

Chapter 1

UV Variables

1.1 UV Dataset

A *MIRIAD* uv dataset is composed of a collection of items and ‘ $u - v$ variables’. The variables are parameters that are known at the time of the observation, and include measured data, and the description of the observation set up (*e.g.* correlator set up and observing centers).

Table 1.1 gives a list of the items that are used to build up a *MIRIAD* uv dataset.

The *Programmers Guide* contains more detailed information on how a visibility dataset is constructed, this Appendix only reports which variables can be found in the item `visdata`. The text item `vartable` contains an ordered (for quick indexing) list of all the variables which exist in the `visdata` item.

A list of all items in a visibility dataset is summarised in Table 1.1 below. A list of all the uv variables can be obtained with the *MIRIAD* program `uvlist` or `uvio` for the brave of heart.

The storage **types** (2nd column) in the table below are:

```
A -- ascii (NULL terminated)
R -- real (32 bit IEEE)
D -- double (64 bit IEEE)
C -- complex (2 * 32 bit IEEE)
I -- integer (32 bit twos complement)
J -- short (16 bit twos complement)
K -- long (64 bit twos complement) *** not currently used in visdata ***
```

They are the same as the data type in the first column of the `vartable` item in a *MIRIAD* uv dataset.

Variables with two dimensions have the first dimension varying fastest, the usual FORTRAN notation.

NB: The formal version of this document is recorded as “*October 1, 2008*”.

Table 1.1: *MIRIAD* items in a uv visibility dataset

Item name	Type	Description
obstype	ascii	value: 'cross', 'auto' or 'mixed'
history	text	history text file (in principle editable)
vartable	text	lookup table for all uv variables (do not edit!)
visdata	mixed	data stream of uv variables
flags	integer	optional flags for narrowband data
wflags	integer	optional flags for wideband data
gains	mixed	antenna gain table (delhd this item to disable gain table)
nfeeds	integer	number of feeds on each antenna
ntau	integer	Number of delay/spectral index terms per antenna in 'gains'
nsols	integer	number of records in 'gains'
ngains	integer	number of antenna gains in each record of 'gains'
interval	double	gain interpolation time tolerance (days)
leakage	complex	polarization leakage parameters
freq0	double	reference frequency for delay terms
freqs	mixed	frequency set up description table for 'bandpass'
bandpass	complex	bandpass function gains (delhd this item to disable passband corrections)
nspect0	integer	number of windows in the bandpass function
nchan0	integer	total number of channels in the bandpass function

Name	Ty	Units	Comments
airtemp	R	centigr.	Air temperature at observatory
antaz(nants)	D	deg.	azimuth of antennas (BIMA was using 0=south CARMA will use 0=north)
antdiam	R	meters	Antenna diameter
antel(nants)	D	deg.	elevation of antennas
antpos(nants, 3)	D	nanosec	Antenna equatorial coordinates, with X along the local meridian (not Greenwich)
atten(nants)	I	dB	Attenuator setting (Hat Ck/CARMA) datatype R ???
axismax(2,nants)	R	arcsec	Maximum tracking error in a cycle. axismax(1,?) is azimuth error, axismax(2,?) is the elevation error.
axisoff(nants)	R	nanosec	Horizontal offset between azimuth and elevation axes (CARMA)
axisrms(2,nants)	R	arcsec	RMS tracking error. axisrms(1,?) is azimuth error, axisrms(2,?) is the elevation error.
baseline	R	-	The current antenna baseline Baseline is stored as $256 * ant1 + ant2$ or $2048 * ant1 + ant2 + 65536$ The uv coordinates are calculated as $uvw = xyz(ant2) - xyz(ant1)$. Note that this is different from the AIPS/FITS convention (where $uvw = xyz(ant1) - xyz(ant2)$). When writing this variable, software must ensure that $ant1 < ant2$. baseline is also known as preamble(4) or preamble(5) depending if you have uv or uvw data resp.
bin	I	-	Pulsar bin number.
cable(nants)	D	nanosec	measured length of IF cable (Hat Ck)
calcode	A	-	ATCA calcode flag
chi or chi(nants)	R	radians	Position angle of the X feed relative to the sky. This is the sum of the parallactic angle and the vector variable. If only one value is present, all antennas are assumed to have identical values.
chi2	R	radians	Second feed angle variation (SMA)
coord(*)	D	nanosec	uv(w) baseline coordinates ?? what epoch ?? coord is also known as preamble(1:2) or preamble(1:3) depending if you have uv or uvw data resp.

corbit	R	-	Number of correlator bits (Hat Ck)
corbw(2)	R	MHz	Correlator bandwidth setting (Hat Ck) Must take the values 1.25, 2.5, 5.0, 10.0, 20.0, 40.0 & 80.0 MHz.
corfin(4)	R	MHz	Correlator LO setting before Doppler tracking (Hat Ck) This is the LO frequency at zero telescope velocity Must be in the range 80 to 550 MHz.
cormode	I	-	Correlator mode (Hat Ck). Values are: 1 : 1 window /sideband by 256 channels 2 : 2 windows/sideband by 128 channels 3 : 4 windows/sideband by 64 channels, single sideband 4 : 4 windows/sideband by 64 channels, double sideband
coropt	I	-	Correlator option (Hat Ck) 0 means cross-correlation 1 means auto-correlation Same as the obstype item?
corr(nchan)	J or R	-	Correlation data corr is really a complex quantity, but the data stream variable can be stored otherwise for efficiency.
cortaper	R	-	On-line correlation taper (Hat Ck) This is the value at the edge of the window The value is from 0-1.
dazim(nants)	R	radians	Offset in Azimuth. (CARMA)
ddec	R	radians	Offset in declination from dec in epoch coordinates. The actual observed DEC is calculated as $dec + ddec$.
dec	R or D	radians	Declination of the phase center/tangent point. See epoch for coordinate definition. See also obsdec
delay(nants)	D	nanosec	delay setting at beginning of integration (Hat Ck)
delay0(nants)	R	nanosec	delay offset for antennas (Hat Ck)
deldec	R or D	radians	Declination of the delay tracking center. See epoch for coordinate definition.
delev(nants)	R	radians	Offset in Elevation (CARMA)
delra	R or D	radians	Right ascension of the delay tracking center. See epoch for coordinate definition.
dewpoint	R	centigr.	Dew point at weather station (Hat Ck)
dra	R	radians	Offset in right ascension from ra in epoch coords. The actual observed RA is calculated as $ra + dra/\cos(dec)$.
epoch	R	years	A badly named variable – this defines the mean equinox and equator for the equatorial coordinates ra , dec , dra and ddec . The epoch of the coordinates is actually the observing time. Values less than 1984.0 are Besselian with coordinates in the FK4 system. Values greater than 1984.0 are Julian with coordinates in the FK5 system. You will typically find 1950.0 or 2000.0 here.
evector or evector(nants)	R	radians	Position angle of the X feed, to the local vertical. If only one value is present, all antennas are assumed to be identical.
focus(nants)	R	volts	Focus setting (Hat Ck)
freq	D	GHz	Rest frequency of the primary line
freqif	D	GHz	? (Hat Ck only?)
inttime	R	seconds	Integration time (see also time)
ischan(nspect)	I	-	Starting channel of spectral window
ivalued(nants)	I	?	Delay step (Hat Ck) Used in an attempt to calibrate amp and phase vs. delay.
jyperk	R	Jy/K	The efficiency Jy/K, calculated during online calibration
jyperka(nants)	R	$\sqrt{Jy/K}$	Antenna based Jy/K, calculated during online calibration (Hat Ck)
latitud	D	radians	Geodetic latitude of the observatory.
lo1	D	GHz	First local oscillator (Hat Ck/CARMA) lo1 is in the range 70 GHz - 115 GHz for 3mm.

lo2	D	GHz	Second local oscillator (Hat Ck)
longitu	D	radians	Longitude of the observatory.
lst	D	radians	Local apparent sidereal time.
modedesc	A	-	Correlator mode description (CARMA only) Example: 500-32-8-X-X-X-X-X
mount or mount(nants)	I	-	The type of antenna mounts. If only one value is given, all antennas are assumed to be the same. Possible values are: 0: Alt-az mount. 1: Equatorial mount. 2: X-Y. 3: orbiting. 4: bizarre.
name	A	-	ATCA raw RPFITS file name.
nants	I	-	The number of antennas Following variables use a dimension of nants : antpos(nants, 3) focus(nants) phaseslo[1-2](nants) phasesm1(nants) systemp(nants, nspect) wsystemp(nants, nwide) temp(nants, ntemp) tpower(nants, ntpower) axisrms(2,nants) dazim(nants) delev(nants) The antennas are always numbered starting at 1.
nbin	I	-	Total number of pulsar bins.
nchan	I	-	The total number of individual frequency channels The following variables have the dimension of nchan : corr(nchan)
npol	I	-	The number of simultaneous polarisations
nschan(nspect)	I	-	Number of channels in spectral window
nspect	I	-	Number of spectral windows Following variables use a dimension of nspect : ischan(nspect) nschan(nspect) restfreq(nspect) sdf(nspect) sfreq(nspect) systemp(nants, nspect)
ntemp	I	-	Number of antenna thermistors Following variables use a dimension of ntemp : temp(nants, ntemp)
ntpower	I	-	Number of total power measurements The following variable depends on ntpower : tpower(nants,ntpower) ntpower is currently 1, could be more later.
nwide	I	-	Number of wideband channels Variables which depend on nwide are: wfreq(nwide) wwidth(nwide) wcorr(nwide) wsystemp(nants,nwide)
obsdec	D	radians	Apparent declination of the phase centre/tangent point at time of observation. See also dec
observer(*)	A	-	The name of the observer
obsline(*)	A	-	The name of the primary spectral line of interest to the observer
obsra	D	radians	Apparent right ascension of the phase centre/tangent point at time of observation. See also ra
on	I	-	Either 1, 0 or -1, for on, off pointing, and Tsys spectrum resp. for auto-correlation data.

operator(*)	A	-	The name of the current operator
pbfwhm	R	arcsec	(Deprecated) Primary Beam at Full Width Half Maximum For Hat Ck, it is approximately 11040.0/101.
pbtype(*)	A	-	Primary beam type to be used in imaging.
phasel01(nants)	R	radians	Antenna phase offset (Hat Ck/CARMA)
phasel02(nants)	R	radians	Second LO phase offset (Hat Ck/CARMA)
phasem1(nants)	R	radians	IF cable phase (Hat Ck/CARMA)
plangle	R	degrees	Planet angle
plmaj	R	arcsec	Planet major axis (note units)
plmin	R	arcsec	Planet minor axis
pltb	R	Kelvin	Planet brightness
pntdec	R or D	radians	Declination of the pointing center. See epoch for coordinate definition.
pntra	R or D	radians	Right ascension of the pointing center. See epoch for coordinate definition.
pol	I	-	Polarization type of the correlation data. Values follow the AIPS/FITS convention, viz: 1: Stokes I 2: Stokes Q 3: Stokes U 4: Stokes V -1: Circular RR -2: Circular LL -3: Circular RL -4: Circular LR -5: Linear XX -6: Linear YY -7: Linear XY -8: Linear YX
precipmm	R	mm	Mm of precipitable water vapour in the atmosphere.
pressmb	R	millibar	atmospheric pressure.
project(*)	A	-	The name of the current project
purpose(*)	A	-	Scientific intent or purpose For CARMA: B=bandpass, F=flux, G=gain (phase/amp) P=polarization, R=radio pointing, S=science target, O=other
ra	R or D	radians	Right ascension of the phase center/tangent point. See epoch for the definition of the coordinate system. See also obsra
rain	R	mm	The current amount of water in the rain gauge. The rain gauge is emptied at 9:00 AEST (ATCA).
refpnt(2,nants)	R	arcsec	Reference pointing offsets. refpnt(1,?) is azimuth offset, refpnt(2,?) is the elevation offset.
relhumid	R	%	Relative Humidity at observatory
restfreq(nspect)	D	GHz	Rest frequency for each spectral window. This may be zero for continuum observations.
rmspath	R	microns	RMS path variation (CARMA, for HatCrk units were %) see also smonrms
sctype	A	-	Scan type (ATCA?)
sdf(nspect)	D	GHz	Change in frequency per channel
sfreq(nspect)	D	GHz	Sky frequency of (center of) first channel in window
smonrms	R	μ m	ATCA seeing monitor rms value (see also rmspath)
source(*)	A	-	The name of the source
srv2k(nants)	R	?	??? (Hat Ck)
systemp or systemp(nants) or systemp(nants,nspect)	R	Kelvin	Antenna system temperatures
tau230	R	-	Optical depth at 230 GHz, as measured with the ... system (Hat Ck/CARMA)
tcorr	I	-	HasTsys correction has been applied (0:none, 1:applied) (CARMA, ATNF)
telescope(*)	A	-	The telescope name. Some standard values are: 'ATCA' 'HATCREEK' 'VLA' 'WSRT'

temp (nants, ntemp)	R	centigr.	Antenna thermistor temperatures (Hat Ck)
themt(nants)	R	Kelvin	temperature of the hemt amplifier (Hat Ck)
tif2(nants)	R	Kelvin	temperature of IF amplifier (Hat Ck)
time	D	days	The time (nominally UT1) stored as a Julian date. For example, noon on Jan 1, 1980 is 2,444,240.0! time is also known as preamble(3) or preamble(4) depending if you have uv or uvw data resp. time is the beginning of an integration with length inttime
tpower (nants, ntpower)	R	volts	Total power measurements (Hat Ck)
trans	R	K	CARMA
tscale	R	-	Optional correlation scale factor Used only when corr is stored as J (16 bits).
tsis(nants)	R	Kelvin	temperature of the SIS mixers (Hat Ck)
tsky	R	-	CARMA
ut	D	radians	The time since midnight Universal time (nominally UT1).
veldop	R	km s ⁻¹	The sum of the radial velocity of the observatory (in the direction of the source, with respect to the rest frame) and the nominal systemic radial velocity of the source.
veltype(*)	A	-	Velocity rest frame. Possible values for veltype are: VELO-LSR: rest frame is the LSR VELO-HEL: rest frame is the barycentre VELO-OBS: rest frame is the observatory FELO-LSR: rest frame is the LSR (deprecated) FELO-HEL: rest frame is the barycentre (deprecated)
version(*)	A	-	The current hardware/software version Current options: oldhat, newhat For carma: x.y.z
vsorce	R	km s ⁻¹	Nominal radial systemic velocity of source. Positive velocity is away from observer.
wcorr(nwide)	C	-	Wideband correlations. The current ordering is: wcorr(1:2) are the digital LSB and USB. wcorr(3:4) are the analog LSB and USB.
wfreq(nwide)	R	GHz	Wideband correlation average frequencies (center?)
wind	R	km/h	Wind speed in km/h (ATCA)
winddir	R	deg	Wind direction (where the wind is blowing from) (note: originally encoded as 'N', 'SE', 'W', etc.)
windmph	R	mph	Wind speed - in imperial units!
wstemp or wstemp(nants) or wstemp(nants,nwide)	R	K	System temperature for wide channels.
wwidth(nwide)	R	GHz	Wideband correlation bandwidths
xsampler (3,nants,nspect)	R	percent	X sampler statistics (ATCA).
xtsys(nants,nspect)	R	Kelvin	System temperature of the X feed (ATCA).
xtsysm(nants,nspect)	R	Kelvin	???
xyamp(nants,nspect)	R	Jy	On-line XY amplitude measurements (ATCA).
xyphase (nants,nspect)	R	radians	On-line XY phase measurements (ATCA).
ysampler (3,nants,nspect)	R	percent	Y sampler statistics (ATCA).
ytsys(nants,nspect)	R	Kelvin	System temperature of the Y feed (ATCA).
ytsysm(nants,nspect)	R	Kelvin	???

1.2 Telescope specific notes

A reminder on some telescope specific variables

1.2.1 ATCA

```

calcode
name
rain
sctype
smonrms
wind
xsampler(3,nants,nspect)
xtsys(nants,nspect)
xyamp(nants,nspect)
xyphase(nants,nspect)
ysampler(3,nants,nspect)
ytsys(nants,nspect)

```

1.2.2 CARMA

```

dazim(nants)
delev(nants)
modedesc
axisrms      "skyErr"  -- temporary sqrt(2) issue
axisoff
lo1 changes, phasel01=0
lo2 still absent
purpose

```

1.2.3 SZA

TBA

1.2.4 SMA

```

chi2

```

1.2.5 BIMA/Hat Creek

Although the telescope name is for historic reasons called **HATCREEK**, they are really the 6m BIMA antennae, but while this array was operational at the Hat Creek site in Northern California. The following UV variables were specifically used for this array, although some of them moved to CARMA as well:

```

atten(nants)
cable(nants)
corbit
corbw(2)
corfin(4)
cormode
coropt
cortaper
delay(nants)          carma
delay0(nants)
dewpoint
focus(nants)
freqif
ivalued(nants)
lo1                   carma
lo2
phasel01(nants)      carma
phasel02(nants)      carma
phasem1(nants)       carma
rmspath              carma
srv2k(nants)
tau230               carma

```

```
temp(nants, ntemp)
themt(nants)
tif2(nants)
tpower(nants, ntpower)
tsis(nants)
```

1.3 Examples

```
% ls -l 3c273/
total 1808
-rw-r--r--  1 teuben  teuben    49952 Oct 12 1998 flags
-rw-r--r--  1 teuben  teuben     136 Jul 24 1998 header
-rw-r--r--  1 teuben  teuben    48700 Oct 12 1998 history
-rw-r--r--  1 teuben  teuben     671 Jul 24 1998 vartable
-rw-r--r--  1 teuben  teuben   1725300 Jul 24 1998 visdata
-rw-r--r--  1 teuben  teuben     1760 Jul 30 1998 wflags

% itemize in=3c273
Itemize: Version 31-JUL-97
nwcrr      = 13608
ncorr      = 387072
vislen     = 1725304
obstype    = crosscorrelation
history    (text data, 48704 elements)
visdata    (binary data, 1725300 elements)
vartable   (text data, 675 elements)
flags      (integer data, 12487 elements)
wflags     (integer data, 439 elements)

% uvio 3c273
uvio Version 16-jan-01 rjs
Ox      0 FILE: 3c273
Ox      0 SIZE: project   Count=12,Type=a
Ox      8 DATA: project  n196d028.cal
Ox     18 SIZE: source    Count=5,Type=a
Ox     20 DATA: source   3C273
Ox     30 SIZE: ra        Count=1,Type=d
Ox     38 DATA: ra       3.26861624
Ox     48 SIZE: dec       Count=1,Type=d
Ox     50 DATA: dec      0.03582093395
Ox     60 SIZE: vsource   Count=1,Type=r
Ox     68 DATA: vsource          0
Ox     70 SIZE: plmaj     Count=1,Type=r
Ox     78 DATA: plmaj          0
Ox     80 SIZE: plmin     Count=1,Type=r
.....
Ox    12b0 DATA: tif2          34.60030746
Ox    12e8 SIZE: pol         Count=1,Type=i
Ox    12f0 DATA: pol         -6
Ox    12f8 SIZE: wcorr       Count=18,Type=c
Ox    1300 DATA: wcorr       0.1456700563      -0.1822117269
Ox    1398 SIZE: tscale      Count=1,Type=r
Ox    13a0 DATA: tscale      0.0009044817416
Ox    13a8 SIZE: corr        Count=1024,Type=j
Ox    13b0 DATA: corr        0
Ox    1bb8 SIZE: coord       Count=2,Type=d
Ox    1bc0 DATA: coord       -96.06886361
Ox    1bd8 SIZE: time        Count=1,Type=d
Ox    1be0 DATA: time        2450671.342      97AUG10:20:12:01.1
Ox    1bf0 SIZE: baseline    Count=1,Type=r
Ox    1bf8 DATA: baseline    260
Ox    1c00 ===== EOR (1) =====
Ox    1c08 DATA: wcorr       0.1115201488      0.1867246479
Ox    1ca0 DATA: tscale      0.001088747638
Ox    1ca8 DATA: corr        0
Ox    24b0 DATA: coord       19.81238265
Ox    24c8 DATA: baseline    516
Ox    24d0 ===== EOR (2) =====
Ox    24d8 DATA: wcorr       0.106826134      -0.0437762402
```

```

0x 2570 DATA: tscale      0.0009396394016
0x 2578 DATA: corr       0
0x 2d80 DATA: coord      -8.372860208
0x 2d98 DATA: baseline   261
0x 2da0 ===== EOR (3) =====
...
0x 15068 DATA: baseline   2314
0x 15070 ===== EOR (36) =====
0x 15078 DATA: obsra      3.268015211
0x 15088 DATA: obsdec    0.03609215511
0x 15098 DATA: chi       -0.7118714452
0x 150a0 DATA: tpower    19.17340851
0x 150d8 DATA: ut        5.289289984
0x 150e8 DATA: lst       2.459578844
0x 150f8 DATA: axisrms   0.2067008913
0x 15160 DATA: focus     7.899638176
0x 15198 DATA: delay     289.0346413
0x 15200 DATA: antaz     1.040362579
0x 15268 DATA: antel     0.5775128425
0x 152d0 DATA: themt     475
0x 15308 DATA: tif2      34.53898239
0x 15340 DATA: wcorr     0.02284911089      -0.1492281109
0x 153d8 DATA: tscale    0.0009604850202
0x 153e0 DATA: corr      0
0x 15be8 DATA: coord     -95.98970399
0x 15c00 DATA: time      2450671.342      97AUG10:20:12:13.0
0x 15c10 DATA: baseline   260
0x 15c18 ===== EOR (37) =====
0x 15c20 DATA: wcorr     0.2651385069      0.05663052946
0x 15cb8 DATA: tscale    0.0009315458592
0x 15cc0 DATA: corr      0
0x 164c8 DATA: coord     19.82889086
0x 164e0 DATA: baseline   516
0x 164e8 ===== EOR (38) =====
0x 164f0 DATA: wcorr     0.2428172529      0.1108904481
.....

```