**Notes on the creation of all sky maps for SPCGEN**

**Required for the simulation pipeline:**

Images at frequencies 408, 1420 and 23000 MHz

Smoothed to resolution of 1 degree.

Image format – ascii listing in healpix format

with nested ordering nside=256/R8

Image coordinates: galactic

**23000 MHz**

WMAP 23000 MHz images full resolution and smoothed to 1-degree resolution 9-yr co-added sky maps available at

<http://lambda.gsfc.nasa.gov/product/map/dr5/m_products.cfm>

in healpix fits format with nside=512 (res=9) nested ordering

I understand that the image that is available as ‘deconvolved’ has been corrected for the asymmetry in the instrument beam. Additionally, it appears to me that the CMB dipole is subtracted from the data product. And the differential measurement lacks the monopole. Both need to be added in by hand.

The file downloaded is wmap\_band\_smth\_deconv\_imap\_r9\_9yr\_K\_v5.fits

This has units of mK thermodynamic temperature.

NSIDE=512 or Res=9 corresponds to NPIX=3145728, which has mean pixel spacing 0.1145 degrees or 6.87 arcmin

We want to reduce the file size via interpolation to

NSIDE=256 or Res=8, NPIX=12\*Nsize\*Nside=786432, which means a pixel spacing of about 0.2290 degrees or 13.74 arcmin.

Pixel coordinates and their ordering in nested (and ring) format is in fits files available at

<http://lambda.gsfc.nasa.gov/toolbox/tb_pixelcoords.cfm>

The useful files are

pixel\_coords\_map\_nested\_galactic\_res8.fits and

pixel\_coords\_map\_nested\_galactic\_res9.fits

Seems to me that the website has listings of coordinates for the images in that website only! Read the top para of the webpage. All the images in that site are in galactic reference frame, so all the listings are for the healpix locations defined for the galactic reference frame.

First step is to create ascii listing of the pixel coord files at both resolutions and ascii listing of the 23000 MHz WMAP image.

The fits files were taken to aips and the ascii listing was made using aips task EXTAB (using inext ‘UK’). Then a C code (make\_23000.c) was used to read in this list, divide the temperatures by 1000.0, add 2.72548, add a dipole of amplitude 3.343 mK towards l=265.6 degrees, b=48.3 degrees, average in groups of four to change from R9 to R8, and write it out as an ascii listing.

Change from R9 to R8 can also be done using an IDL procedure [ud\_grade.pro](http://udgrade.pro/) to perform this conversion.

The code also creates a listing with an integer index column and a second column containing the temperatures. This is used to create a healpix fits file as follows. A template healpix fits file containing R8 nested ordered image is taken, the table is written out as a text file using TBOUT. This table is edited to change the format (D19.15 format is needed!) and the values are replaced with the 2-column listing from the c code. Then the edited table is read back with TBIN to make a UK type table in a new dummy file (in which the UK table has been extdest’ed).

The c code also has an option that does a nearest neighbor interpolation to a coarse grid and creates a miriad format image using nearest pixels (as a visual check!).

Final files are

wmap\_skytemp\_nside256\_deconv\_9yr\_wdip2.txt (this is the 1-deg resolution nested healpix R8 listing)

WMAP\_23GHZ\_1DEG\_WDIP\_UK\_R8.FITS (this is the corresponding fits file)

The units are K

PIXEL\_LISTING\_R8.TXT contains the pixel coordinates (these are galactic coordinates)

Download the Internal Linear Combination (ILC) Map – galactic coodinates, healpix fits, nested, res 9 (Nside=512), 1 degree resolution. The file downloaded is wmap\_ilc\_9yr\_v5.fits. Ought to represent the CMB anisotropy! Perhaps this could be subtracted from the K band image (which already has the monopole and dipole removed) to yield the foreground?

Take the healpix fits to aips – imlod, extab – to get an ascii listing of the UK table. This is now wmap\_ilc\_9yr\_v5.txt

Units are mK and range is +/- 450 microK

Subtract the ILC map from WMAP\_CMB:

ILC has range (mK): -0.452455163002 0.442229986191

WMAP has range (mK): -0.204526513815 133.25932312

Difference has range (mK): -0.0378017630428 133.2862138

Download the synchrotron foreground emission MEM map, which has nside=128 (resolution R7 map): wmap\_K\_mem\_synch\_9yr\_v5.fits

This map is in mK antenna temperature, not thermodynamic temperature.

Range is (mK): 0to 32 mK (the minimum ought to be 0.2-0.4 mK, and the maximum ought to be at least as much at the WMAP peak temperature, unless towards the peak the dominant emission is thermal!)

Look at the thermal foreground emission map.

**408 MHz**

Original image available at

<http://lambda.gsfc.nasa.gov/product/foreground/fg_haslam_get.cfm>

where the file to be used is [lambda\_haslam408\_nofilt.fits](http://lambda.gsfc.nasa.gov/data/foregrounds/haslam/lambda_haslam408_nofilt.fits)

This is now called haslam\_408\_K\_0.8d\_512\_nested.fits

The 408-MHz image has a quoted uncertainty of +/-3 K in the zero point and 10% in absolute scale.

Destriped image available from the data repository of Platania et al. (2003).

This is called 408\_destriped\_Healpix\_Platania.fits.

Unfortunately this image is in celestial reference frame! To use this we need to be able to convert healpix images from one reference frame to another.

I looked at other literature and the original paper of Haslam et al. The 408-MHz survey had a resolution of 0.85 degrees. Both of the above images have this resolution.

(a) The image needs to be smoothed using [ismoothing.pro](http://ismoothing.pro/) which utilized the smoothing Fortran facility of healpix (with fwhm\_arcminset to 60). (Smoothing f90 - This program can be used to convolve a map with a Gaussian beam. The input map can be given in RING or NESTED scheme and the smoothed map is written to a FITS file in the RING scheme.)

<http://healpix.jpl.nasa.gov/html/facilitiesnode12.htm>. To smooth any of these the image needs to be convolved with a Gaussian of FWHM 0.526782688 degrees (or 31.60696126 arcmin).

(b) Then nested R9 needs to be averaged every set of four successive number to give nested R8.

Final images (not destriped) are stored as nested R8 healpix with 1-degree beam. Units are mK brightness temperature (not thermodynamic, but the difference is a fraction of a percent and so the difference is small compared to the errors).

lambda\_haslam408\_nofilt\_1deg\_r8.fits

lambda\_haslam408\_nofilt\_1deg\_r8.txt

The pixel coordinates are galactic and so the file PIXEL\_LISTING\_R8.TXT contains the pixel coordinates for this image.

**1420 MHz**

All-sky image is in the files available in the website

<http://oceancolor.gsfc.nasa.gov/AQUARIUS/DinnatEtAl2010/>

The data is in binary format, which I could read with a c program

make\_1420\_mir.c

I have placed the fits image in the file (1420\_0.6d.fits). This is in J2000 celestial coordinates.

I understand that the image is in K units and beam size is 0.6 degrees and has pixel size 0.25 degrees.

For the northern sky, a destriped image is available from Platania et al. (2003).

This is got via ftp as follows:

ftp 130.79.128.5

anonymous

[rsubrahm@nrao.edu](mailto:rsubrahm@nrao.edu)

cd /pub

cd A+A/410/847

cd maps

get 14de\_ecp.fit

get 14de\_hea.fit

quit

The ‘ecp’ file is in equi-cylindrical projection, ‘hea’ file is in healpix format.

The ‘ecp’ file is 1023x512 pixels, pixel size is close to 21.09 arcmin.

I can view the 14de\_ecp.fit file in kvis; however, the 14de\_hea.fit cannot be viewed in CMBview!

The reference frame for the ‘normal’ fits files are celestial coordinates.

Ideally we want to use the destriped image where available and the raw image elsewhere. Use ‘ecp’ images in both regions, write a c-code to make a weighted average using a smoothing beam onto a R8 nested healpix grid.

I wrote a C code:

conv\_cel2gal.c and conv\_cel2gal\_v2.c

They read in the 1420 MHz images – both all-sky images and the northern sky destriped images. Also the listing of healpix celestial coordinates corresponding to the healpix galactic coordinates (i.e., the listing PIXEL\_LISTING\_CEL\_R8.TXT contains J2000 epoch celestial coordinates corresponding to the galactic coordinates listed in PIXEL\_LISTING\_GAL\_R8.TXT, which is the same as PIXEL\_LISTING\_R8.TXT). The images are gridding convolved with a Gaussian to yield 1-deg final resolution and healpix listings are generated corresponding to the celestial R8 coordinate listing in PIXEL\_LISTING\_GAL\_R8.TXT. The C-code also creates a text file that may be used to make a healpix fits file via aips.

1420\_1D\_R8.FITS and corresponding text file 1420\_1deg\_R8.txt are made using the all sky 1420 MHz maps.

1420\_1D\_R8\_2.FITS and corresponding text file 1420\_1deg\_R8\_2.txt are made using the destriped Platania map where available and the all sky 1420 MHz map in other regions.

All these are galactic coordinate healpix nested ordered R8 resolution files in K units.

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