BACKGROUND **P. C. Gregory, Physics and Astronomy, University of British Columbia, June 2016**

The NRAO seven-beam receiver was used on the former Green Bank 91 m telescope, during 1986 November and 1987 October, to repeatedly survey the declination band (0 degrees < Declination < 75 degrees) at 4.85 GHz. This database has been used to extract variability information for sources in the GB6 catalog, a large unbiased sample of sources derived from the combined survey images.

This variability information consists of two parts. First, there is an indicator of the long term variability, based on two flux density measurements, one derived from the 1986 image set and the other from the 1987 image set. Long term variability information is available for 95% of the 75,162 GB6 sources.

Second, there is an indicator of the short term variability, based on an analysis of the daily scan data that was used to construct the images. These results are based on a Bayesian analysis of the 7 feed data where the beams are separated by 1 half-power beam width (HPBW) perpendicular to the sky track. Warning: these results are intended to provide only a coarse indicator of short term variability. In this way it has been possible to derive short term variability information for 20,931 GB6 sources. The exact number of daily measurements depends on source declination, ranging from a mean of 7 (both epochs) for a source at declination 0 degrees to a mean of 20 for a declination of 73 degrees.

The Green Bank 4.85 GHz survey was carried out with the following three types of data products in mind.

(a) A set of sky maps (Condon et al., AJ, 97, 1989 & AJ, 107, 1994).

(b) These sky maps were used to construct catalogs of discrete radio sources (Gregory, P. C. & Condon, J. J., ApJS, 75, 1991; Gregory, P. C. et al. ApJS, 103, 1996). The GB6 catalog of 75,162 discrete sources, with angular sizes < 5 arcmin and flux densities > 18 mJy, was based on the sky maps constructed from both epochs.

The same software was also used to catalog 15,045 discrete sources (-88 degrees < Declination <-37 degrees), with angular sizes < 15 arcmin, from the Parkes-MIT-NRAO survey of the Southern Hemisphere using the same 7 feed receiver on the Parkes 64 m telescope (Gregory, P.C. et al., ApJ Supplement 90, 173, 1994).

(c) The final goal was to extract variability information for the entire catalog of GB6 sources.
References: Gregory, P., Scott, W. K., and Poller, B. J., 1998, IAU Colloquium 164;
Gregory, P. C., Capak, P., Gasson, D., Scott, W. K., 2001, IAU Symposium 205.

Downloads: the following files contain Radio Patrol variability information obtained with the 7 feed 14 channel receiver in 1986 and 1987. *(Note: an earlier phase of the Radio Patrol was carried out with the Green Bank 91 m telescope between 1977-1984. See Gregory, P. C. & Taylor, A. R., ApJ, 248, 596, 1981; Taylor, A. R. & Gregory, P. C., Astron. J., 88, 1784, 1983; Gregory, P. C. & Taylor, A. R., Astron. J., 92, 371, 1986 and references therein.)*

Long term variability summary information is avalable in the ASCII file publt4.dat which is available as a the zipped file **publt4.zip**. publt4.dat is a space delimited ASCII file. Each line contains summary information for one source. The data in each line is organized as follows:

1) HH:MM:SS.S GB6 Right Ascension (B1950)
2) SS.S Uncertainty in right ascension (s)
3) SDD:MM:SS GB6 Declination (B1950)
4) SS Uncertainty in declination (arcsec)
5) GB6 Right Ascension in decimal degrees
6) GB6 Declination in decimal degrees
7) HH:MM:SS.S GB6 Right Ascension (J2000)
8) SDD:MM:SS GB6 Declination (J2000)
9) GB6 Right Ascension in decimal degrees (J2000)
10) GB6 Declination in decimal degrees (J2000)
11) GB6 Galactic Latitude B in decimal degrees
12) GB6 Galactic Longitude L in decimal degrees
13) GB6 flux density (mJy)
14) GB6 flux density uncertainty (mJy)
15) Flag "E" for significant extension
16) Flag "W" for Warning
17) Flag "C" for Confusion
18) Fitted FWHM major axis divided by point source FWHM of major axis
19) Fitted FWHM minor axis divided by point source FWHM of minor axis
20) Fitted major axis position angle PA (degrees east of north)
21) Local sky (mJy)
22) Map pixel column number counted from left
23) Map pixel row number counted from the bottom
24) 1986 epoch flux density S86 (mJy)
25) S86 flag ("F" = fitted flux density, "P" = peak pixel flux density, "N" = no flux density)
26) 1986 epoch flux density uncertainty (mJy)
27) 1987 epoch flux density S87 (mJy)
28) S87 flag ("F" = fitted flux density, "P" = peak pixel flux density, "N" = no flux density)
29) 1987 epoch flux density uncertainty (mJy)
30) Variability index V = Abs[S86-S87]/(S86+S87)
31) Variability index error Verr = Sqrt[(error S86)^2+(error S87)^2]/(S86+S87)
32) ratio = V/Verr

Short term variability summary information is avalable in the ASCII file pubcat10Jun16.dat which is available as a the zipped file **pubcat10Jun16.zip**. pubcat10Jun16.dat is a space delimited ASCII file. Each line contains summary information for one source. The data in each line is organized as shown on the following page.

Explanation of the - Log(p-value) variability indicator. We employ the common χ^2 statistic in a frequentist statistical test of the null hypothesis that the source is a constant, equal to the weighted mean of the daily flux densities. The p-value measures the area in the tail of a χ^2 distribution with m degrees of freedom for a value of χ^2 greater than or equal to the measured χ^2 for the observed set of daily flux densities. The number of degrees of freedom m = N - 1, where N is the number of daily flux densities. The total area under the χ^2 distribution is 1.

Suppose the area in the tail region is 0.05 or 5%. What does this mean? It means that if the flux density of this object is really constant and we repeately obtained sets of N measurements under the same conditions (hypothetical data sets), then only 5 % of the χ^2 values derived from these hypothetical data sets would be expected to be greater than or equal to the value of χ^2 computed for the one actually measured data set. The statistical confidence for rejecting the null hypothesis that the source has a constant flux density is = 1 - (p-value), which in this example is 0.95 or 95 %. Thus, the smaller the p-value the more likely the source is not constant. It is convenient to compute the statistic $-\log_{10}$ (p-value). The larger the value of $-\log_{10}$ (p-value) the more confident we are in rejecting the null hypothesis that the source has a constant flux density.

Format of "pubcat10Jun16.dat" that contains summary information and statistics on the daily flux density measurements.

1) Serial Number 014050196
2) $\Delta\theta$ = (daily scan data derived position - GB6 position) arcmin
3) HH:MM:SS.S GB6 Right Ascension (RA) (B1950)
4) SS.S Uncertainty in right ascension (s)
5) SDD:MM:SS GB6 Declination (Dec) (B1950)
6) SS Uncertainty in declination (arcsec)
7) GB6 RA (B1950, decimal degrees)
8) GB6 Dec (B1950, decimal degrees)
9) HH:MM:SS.S GB6 RA (J2000)
10) SDD:MM:SS.SS GB6 Dec (J2000)
11) GB6 RA (J2000, decimal degrees)
12) GB6 Dec (J2000, decimal degrees)
13) GB6 Flux density (mJy)
14) GB6 Flux density Error (mJy)
15) Number of confusing sources subtracted
16) Maximum Scan Flux density (mJy)
17) Fitted RA in minutes of time (1950)
18) Fitted RA in minutes of time error
19) Fitted Dec in decimal degrees (1950)
20) Fitted Dec in decimal degrees error
21) Galactic Latitude (decimal degrees)
22) Galactic Longitude (decimal degrees)
23) Number of fits in epoc 1986
24) Number of fits in epoc 1987
25) Average Flux density (both epochs) (mJy)
26) Average Flux density epoc 1986 (mJy)
27) Average Flux density epoc 1987 (mJy)
28) Weighted average Flux density (both epochs) (mJy)
29) Error in weighted average (mJy)
30) Weighted average Flux density $\overline{S_{\mathrm{wt86}}}$ epoc 1986 (mJy)
31) Error in weighted average1986 (mJy)
32) Weighted average Flux density $\overline{S_{\mathrm{wt87}}}$ epoc 1987 (mJy)
33) Error in weighted average 1987 (mJy)
34) Modulation Index epoc 1986 given by $\frac{1}{\overline{S_{\mathrm{wt86}}}}\sqrt{\frac{\sum w_i(S_{i86}-\overline{S_{\mathrm{wt86}}})^2}{\Sigma w_i}}$, where $w_i = \frac{1}{\sigma_i^2}$
35) Modulation Index epoc 1987 given by $\frac{1}{\overline{S_{\mathrm{wt87}}}}\sqrt{\frac{\sum w_i(S_{i87}-\overline{S_{\mathrm{wt87}}})^2}{\Sigma w_i}}$, where $w_i = \frac{1}{\sigma_i^2}$
36) Modulation Index due to noise from 1000 simulations for epoc 1986 (-9 means ignore)
37) Modulation Index due to noise from 1000 simulations for epoc 1987 (-9 means ignore)
38) Std deviation from 1000 simulations for Modulation index due to noise for epoc 1986 (-9 means ignore)
39) Std deviation from 1000 simulations for Modulation index due to noise for epoc 1987 (-9 means ignore)
40) Corrected Modulation Index epoc 1986
41) Corrected Modulation Index epoc 1987
42) $-\log_{10}$ (p-value)
43) $-\log_{10}$ (p-value) for epoc 1
44) $-\log_{10}$ (p-value) for epoc 2

Daily flux density information is avalable in the ASCII file pubfit10Jun16.dat which is available as a the zipped file **pubfit10Jun16.zip**. pubfit10Jun16.dat is a space delimited file. Each line contains summary information for one source. The data in each line is organized as follows:

1) Unique source serial number
2) Scan number
3) Daily flux density (mJy)
4) Daily flux density uncertainty (mJy)
5) Modified Julian Day number (accurate to 4 decimal places) MJD = JD - 2,400,000.5
6) Flag (1= successful fit ; 0= fit but (ave or wtd ave) flux too low compared to GB6)

The following *Mathematica* notebooks provide easy access to the variability information.

Mathematica version 7 notebook name:
RadioPatrol_VariabilityAnalysis_19Jun2016M7.nb

Mathematica version 10 notebook name:
RadioPatrol_VariabilityAnalysis_19Jun2016M10.nb