AIPS MEMO NO. 76

Summary of AIPS Continuum UV-data Calibration

From VLA Archive Tape to a UV FITS Tape

Supersedes AIPS Memo 68

91 November 27

The Gentle User enters the Computer room with a VLA archive tape containing a scientific breakthrough. The user's sources are named `source1` and `source2`. The interferometer phase is calibrated by observations of `cal1` and `cal2`. The flux density scale is calibrated by observing 3C286 (=1328+307 or 1331+305). Mount the tape on drive number n, log in and start *AIPS* . Example input: `AIPS NEW`. Mount the tape: `INTAPE=`n`; DENS=6250; MOUNT`.

PRTTP Find out what is on the tape, get project number and bands. `TASK='PRTTP'; PRTLEV=-2; NFILES=0; INP;GO; WAIT; REWIND.`

FILLM Load your data from tape. Select only one band at a time to process. `TASK='FILLM'; VLAOBS='?'; BAND='?'; NFILES=`m`; INP;GO`. FILLM will load your visibilities (*uv*-data) into a large file and create 6 *AIPS* tables. The tables have two letter names described below.

- HI Human readable history of things done to your data. Use PRTHI to read it.
- AN Antenna location and polarization tables. Antenna polarization calibration is placed here.
- NX Index into visibility file based source name and observation time. Not modified by calibration.
- SU Source table contains the list of sources observed and indexes into the frequency table. The flux densities of the calibration sources are entered into this table.
- FQ Frequencies of observation and bandwidth with index into visibility data. Not modified.
- CL Calibration table describing the antenna based gains. Version 1 should never be modified. The CL table contains entries at regular time intervals (i.e. 2 minutes) for each antenna. **The ultimate goal of calibration is to create a good CL version 2.** Use PRTAB to read tables.

PRTAN Print out the antenna locations. `TASK='PRTAN'; PRTLEV=0; INP; GO`. Choose a good *Reference* antenna (called R) near the center of the array (`REFANT=R`). Check the VLA operator log to make sure the antenna was OK during the entire observation.

QUACK Flag the bad points at the beginning of each scan, even the ones with good amplitudes could have bad phases. Creates a Flag Table (FG). You want to use FG table version 1 for all tasks. `TASK='QUACK'; FLAGV=1; OPCOD=' '; APARM=0; SOUR=' '; INP;GO`

- FG A flag table marks bad data. FG tables contain an index into the UV data based on time range, antenna number, frequency and IF number.

LISTR Lists your UV data in a variety of ways. Make a list of your observations. `TASK='LISTR'; OPTYP='SCAN'; DOCRT=-1; SOUR=' '; CALC='*'; TIMER=0; INP;GO`. NOTE: IF you have observed in a such a way as to create more than one FREQID, you must run through the entire calibration once for EACH FREQID. For new users, it is better to use `UVCOP` to copy each FREQID into separate files and calibrate each file separately.

UVCOP Skip this step if your data consists of only one FREQID. Copy different FREQIDs into separate files. `TASK='UVCOP'; FREQID=?; CLRON; OUTDI=INDI; INP; GO`. The result will be a `??.UVCOP` file.

SETJY Sets the flux of your flux calibration source in the SU table. `TASK='SETJY'; SOUR='3C286',' '; OPTYP='CALC'; FREQID=1; INP;GO`. Correct for partial resolution using the VLA Calibration Source Manual or the *AIPS* Cookbook.

TASAV As insurance, make a copy of all your tables. TASK='TASAV'; CLRON; OUTDI=INDI; INP;GO.

CALIB CALIB is the heart of the *AIPS* calibration package. RUN VLAPROCS, an *AIPS* *runfile*, to create procedures VLACALIB, VLACLCAL and VLARESET. The procedure VLACALIB runs CALIB. Set the UV and Antenna limits for 3C286. For L, C and X band 10% and 10 degree errors are OK; for other bands the limits are higher. CALIB places antenna amplitude and phase corrections into an SN table for the time of observation of phase calibration sources.

SN Solution table contains antenna based amplitude and phase corrections for the time of observations of the calibration sources. These SN table results are latter interpolated for all times of observation and placed in a CL table. Only the CL table corrections will be applied to the program sources.

TASK='VLACAL'; CALS='3C286',' '; CALCODE='*'; REFANT=*R*; UVRA=?; SNVER=1; MINAMP=10; MINPH=10; INP; VLACAL. The task CALIB lists antenna pairs which deviate significantly from the solution. If you have lots of errors, then carefully examine your data using TVFLG. (See *AIPS* Cookbook) If one antenna is bad over a limited time range, use UVFLG to flag that antenna for the time from just after the previous good cal observation to before the next good cal observation.

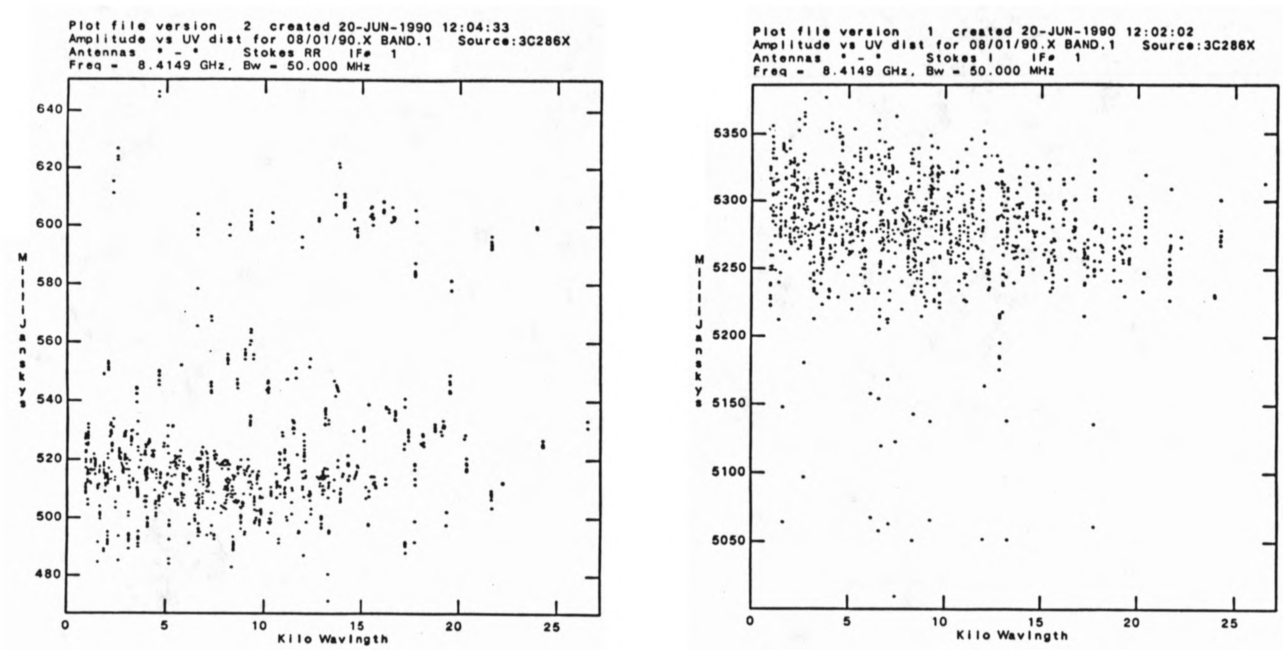
UVFLG Flag bad UV-data. TASK='UVFLG'; ANTEN=?,0; BASELI=?,0; TIMER=?; FLAGV=1; SOUR=' '; OPCOD=' '; INP;GO. If in doubt about any data, FLAG THEM!

CALIB Now calibrate the antenna gain based on the rest of the cal sources. Look in the Calibrator manual for UV limits; if there are limits, VLACAL must be run separately for these sources. TGET VLACAL; CALS='cal1','cal2',' '; ANTEN=0; BASELI=0; INP; VLACAL. Flag bad baselines listed. Each execution of CALIB replaces previous corrections in the SN table or appends new corrections. If unsatisfied with a VLACAL execution, all effects of it are removed by running VLACAL again for the same sources (but different ADVERBS or after flagging bad data).

GETJY Sets the flux of phase calibration sources in the SU table. TASK 'GETJY'; SOUR='cal1,'cal2',' '; CALS='3C286',' '; BIF=0; EIF=0; INP;GO. GETJY overwrites existing SU table entries, and is not effected by previous executions.

TASAV Good time to save your tables. TGET TASAV; INP;GO.

CLCAL Read the antenna amplitude and phase corrections from the SN table and interpolate the corrections into a new CL table. CLCAL applies calibration source corrections to the program sources. Each execution of CLCAL adds to output CL table version 2. CLCAL is run using the procedure VLACLCAL. TASK='VLACLC'; SOUR='source1','cal1',' '; CALS='cal1',' '; OPCODE='CALI'; TIMER=0; INTERP='2PT'; INP; VLACLC. Run CLCAL for the second source using the second calibrator. TGET VLACLC; SOUR='source2','cal2',' '; CALS='cal2',' '; INP; VLACLC. Move the SN table corrections for 3C286 into the CL table. TGET VLACLC; SOUR='3C286',' ';CALS='3C286',' '; INP; VLACLC. (3C286 could also be calibrated with cal1 or cal2.)



a) *b)*

Figure: *a)* Un-calibrated *uv*-data and *b)* calibrated *uv*-data from an X-band snapshot of 3C286. Default VLA gains are a tenth of the actual gains and show significant scatter. Only wild *uv* points ∼50 % greater than the average can be detected before calibration.

LISTR Make a matrix listing of the Amplitude and RMS of calibration sources with calibration applied. Look for wild points. `TASK='LISTR'; OPTYP='MATX'; SOUR='cal1','cal2',' '; DOCAL=1; DOCRT=-1; DPARM=3,1,0; UVRA=0; ANTEN=0; BASELI=0; BIF=1; INP;GO`. If only a few points are bad, flag them and continue. If too many are bad, delete CL table 2 and the SN tables using `VLARESET`. Then return to the first `CALIB` step. If the data look good, run `LISTR` again for IF two. `TGET LISTR; BIF=2; INP;GO`

UVPLT Plot the *uv*-data in a variety of ways. Make at Flux versus Time plot first. Choose `XINC` so the plot will have no more than 1000 points. `TASK='UVPLT'; SOUR='source1',' '; XINC=10; BPARM(1)=11; DOCAL=1; BIF=1; INP;GO`. Look at the plot with `LWPLA, QMSPL, TVPL` or `TXPL`. Plot other IF . Flag wild points. Plot Flux versus baseline. `TGET UVPLT; BPARM=0; INP;GO`.

Calibration is now complete for continuum, un-polarized observations. Write the calibrated data to tape with `FITTP`. To create images from the *uv*-data use `SPLIT` to calibrate the multi-source data and create a single source *uv*-data set. (`FITTP` and `SPLIT` are described at the end of the polarization calibration process.)

POLARIZATION CALIBRATION

For polarization observations, the following steps are required. For 21cm or longer wavelength observations, ionospheric Faraday rotation corrections may be needed. See FARAD in the *AIPS* cookbook.

TASAV As added insurance, save your tables again. `TGET TASAV; INP; GO.`

LISTR Print the parallactic angles of the calibration sources. `TGET LISTR; SOUR=' '; CALC='*'; OPTYP='GAIN'; DPARM=9,0; INP;GO`

PCAL Intrinsic antenna polarization calculation. `PCAL` will be successful only if cal. sources are observed at several parallactic angles. `PCAL` will modify the `AN` and `SU` tables. `TASK='PCAL'; CALS='cal1','cal2',' '; BIF=1; EIF=2; REFANT=`R`; INP;GO`

LISTR Now determine the absolute linear polarization angle. Make a matrix listing of the angle of 3C286. `TGET LISTR; SOUR='3C286',' '; DOCAL=1; BIF=1; DOPOL=-1; GAINUSE=2; OPTYP='MATX'; DPARM=1,0; STOKES='POLC'; INP; GO.` Record the matrix average angle, ϕ_1, for `IF` 1. The observed angles are different for each frequency and `IF` . Record the matrix average angle, ϕ_2, for `IF` 2 (`BIF=2; INP; GO`).

CLCOR Now apply the angle correction to CL table 2. `CLCOR` needs only to be run once, unless you make a mistake. The phase correction is applied to the Left circularly polarized signal. (The relative phase of L and R produces the linear polarization angle.) The angle of linear polarization for 3C286 is 66^o and for 3C138, $\phi = -24^o$. `TASK='CLCOR'; STOKES='L'; SOUR=' '; OPCOD='POLR'; BIF=1; EIF=2; CLCORPRM=66-`ϕ_1`,66-`ϕ_2`,0; GAINVER=2; INP; GO.` Run LISTR again to check the phases. `TGET LISTR; DOPOL=1; INP; GO.` If the phases are wrong run `CLCOR` again. `TGET CLCOR; OPCOD='PHAS'; CLCORPRM=66-`ϕ'_1`,66-`ϕ'_2`,0; INP; GO`

FITTP Writes the output *uv*-data to tape. `DISMOUNT` your archive; `MOUNT` your output tape. `TASK='FITTP'; DOEOT=-1;BLOCK=8; OUTTAP=INTAP; INP; GO.`

SPLIT The *AIPS* calibration process only modifies the tables associated with the multi-source *uv*-data set. SPLIT selects individual sources, reads the CL table and multiplies the visibilities by the corrections to produce a calibrated single-source *uv*-data set. `TASK='SPLIT'; SOUR=' '; CALC=' '; UVRA=0; TIMER=0; DOCAL=1; FLAGVER=1; GAINUSE=2; DOPOL=1; DOBAN=-1; BIF=0; EIF=0; STOKES=' '; BLVER=-1; APARM=0; DOUVCOM=1; CHANSEL=0; INP; GO`

Mapping Use your favorite Fourier Transform task (e.g. `MX` or `HORUS`) to produce images from the calibrated data. A set of *AIPS* procedures (called `MAPIT`) has been developed to automatically Fourier Transform, deconvolve and self-calibrate the *uv*-data. See *AIPS* Memo 72.

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