters
```

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

5.34.1 VARIABLES READ_WRITE

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

Input/Output file information (Global).

```
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)
IVERSION         Observation version (header)
DVERSION         Observation version (data if applicable)
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
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
```

The following additional variables are defined by the command FIND:

```
  FOUND            Number of observations in current index
```

5.34.2 VARIABLES GENERAL

```
    CLIC\VARIABLES GENERAL ON|OFF
```

General information (Scan based).

```
  TELESCOPE        Telescope name
  RECEIVER         Receiver number
  CONFIGURATION    Interferometer configuration
  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)
  IQUAL            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)
  AIR_MASS         Airmass of observation
  TSYS             System temperature (K)
  TIME             Integration time (minutes)
  PROJECT          Project name
  PROC             Procedure used (internal format)
  PROCEDURE        Procedure used (in clear)
  TYPE_OFF         Type of offsets
  N_BOXES          Number of plotted boxes
  NEW_RECEIVERS    Logical indicating if receiver are from > 2006
```

5.34.3 VARIABLES POSITION

```
    CLIC\VARIABLES POSITION ON|OFF
```

Source related information (Scan based).

```
  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
SPIDX           Source spectral index for calibrators
TYPE_COORD      Type of coordinates
```

5.34.4 VARIABLES CONFIG

```
  CLIC\VARIABLES CONFIG ON|OFF

Array configuration related information (Scan based).

  NANT                      Number of antennas
  NBAS                      Number of baselines
  ITYPE                     Type of observation (Object:1 or Phase:2)
  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)
  PHLO1           [NANT]    LO1 phase
  PHLO3           [NANT]    LO3 phase
  NBAND_WIDEX               Number of WIDEX units
```

5.34.5 VARIABLES RF_SETUP

```
  CLIC\VARIABLES RF_SETUP ON|OFF

Receiver related information (Scan based).

  LINE            Line name (in OBS)
  FREQUENCY       Rest Frequency (in OBS) (MHz)
  ISB             Side band (1:upper, -1:lower)
  LOCK            Lock
  FLO1            Frequency of First LO (MHz)
  FLO1_REF        Frequency of First LO reference (MHz)
  FIF1            First intermediate frequency (MHz)
```

```
VELOCITY         Velocity entered in OBS (km/s)
TYPE_VEL         Velocity type
DOPPLER          Doppler correction factor (v/c)
N_IF                  Number of IFs
IFNAME [N_IF]         IF name
KIF    [N_IF]        "Physical" IF number
R_IFATTN [NANT,N_IF]  IF attenuation (dB)
R_NBB                 Number of basebands
R_BBNAME [R_NBB]      Baseband names
R_KBB [R_NBB]         "Physical" baseband numbers
R_MAPBB  [NANT,R_NBB] Baseband indexing
R_MAPPOL [NANT,R_NBB] Baseband polarisation
```

5.34.6 VARIABLES CONTINUUM

```
CLIC\VARIABLES CONTINUUM ON|OFF
```

Continuum correlator related information (Scan based).

```
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
CFCEN [10]       Center frequency for subband (MHz)
CFWID [10]       Width of subband (MHz)
```

5.34.7 VARIABLES LINE

```
CLIC\VARIABLES LINE ON|OFF
```

Spectral correlator related information (Scan based).

```
N_LINE_BANDS              Number of line subbands
FOURIER                   (Logical) FFT done, data in frequency space
TOTAL_CHANNELS            Total number of line channels
N_CHANNELS     [NSUBB]    Number of channels in subband
FIRST_CHANNEL  [NSUBB]    First channel in subband
LFCEN          [NSUBB]    LO3 frequency (channel 1)
```

```
LFRES          [NSUBB]   Frequency resolution (signed)
REF_CHANNEL  [2,NSUBB]   Reference channel for spectrum
F_RESOLUTION [2,NSUBB]   Frequency resolution
F_OFFSET     [2,NSUBB]   Rest frequency in reference channel
V_RESOLUTION [2,NSUBB]   Velocity resolution
V_OFFSET     [2,NSUBB]   Velocity in reference channel
R_LILEVU  [NSUBB,NANT]   Sampling levels (USB)
R_LILEVL  [NSUBB,NANT]   Sampling levels (LSB)
REF_NUM        [NSUBB]   Spectral window reference channel
UNIT_NUMBER    [NSUBB]   Unit "physical" number
R_FLO2         [NSUBB]   LO2 frequency (MHz)
R_BAND2        [NSUBB]   LO2 conversion sign
R_FLO2BIS      [NSUBB]   LO2bis frequency (MHz)
R_BAND2BIS     [NSUBB]   LO2bis conversion sign
R_FLO3         [NSUBB]   LO3 frequency (MHz)
R_FLO4         [NSUBB]   LO4 frequency (MHz)
BAND4          [NSUBB]   Sign of band 4 conversion
R_LPOLMODE     [NSUBB]   Polarisation mode
R_LPOLENTRY[NANT,NSUBB]  Polarisation connected to spw
R_BB           [NSUBB]   Spectral window baseband
R_IF           [NSUBB]   Spectral window IF
R_SB           [NSUBB]   Spectral window sideband
R_STARTING_CHUNK [NSUBB] Spectral widow starting chunk
R_NB_CHUNK       [NSUBB] Spectral window number of chunk
PHSELECT  [NANT,NSUBB]   Real-time atm. correction (1: TP, 2:WVR)
```

5.34.8 VARIABLES SCANNING

```
CLIC\VARIABLES SCANNING ON|OFF
```

Special scanning information (Record based). This is for Pointing, Focus, Holography, ...

```
SCAN_TYPE        Type of special scan (1 focus 2,3 point 4,5 calibr)
MOBIL   [NANT]   Antennas in motion (logical)
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
```

5.34.9 VARIABLES ATMOSPHERE

```
CLIC\VARIABLES ATMOSPHERE ON|OFF
```

Atmospheric calibration parameters and results (Scan based).

```
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_COLD         [NANT]    Temperature of cold load (K)
T_REC          [NANT]    Receiver temperature (K)
GAIN_IMAGE     [NANT]    Gain ratio image/signal
CHOPPER_COUNTS [NANT]    Measured counts on ambiant load
COLD_COUNTS    [NANT]    Measured counts on cold 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
JY_TO_KEL      [NANT]    Jansky to Kelvin conversion factor
TOTAL_SCALE    [NANT]   Scaling factor for physical total power
T_CABIN        [NANT]    Temperature in cabin (K)
T_DEWAR      [3,NANT]    Temperatures in dewar (K)
```

5.34.10 VARIABLES MONITOR

```
CLIC\VARIABLES MONITOR ON|OFF
```

```
Total power monitor information (Scan based).

  NREC_MON
  FRS_MON
  FRI_MON
  MAGIC_MON
  WATER_MON       [NANT]
  TAU_S_MON       [NANT]
  TAU_I_MON       [NANT]
  TATM_S_MON      [NANT]
  TATM_I_MON      [NANT]
  FORWARD_EFF_MON [NANT]
  T_CHOPPER_MON   [NANT]
  T_COLD_MON      [NANT]
  T_REC_MON       [NANT]
  GAIN_IMAGE_MON  [NANT]
  CHOP_COUNTS_MON [NANT]
```

```
SKY_COUNTS_MON  [NANT]
COLD_COUNTS_MON [NANT]
T_SYS_MON       [NANT]
CAL_MODE_MON    [NANT]
PATH_MON        [NANT]
TEM_MON         [NANT]
DPATH_MON       [NANT]
OK_MON          [NANT]
```

5.34.11 VARIABLES WVR

```
CLIC\VARIABLES WVR ON|OFF
```

Water Vapor Radiometer information (Scan based).

```
WVRNCH            [NANT]   Number of channels (=3; 0 if no WVR)
WVRFREQ    [WVRNCH,NANT]   Central frequencies (MHz)
WVRBW      [WVRNCH,NANT]   Bandwidths (MHz)
WVRTAMB           [NANT]   Temp ambient load (K)
WVRTPEL           [NANT]   Temp Peltier cooler (K)
WVRTCAL           [NANT]   Calibration temperature (K)
WVRREF     [WVRNCH,NANT]   Average counts on reference observation
WVRAVER    [WVRNCH,NANT]   Average counts on current observation
WVRAMB     [WVRNCH,NANT]   Average counts on last ambient measurement
WVRTREC    [WVRNCH,NANT]   Receiver temperatures (K)
WVRLABTREC [WVRNCH,NANT]
WVRLABTCAL [WVRNCH,NANT]
WVRLABTDIO [WVRNCH,NANT]
WVRFEFF    [WVRNCH,NANT]   Coupling factor
WVRMODE           [NANT]   Calibration mode
WVRH2O            [NANT]   Precipitable water vapor (mm)
WVRPATH           [NANT]   Water vapor pathlength (mum)
WVRTSYS    [WVRNCH,NANT]   System temperature (K)
WVRDPATH   [WVRNCH,NANT]   K to H2O vap. pathlength (model, mum/K)
WVRFPATH   [WVRNCH,NANT]   K to H2O vap. pathlength (empirical, mum/K)
WVRLIQ     [WVRNCH,NANT]   K to H2O liquid emission (K/K)
WVRDCLOUD[WVRNCH,NANT]     K to H2O liquid pathlength (mum/K)
WVRTATM           [NANT]   Temperature of atmosphere (K)
WVRQUAL           [NANT]   Quality code
WVRAVERTIME                Averaging time for wvr (s)
```

5.34.12 VARIABLES DESCRIPTOR

```
CLIC\VARIABLES DESCRIPTOR ON|OFF
```

Data descriptor information (Scan based).

```
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)
```

5.34.13 VARIABLES DATA_HEADER

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

```
Data header information (Record based).

  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_RATEC      [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 *arc sec.)
  DH_UTC                    UT Time (sec)
  DH_TIME                   UT Time (hh:mm:ss.ss)
  DH_ATFAC    [2,NANT]      Atm. calibration factor [sideband,ant] (K)
  DH_BFLAG      [NBAS]      Baseline Flag word
  DH_INFAC  [2,2,NBAS]      Instrumental factor [real/imag,upp/low,base]
  DH_WVR [WVRNCH,NANT]      Counts of each WVR channel
  DH_WVRSTAT    [NANT]      WVR status word
  DH_TEST0        [20]      Test variables
  DH_TEST1   [20,NANT]      Test variables (by antenna).
  DH_GAMME  [    NANT]      Gamme (obsolete)
  DH_RMSPHA   [2,NBAS]      Phase rms
  DH_RMSAMP   [2,NBAS]      Amplitude rms
  AMPFAC_L  [2,2,NBAS]
  AMPFAC_U  [2,2,NBAS]
  DH_ACTP          [2,NANT,NSUBB]   Autocorrelation total power
```

```
DH_ANTTP              [N_IF,NANT]  Warm-IF total power (dBm)
DH_SAFLAG         [2*NSUBB,NANT]   Antenna spectral flags
DH_SBFLAG         [2*NSUBB,NBAS]   Baseline spectral flags
IS_SAFLAG                 [NANT]   Is there any antenna spectral flag
IS_SBFLAG                 [NBAS]   Is there any baseline spectral flag
DH_CABLE_ALTERNATE        [NANT]   Cable phase for the other reference
DH_NTIME                           Number of recorder time parameters
DH_TIME_MONITORING   [DH_NTIME]    Time parameters
DH_INCLI                [NANT,2]   Station inclination (X,Y)
DH_INCLI_TEMP             [NANT]   Inclinometer temperature (C)
DH_TILFOC               [NANT,3]   Subreflector tilt (/X,/Y,/Z)
DH_OFFFOC_XY            [NANT,2]   Subreflector offset (X,Y)
```

5.34.14 VARIABLES DATA_RECORD

```
    CLIC\VARIABLES DATA_RECORD ON|OFF

Data values (Record based).

  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
```

5.34.15 VARIABLES INDEX

```
    CLIC\VARIABLES INDEX ON|OFF

Index variables
  CX_NUM   [FOUND]     Observation numbers in current index
  CX_BLOC  [FOUND]     Blocks numbers of observations in current index
```

5.34.16 VARIABLES AIC

```
    CLIC\VARIABLES AIC ON|OFF

Index variables
```

```
AIC                           Has a solution been stored
AICDEG                        Solution degree
AICPHA [2,2,NANT,AICDEG]      Phase solution (pol,sb,nant,deg)
AICAMP [2,2,NANT,AICDEG]      Amplitude solution (pol,sb,nant,deg)
```

5.34.17 VARIABLES SIZE

```
CLIC\VARIABLES SIZE ON|OFF
```

```
Dimensioning parameter.
  MAXANT                    CLIC maximum number of antennas
  MAXBAS                    CLIC maximum number of baselines
  NSFLAG                    Maximum numbers of spectral windows
```

5.34.18 VARIABLES INSTRUMENT

```
CLIC\VARIABLES INSTRUMENT ON|OFF
```

```
Instrument parameters.
  HIQ_ATTEN        [NANT,2]       High-Q cables attenuation (dB)
  LASER_LEVEL   [NANT,N_IF]       Optical link power (V)
  WIDEX_TEMPERATURE      [4]       Widex temperatures C()
```

5.34.19 VARIABLES SPW

```
CLIC\VARIABLES SPW ON|OFF
```

```
Spectral window parameters.
  SPW%NSPW
  SPW%NAME  [NSPW]  Spectral window name
  SPW%TOPO  [NSPW]  Spectral window topocentric ref frequency (MHz)
  SPW%FREQ  [NSPW]  Spectral window rest frequency (MHz)
  SPW%BW    [NSPW]  Spectral window bandwidth (MHz)
  SPW%POL   [NSPW]  Spectral window polarisation (1:H, 2:V)
  SPW%SB    [NSPW]  Spectral window sideband
```

5.35 WVR

```
CLIC\WVR [/CMODE wvrmode wvrcpol] [/NOWRITE]
```

```
This command is used to prepare the atmospheric phase  correction  based
on the 22 GHz Water Vapor Radiometers (WVR). It process all scans in the
current index and performs two operations.
```

```
First, it processes the WVR calibration scans (CWVR) to compute receiver
and  calibration  temperatures of each radiometer. Option /CMODE is used
to specify the WVR calibration mode:  the  'wvrmode'  parameter  can  be
equal to:
  - TR_GE: Trec + gain external
  - LAB
  - TREC
  - DIODE
  - NOCAL: no calibration, for test purposes only

The second argument of /CMODE is 'wvrcpol' which gives the degree of the
poynomial fit removed from the data.  Default value are: wvrmode = TREC,
and wvrcpol = 0.
```

Index