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Australia Telescope Data Analysis

Continuum Mapping using the AIPS system

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1.0 Introduction

This document aims to summarize as concisely as possible our experiences in analysing Australia Telescope continuum radio data. It may at times be somewhat criptic to achieve brevity but nevertheless includes all those steps undertaken by us in processing some of the first maps made with the AT facility.

2.0 Aim

In using the AT one clearly wishes to maximise UV coverage. To that end we undertook continuum bandwidth synthesis (the process of observing the same source at a number of frequencies across the observable band-pass) so obtaining a larger number of baseline separations. Each observation thus consisted of observing the required source for ≤12 hours while at the same time observing in rotation at each of 3 frequencies across the available continuum band. Position and flux calibration observations lasting of the order of 6 mins (2 mins at each of the same frequencies) were also made itermitantly.

3.0 The Data Analysis Steps

Here we list the main AIPS **tasks** used in the processing (3.1) and then for a typical observation data set we run through each task outlining the parameters used by us (3.2). The described tasks cover a range from loading AT data into the AIPS system to the production of a map after several data reduction steps in the UV plane.

The assumption is made that the reader is familiar with the basic facilities of AIPS and can access the AIPS Cookbook to clarify AIPS philosophy.

N.B.: Each of the frequencies of the bandwidth synthesis are chosen for analysis is assumed to be a separate source (A,B,C).

3.1 A Basic Step Itinerary of Reduction Procedures and Tasks

a) Starting

Steps to load data from tape and get started on the Sun Workstation and the CONVEX

b) Construction of multifile UV data set

ATLOD - task to load RPFITS data into the AIPS system

UVSRT - task to sort UV data (here: increasing times, or TB)

DBCON - task to concatenate related files of RPFITS files into a single file

AVSPC - task to average channels of data together

c) Inspection of UV data

PRTAB - task to print table information associated with the data files

UVAVG - task to average data points to reduce total no. of visibilities

VBPL - task to construct plotfile from UV data (e.g. amplitude vs. time display)

MIXPL - task to display plot-file on output device - usually a laser printer.

TVPL - task to display plot-file on a TV screen (e.g. SUN workstation)

PRTUV - task to print selected set of UV data

LISTR - alternative task to print UV data and calibration tables

d) Editing of UV data in multifiles

QUACK - task to flag bad data on a time-based selection

UVFLG - task to flag (bad) UV data to be specified e.g. by no. of visibilities

TVFLG - task to flag large UV data bases directly at TV screen

e) Calibration of UV data

INDXR - task to make an index file for following tasks

SETJY - task to set the flux tables of the calibrator sources

CALIB - task to reset the amplitude of calibrators and determine the phase errors of the system using the calibrators

CLCAL - task to reset data for non-cal sources using the calibrator data

SPLIT - task to divide a multi-source data file into individual files (and to apply calibration)

f) Building an image (map), Cleaning and image display

DBCON - concatenate related files (here: different frequencies A,B,C)

UVSRT - task to sort UV data (here: XY order)

MX - general task for creating images and cleaning

tvall - verb for displaying image on TV screen

tvlabel - verb providing a grid for TV image

g) Some help

helpful verbs , e.g. **explain, imhead, clrstat** and warnings

3.2 How we actually did it

a) Start by getting your data on the CONVEX

We suggest that for most operations it is best to use the SUN workstations as that gives both the facilities to manipulate multiple windows to the Convex (and thus undertake a range of processing separately) but also gives the best display facilities for colour viewing etc of the data.

Logging In - provide your user name and password as requested on SUN workstation

rlogin ateles - to get to the CONVEX

tpalloc -d 6250 -f /dev/rmt17 - allocates the left tape drive on CONVEX (or **rmt16** for the right tape drive)

cd /scratch/rbloggs - changes directory to scratch/rbloggs ready for data

/mnt/cjacka/bu/vmsbup -d17 -f0 - loads the RPFITS data to . CONVEX (or **d16** for the other tape drive)

mv - allows one to change a file name after loading. NB. That all the RPFITS files must be in upper case only

history - use to have a look at the history of commands issued to the CONVEX. One can reissue a command under UNIX using e.g.!45 to refer to the 45th command in the history listing.

ll - gives a directory, file sizes and file dates

quota -v - the disk quotas on all disks available

chmod 777 /scratch/rbloggs/<files> - makes the following link-command possible

ln -s /scratch/rbloggs /AIPS/FITS/RBLOGGS - this links the user area /scratch/rbloggs to the AIPS working directory. One must first ask Mark Calabretta to allow you to use AIPS in this manner before making the link please.

logout - logout of your user area now and enter AIPS for further work

N.B.: Concerning ***sunview****. This is a multi-screen mode on the workstations, containing three alphanumeric and one TV screen. The procedure is built up automatically on SUN stations if login occurs via AIPS usernumber. (otherwise can be called with the command* ***sunview****). A description of this can be found later (#g).*

Now Enter AIPS to continue

Logging in - provide user name AIPS and its password

rlogin ateles - to get to the CONVEX (to AIPS)

$CDTST - to start the most recent version of AIPS (15Oct89)

AIPS - to start AIPS running

Enter your user number (e.g. RFH: **487**, RTS: **15**)

N.B.: In the following paragraphs (#b-g) a description is given of different AIPS tasks used in our footpath. Important adverbs of the tasks are underlined and shortly described..All other adverbs keep default values.

b) Construction of multifile UV data set

ATLOD - task to load RPFITS data into the AIPS system. This will look at the inputs for the task and these should be set as follows

infile =	'/AIPS/FITS/RBLOGGS/FILENAME.RPF'	
outname =	(eg: 'GAL8')	
outclass =	' '	
cparm (1) =	0 -	no autocorrelation
(2) =	1 -	last spectral channel contains Tsys
(3) =	1 -	negate the UVW phases
		(see Mark Calabretta for update)

(4) =	0 -	all the rest zeros
dparm (1,2,3) =	-42,-43,0	We need to exclude baselines of the type -42, -43 and use only 2-3, 3-4, 2-4 .

N.B.: Data are organized in 32 channels, no. 32 giving Tsys for the observation.

UVSRT - task to sort the data into (for example) increasing UT times

sort =	'TB'	- a time-based sort of the data file based on UT time

When sorting note the number of visibilities that are in each finished (& sorted file). You will need this number later to compare with the number of visibilities not flagged as bad data.

DBCON - task to concatenate related files of data into a single file

One has to do this in stages by adding 2 files together and then taking the output file and adding the next file etc.. Parameters that we used include:

doarray =	-1	- implies not to check header
dopos =	all 0	

AVSPC - task to average channels of data together for the purpose of reducing the amount of data to display.

We changed the following Parameters (for 32 channels of data at this stage of the AT's evolution):

bchan =	5	- channel lower than this are rubbish
echan =	28	- channel higher than this are rubbish
chansel =	5, 28, 1	- average all channels from 5 to 28

c) Inspection of UV data

*N.B.: Inspection of UV data using the following tasks (especially **PRTAB**, **PRTUV** and plots with **VBPL**) is recommended after all steps of data reduction (#b-e).*

PRTAB - task to print table information associated with the data files; different tables are chosen with the adverb inext

Typical parameters that one uses here are

bcount =	1	
inext =	'SU'	- which gives a list of sources in the file
=	'FQ'	- a list of frequencies used
=	'NX'	- an index table
=	'AN'	- an antenna used table
=	'FG'	- table of flagged data
=	'HI'	- history of file creation and change

UVAVG - task to average data points to reduce total no. of visibilities in the UV plane

Typical parameters that one uses here are:

inname =	'Source A'	
xinc =	1	
yinc =	30	(average over e.g. 30sec)
inclass =	' '	(default: UVAVG)

VBPL - task to construct plotfile from UV data (e.g. amplitude vs. time display) A selection of visibilities to plot is possible with timerange (cf. **LISTR**) and other adverbs.

Typical parameters that one uses here are:

bparm (1).=	12	x-axis will be UT time
(2) =	1	y-axis will be amplitude (2: phase)

MIXPL - task to display plot-file on output device - usually a laser printer.

TVPL - task to display plotfile on a TV screen (SUN workstation)

PRTUV - task to print selected set of UV data (No. of Visibilities, time, amplitude and phase).

Typical parameters are:

sources=	'30dor a',' '	
ncount =	100	max. no. of printed visibilities
cparm =	1,19,40,0,1,20,0,0,304	

Here we select with cparm the time interval 19h40m to 20h (values 1-8) and only baseline 3-4 from the first day of observation.

LISTR - alternative task to print UV data and calibration tables.

timerange = 1,19,40,0,1,20,0,0 (analog to values 1-8 in cparm)

d) Editing of UV data in multifile

QUACK - task to select bad data to be flagged for exclusion. In general we chose the option to throw away about 1 min of data from the beginning of each observing cycle and only thus to keep 2 (Cal sources) or 5miutes (field sources) of data at the end of each time cycle (because setup time causes bad data in the beginning of each observing scan). The value you choose should be based upon the time of each of the observed sources.

Typical parameters that one uses here are:

source =	'Source A', 'Source B', ' '	- sources in the data file to process
opcode =	'END'	
aparm =	2	- time kept at the end of each scan
flagver =	1	
antennas.=	2,3,4	

UVFLG - task to flag (bad) UV data which can be specified e.g. by no. of visibilities (bdrop, edrop) or timerange

*N.B.: In multisource files flagged data are only marked in the FG table, in single source files the weight (display via **PRTUV**) is set to negative values for flagged data.*

TVFLG - task to flag large UV data bases directly at the TV screen (using mouse and colour code facilities), necessary e.g. in case of many baselines (VLA data). Difficult to use , and causes some trouble in colour facilities , therefore not recommended here.

e) Calibration of UV data

INDXR - task to create a calibration table (CL) for a data file (**getn** <cat.no.>, all other parameters default)

SETJY - task to set the amplitude flux tables of the calibration sources

Typical parameters that one uses here are:

zerospc =	5.5	flux density of the calibrator
optype =	' '	
calcode =	' '	
freqid =	1	(or 2, 3 in succeeding runs).

CALIB - task to reset the phase information of calibrators and determine the phase errors of the system using those calibrators. This will produce an 'SN' table for each calibration source. We are effectively undertaking a self-cal on each calibrator for each observing frequency. This task must be run 3 times (we used 3 frequencies) for each calibration source

Typical parameters that one uses here are:

calsour =	'CALSRC A','CALSRC B', ' '	
soltype =	'L1'	- solution type for the fitting
solmode =	' '	- blank is required
smodel.=	0	- (all values 0)

*N.B.: If calibration of the data is repeated, it is necessary to delete old calibration tables 'SN' and 'CL' with **extdes** (cf. #g)*

CLCAL - task to apply the calibation results to non-cal sources using the correction table deduced by task **CALIB**. This task must be run 3 times (we used 3 frequencies) for each calibration source.

Typical parameters that one uses here are:

freqid =	1,2 and then 3	- for all 3 frequencies used in. observation (3 succeeding runs).
opcode =	'CALI'	
timerange =	'0'	
sources =.	'0637 a','30dor a','0637 b','30dor b','0637 c','30dor c'	
calsour.=	'0637 a','0637 b','0637 c'	

Here put in all calibration and field sources which shall be calibrated. Selection of frequencies for different runs of **CALIB** is done by freqid

SPLIT - task to divide a multi-source data file into individual files each contained the data for **one** source.

Typical parameters that one uses here are:

freqid =	1	(2,3 in following runs)
bchan =	0	
echan =	0	
sources =	'30dor a','30dor b','30dor c',' '	
docalib =	+1	- do apply the calibration tables

N.B.: If DOCALIB is set to -1 here the calibration tables determined in CALIB are not yet applied during the split. One needs to decide where to do the split and then apply the calibration at the most appropriate time.

SNPLT - task for building plotfiles of the gain variations for different antennas

inext =	'CL'	(calibrators)
inext =	'SN'	(sources)
xinc =	1	
optype =	'AMP' or 'PHS'	plot amplitude or phase vs. time

f) Building an image. Cleaning and image display

DBCON - task to concatenate related files of data into a single file, here: concatenate different frequencies A,B,C)

One has to do this in stages by adding 2 files together and then taking the output file and adding the next file etc.. Parameters that we used include:

doarray =	-1	- implies not to check header
dopos =	all 0	

UVSRT - task to sort the data.

sort =	'XY'	- sort of the data in order of descending baselines

MX - general task for creating images and cleaning. In the following we list our input parameters for running **MX** the first time (succeeding runs with changed parameters - deeper cleaning - are necessary in general).

cellsize =	1, 1	grid in arcsec (at least two grid points per beam, here 4.7")
imsize =	32, 32	minimum field size
fieldsize =	1024, 1024	field size (in grid points)
niter =	500	No. of iterations for cleaning
flux =	0.001	flux limit in Jy for cleaning (should be above the noise limit for observations)

tvall - verb for displaying image file in grey scale or colour on TV screen.(wedge at bottom of screen). This command allows adjusting the grey- or colour scale via mouse button on the screen.

Additional verbs in connection with **tvall** are

tvinit clears TV screen

tvlabel draws a grid around TV image

A colour hardcopy facility is provided at the TUCANA workstation near the CONVEX room.

g) Some help

The following verbs are useful when running AIPS:

explain <taskname>	- can help one understand the task in question
input <taskname>	- gives input parameters ("adverbs") for the specified task
task '<taskname>'	- all following commands are referred to this task
tget <taskname>	- to get the parameters used in the last run of that task. Very useful to check against someone else's run
ucat	- gives a catologue listing of your UV-files
mcat	- gives a catologue listing of your map- or image-files
getn <cat-no.>	- attached a file to AIPS for processing in a Task (includes setting of task - cf. **task**).
go <taskname>	- makes the task run again with the same inputs
free	- gives the amount of free space on the AIPS disk
spy	- shows tasks which are running at the moment
indisk <n>	- switch between different disks (n=1,2,3).Files on disk shown via **ucat/mcat.**
imhead	- verb to see the contents of an AIPS file header
clrstat	- verb to clear out WRITE- or READ-status of files if a task has been cancelled (shown via **ucat/mcat,** last column)
zap	- zaps a file that has been **getn'ed**
prtmsg	- prints the messages on the AIPS message file
clrmsg	- clears out messages of the AIPS message file
save <newname>	- saves task with all chosen adverbs under new name (can be loaded again with **get** <newname>)

sunview - is a multi-user windowing environment of the SUN workstations, containing three alphanumeric and one TV screen. The procedure is built up automatically on SUN workstations if login occurrs under AIPS (or can be called with the command **sunview**). It is recommended that one enlarges the TV screen to maximum size (Option **Move** to upper left corner, then option **Resize** to lower right corner, both called with mouse-click on upper edge of screen). A direct switch between the different screens is possible with the **<L5>**-button. Screens not in use can be closed or quit (options **Close, Quit**). At the end of work sunview **must** be shut down (Option **shutdown** on grey command screen).

Warning: - A lot of our problems were caused by improper use of adverbs in different tasks. It should be noted that the values of the adverbs are not changed automatically when a different task is started. Therefore one should always call a new task by **tget** <task> which automatically changes adverbs to values last used with that task. It is also possible to save successful runs of one task with different values under different names (**save** <task>, so that one can call next time successfully with a **get** <task>). Also necessary is a careful inspection of the data during all the different steps of the data reduction. One should check tables (**PRTAB**), lists (**PRTUV** or **LISTR**) and plots (**VBPL**) after all of the steps described in #b, #d-f.