AIPSLETTER

Volume XLIII, Number 1: June 30, 2023

A newsletter for users of the NRAO
*A*stronomical *I*mage *P*rocessing *S*ystem

Written by a cast of *AIPS*

Edited by
Eric W. Greisen
National Radio Astronomy Observatory
P.O. Box O, Socorro, NM 87801–0387
575–835–7236; Fax 575–835–7027
daip@nrao.edu
http://www.aips.nrao.edu/

Happy 44th birthday *AIPS* and FITS

The FITS format was devised in a meeting at the VLA site on March 27 and 28, 1979. Don Wells (then of NOAO) and Eric Greisen (still of the NRAO) were the primary authors while Barry Clark and other NRAO staff members provided valuable suggestions. The FITS format, enhanced by later extensions, is still in wide spread use in astronomy and is the envy of other scientific fields. The FITS format then colored the design of the *AIPS* internal formats. The *AIPS* project was begun officially on July 1, 1979 and has stood the test of time remarkably well.

Your editor does find times when he would like interesting things to do. If you find any problems with *AIPS* or have any suggestions for new or improved functions, please do not hesitate to e-mail `daip@nrao.edu`.

AIPSLetter publication

We have discontinued paper copies of the *AIPSLetter* entirely. The *AIPSLetter* will be available in PostScript and pdf forms as always from the web site listed above. New issues will be announced in the NRAO eNews mailing and on the bananas and MNJ list server.

Current and future releases

We have formal *AIPS* releases on an annual basis. While all architectures can do a full installation from the source files, Linux (32- and 64-bit), and MacIntosh OS/X (Intel and ARM) systems may install binary versions of recent releases. The last, "frozen" (actually "slushy") release is called `31DEC22` while `31DEC23` remains under active development. You may fetch and install a copy of these versions at any time using *anonymous* `ftp` for source-only copies and `rsync` for binary copies. This *AIPSLetter* is intended to advise you of improvements to date in `31DEC23`. Having fetched `31DEC23`, you may update your installation whenever you want by running the so-called "Midnight Job" (MNJ) which copies and compiles the code selectively based on the changes and compilations we have done. The MNJ will also update sites that have done a binary installation. There is a guide to the install script and an *AIPS* Manager FAQ page on the *AIPS* web site.

The MNJ for binary versions of *AIPS* now uses solely the tool `rsync` as does the initial installation. For locally compiled ("source") installations, the Unix tool `cvs` running with anonymous ftp is used for the MNJ. Linux sites will almost certainly have `cvs` installed; but other sites may have to install it from the web. We have found that `cvs` works very well, although it has one quirk. If a site modifies a file locally, but in an *AIPS*-standard directory, `cvs` will detect the modification and attempt to reconcile the local version with the NRAO-supplied version. This usually produces a file that will not compile or run as intended. For local versions, use a copy of the task and its help file in a private disk area instead.

31DEC20 contains a change to the TV display program XAS that makes it incompatible with previous releases when characters are displayed. 31DEC14 contains a change to the "standard" random parameters in *uv* data and adds columns to the SN table. Note, however, that the random parameters written to FITS files have not been changed. Older releases of *AIPS* cannot handle the new *internal uv* format and might be confused by the SN table as well. 31DEC09 contains a significant change in the format of the antenna files, which will cause older releases to do wrong things to data touched by 31DEC09 and later releases. You are encouraged to use a relatively recent version of *AIPS*, whilst those with recent VLA data to reduce should get release 31DEC22 or, preferably, the latest development release.

Improvements of interest in 31DEC23

We expect to continue publishing the *AIPSLetter* approximately every six months, but the publication is now primarily electronic. There are nine new tasks in 31DEC23. These are LISUN which does a LISTR OPTYPE 'SCAN' listing with the addition of the angle from each scan to the Sun, SNRMS which does statistics on selected columns in tables, BLPCL which divides pre-computed full polarization models into *uv* data to determine a baseline-based full polarization calibration, AVGWT which computes the average and rms weights of selected *uv* data, SYFIX which corrects source numbers in the SY table to match the *uv* data, BPPLT which plots bandpass data as a function of time, TEPLT which plots the output table from TECOR, MFIMG which makes images of *AIPS*' magnetic field models and of TEC data downloaded for use with TECOR, and AMKAT which changes antenna numbers in MeerKAT data files to match the station numbers. A new procedure, BLPOLCAL implements a baseline-based calibration for polarization data. Numerous bug fixes and minor improvements have also been made. Tests have confirmed that *AIPS* works fine on computers with Apple's new M2 version of the ARM chip using binaries computed on our M1 Mac mini. The performance is similar to the M1 chip, but that is very good.

Polarization

The calibration of polarization received a lot of attention in this 6-month period. It was realized that one must not apply second-order D terms to the parallel polarizations if those D terms had not been used when the parallel-hand gain calibrations were determined. Doing this correctly by measuring the D terms at the same time as the instrumental gains are determined is beyond the scope of the current software.

Ionospheric Faraday rotation ("IFR") is computed by TECOR from data of the total electron content ("TEC") as provided by the cddis data center run by Goddard Space Flight Center. A bug in this task was discovered that caused it to compute the location of the ionospheric pierce point (of the line of sight to the source) incorrectly, with an abrupt jump at zero hour angle. TECOR was changed thereafter to write a TE table containing all of the various parameters used in computing the IFR and task TEPLT was created to plot a selection of these parameters as a function of time.

One of the important contributors to the computation of the IFR is the model of the Earth's magnetic field. *AIPS* has had a simplified model for some time. A new time-dependent model was downloaded from ngdc.nasa.gov, conveniently provided in Fortran. After modification to meet *AIPS* software standards and the requirements of gfortran 11, this model was added as an option in TECOR. The two models do not differ a lot in the Northern Hemisphere, but are seriously different for Southern observatories such as MeerKAT. MFIMG was written to make global images of the two models. It also makes an image cube from the TEC found in the data file downloaded for TECOR with time as the third axis.

Leonid Petrov (AJ, 2023 April, 165:188) has proposed a modification of the formulæ used in `TECOR`. Extensive tests of the current `TECOR` have been made on the numerous flux density data sets taken over many years at L-band. These data had IFRs up to 5 or more radians/meter squared and appear to show that `TECOR`'s IFR is nearly correct without the approximately 15 per cent change suggested by Petrov. Further tests, including P band, are being made however. The procedures `VLATECR` and `VLBATECR`, found in `RUN` files `VLAPROCS` and `VLBAUTIL`, respectively, were upgraded to make the new `TECOR` options available.

The calibration of linear polarization was also changed significantly. The parallactic angle and IFR were only applied to the data when the visibilities were converted to true Stokes. Unlike with circular polarization, the observed visibilities were left in the antenna frame rather than the sky frame even when `DOPOL` was applied. This has changed. The polarization application has become rather more complicated, involving parallactic angles, IFRs, and a 4x4 matrix multiplication, so that the data are left in the sky frame. Conversion to true Stokes is then simple. `VHDIF` was modified to match this change.

All of the studying of `TECOR` has led to modest changes to the formula for the polarization angle of 3C286 used by `RLDIF`.

$$\begin{array}{lll} A = & 29.5 & (F \leq\ 1.5\ \mathrm{GHz}) \\ A = & 32.6 - 7/F^2 & (1.5 < F \leq\ 10\ \mathrm{GHz}) \\ A = & 32.6 + 5.38 \times\ (\log_{10}(F) - 1.0) & (10 < F \leq\ 45\ \mathrm{GHz}) \\ A = & 36.0 & (F > 45\ \mathrm{GHz}) \end{array}$$

UV data

Interferometry correlators are very good, but slight imbalances may remain. Baseline-based calibration has been used to attempt to correct for this issue. While baseline-based calibration can force the data to match *any* source model when done with a small `SOLINT`, a much less biased result may be had with a long integration time, typically the full data set. The continuum implementation of this is done by task `BLCAL` and the resulting `BL` table factors are applied by the standard calibration routines. With the EVLA, however, it was discovered that the calibration needs to be different for different spectral channels, not just IFs. Task `BLCHN` can compute this correction, writing both an output corrected data set and a `BD` table with the calibration values. `POSSM` and `BPLOT` can plot the `BD` table and `BDAPL` can apply it to another data set.

On the theory that correlators of cross-hand data, *e.g.*, RL, LR, VH, HV visibilities also suffer from this issue, a new `RUN` file named `BLPOLCAL` and task named `BLPCL` were created. The procedure computes the model data sets matching the input data set from models of I, Q, U, and, optionally, V Stokes. The task then applies the models to the input data and computes a full polarization `BD` table and writes out a corrected data set. Initial tests on a high dynamic range data set on 3C273 suggest that the data may be improved by this function.

LISUN is a new task which replicates the display of `LISTR OPCODE = 'SCAN'` with the addition of the angle to the Sun for each scan. It is a simpler means to this useful display but it does honor the `SOURCES` and `TIMERANG` adverbs, unlike `LISTR`.

CLIP was given the option `STOKES = 'PDIF'` to cause it to flag on the difference between the parallel-hand visibilities.

FRING has the option `CHINC` to reduce the number of spectral channels and therefore the size of its computations. Procedure `FINDCHIN` was added to return a recommended `CHINC`. It was then added to `VLBARUN`, `VLBAPCOR`, `VLBAFRNG`, `VLBAFRGP`, and `VLBAMPCL` as an option; `CHINC = -1` requests the use of `FINDCHIN`.

FITLD would sometimes make a mess of FITS IDI data when attempting to select only a range of IFs or spectral channels. An adjustment to the buffer handling corrected the problem.

SPFLG and `FTFLG` were given a `FLAG CHANNEL RANGE` option.

UVFIX was given the new `SRCNAME` option to allow correcting the position of one source from a multi-source data set while computing *uvw* for all sources.

UVSUB and OOSUB were given the new option 'MODU' to compute the source model for all visibility samples including those previously flagged. Option 'MODL' honors any flagging. The handling of compressed data when computing models was corrected.

SNRMS is a new task to compute and display statistics of table data. A wide range of tables and data types, similar to SNPLT, are available.

AVGWT is a new task to display statistics about weights of selected *uv* data. Use it to help set DBCON weights among other possible uses.

UVADD was changed to allow a spectral data set to be massaged by a continuum (single channel) data set.

VBRFI and VLBRF were changed to also print and plot the actual rms as well as the rms divided by the mean. PLRFI and PRRFI were changed to read both new and old format text files. Plotting and labeling of the frequency axis were corrected.

CLCOR options 'ANTP' and 'ANTC' were changed so that the proper motion correction starts at the first time for the source rather than 0 hours on the start day.

SYFIX is a new task to correct the source numbers in SY tables to match those in the data, a problem that arose with on-the-fly data.

AMKAT is a new task to renumber MeerKAT antennas to match their station numbers (+1), making a uniform nomenclature for all data sets.

PP table (output of RLDIF and VHDIF) copying was added to several tasks.

Imaging and display

The plot file format was changed to add a record following the adverb values and preceding the plot instructions. This record lists the adverbs found in the INPUTS section of the task help file. The sole use of this so far is for the verb PLGET which fills in the adverbs for the task that created the specified plot file. With the list of adverbs at the time of plot file creation, this function will not suffer the confusion which previously arose whenever the task adverbs were changed. All *AIPS* display tasks recognize both the old and new formats.

POSSM again received considerable attention in this period. The options POLPLOT = 'RMS' or 'RMSN' were added to have the rms and rms divided by mean in each SOLINT be plotted rather than the mean. It was changed to support multiple times in BD tables from BLCHN and BLPCL. POSSM attempts to label the horizontal axis with frequencies or velocities computed across spectral windows with dividers optionally plotted between spectral windows. Several issues with this new capability, including for overlapping SPWs, were corrected.

APCLN and VTESS would cause the *AIPS* TV to die when using their DOTV option. The computation of the TV display was changed to that used elsewhere and the problem seems to have gone away.

BPPLT is a new task to display bandpass table values as a function of time; this is helpful when BPASS is used to do the full calibration and CALIB is not used.

Mercator coordinate axis labeling was corrected.

TV setting of Clean boxes could change the box coordinates of boxes other than those deliberately changed by the user when the image pixel increment was not 1.

General

SRCNAME is a new adverb to be used by tasks that previously allowed only SOURCES(1). It now appears in numerous tasks, most notably in IMAGR. Use COMPRESS or RESTORE 0 if you have error messages regarding this adverb.

GMRT primary beam parameters are now available in *AIPS*. They will be used for GMRT data wherever primary beam values are computed.

CookBook chapters were updated in early January primarily for polarization and late June primarily for the new tasks and more polarization.

UVHOL and HOLOG were changed to handle on-the-fly holography observations.

Patch Distribution for 31DEC22

Normally, this section lists the patches that have been released for 31DEC22. This was based on the assumption that users would want to download individual files to compile them locally. However, the "Midnight Job" ($HOME/do_daily.*hostname*) will do this for you on locally-compiled installations. It will also do a proper update for binary installations. Therefore there is no reason to continue the old procedure. Major bug corrections will be moved to 31DEC22 as they occur and users should use the MNJ on occasion on both the NEW and TST versions of *AIPS*. The 31DEC22 release has had a number of these "patches":

1. VHDIF lost the DOINVERS true (add 180 degrees) result when smoothing the output average PP spectrum. *2023-01-03*
2. POSSM failed to make IF divider lines in columns > 1. Added numeric labels to all subimages. *2023-01-13*
3. TADIF had wrong length for units string and needed to trim the units and labels and take differences less seriously. *2023-01-13*
4. TECOR had an error in geometry affecting the IFR. *2023-01-23*
5. LISTR option POLD (difference of polarizations) failed mysteriously. *2023-02-10*
6. UVPLT would quit on a degenerate axis even if a plot range was specified. *2023-02-16*
7. FIXFR had bad file references. *2023-02-16*
8. UVADD did not copy essential tables (SU, FQ, AN, PO). *2023-02-24*
9. Mercator coordinates were not handled correctly. *2023-03-01*
10. PCNTR did not plot the polarization scale when requested if XYRATIO was set. *2023-03-20*
11. FITLD could overflow buffers when selecting IFs or channels with IDI format. *2023-03-28*
12. RLDIF has a new formula for the position angle of 3C286. *2023-03-28*
13. SOUSP used incorrect frequencies if IF selection was done after SETJY was run. *2023-03-29*
14. POSSM had several axis labeling issues. *2023-04-14*
15. VBRFI and VLBRF had errors in plotting data and in labeling the X axis. *2023-04-24*
16. IMAGR had an array that limited the number of channels entering an image to about 2000. *2023-04-28*
17. UVMOD was corrected to handle FQCENTER properly. *2023-05-24*
18. UVSUB and OOSUB did not compute OPCODE 'MODL' correctly for compressed data sets. *2023-06-12*
19. UV data sets without an FQ table could get wrong frequencies. *2023-06-14*
20. POSSM had horizontal axis labeling issues when not plotting all IFs and polarizations together (APARM(9) $\neq 0$). *2023-06-26*

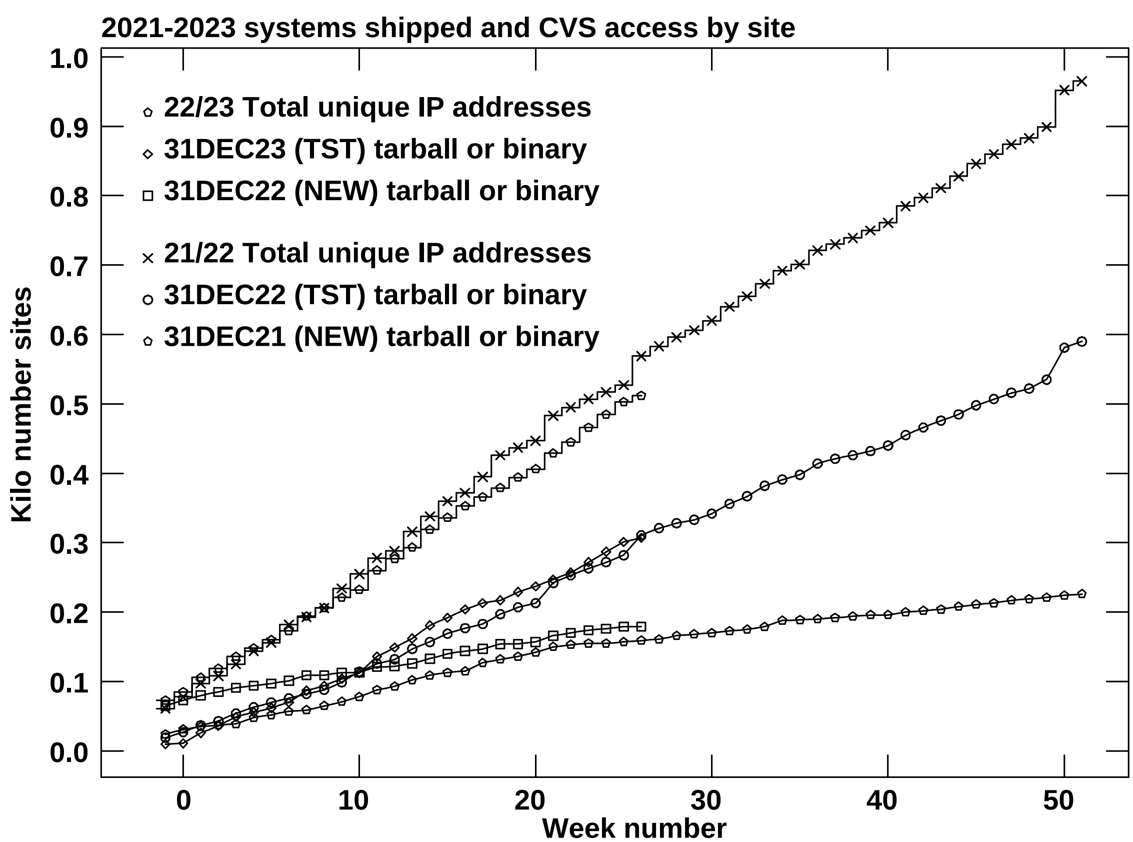
Recently revised *AIPS* Memoranda

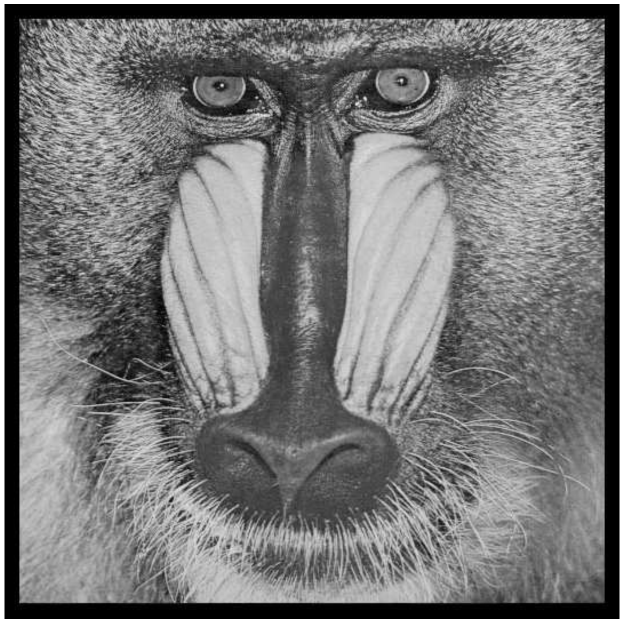
All *AIPS* Memoranda are available from the *AIPS* home page. Memo 117 was revised for the new `TE` file format.

117 *AIPS* **FITS File Format**
Eric W. Greisen, NRAO
February 1, 2023 revision
AIPS has been writing images and *uv* data in FITS-format files for a very long time. While these files have been used widely in the community, there is a perception that a detailed document in still required. This memo is an attempt to meet that perception. *AIPS* FITS files for *uv* are conventions layered upon the standard FITS format to assist in the interchange of data recorded by interferometric telescopes, particularly by radio telescopes such as the EVLA and VLBA.

AIPS Distribution

We log apparent MNJ accesses and downloads of the tar balls and binary installations. We count these by unique IP address. Since some systems assign the same computer different IP addresses at different times, this will be a bit of an over-estimate of actual sites/computers. However, a single IP address is often used to provide *AIPS* to a number of computers, so these numbers are probably an under-estimate of the number of computers running current versions of *AIPS*. So far in 2023 more than 180 IP addresses have downloaded the slushy form of `31DEC22`, while more than 307 IP addresses have downloaded `31DEC23`. A total of 512 different IP addresses have appeared in one of our transaction log files. These numbers are about the same as those of last year at this time.





June 30, 2023

AIPSLETTER
National Radio Astronomy Observatory
Post Office Box O
Socorro, NM 87801-0387
USA