

COBE-DMR Project Data Sets (PDS), Analyzed Science
Data Sets (ASDS), and Galactic Coordinate Data Sets
Explanatory Supplements

Preface

This document is a concise description of the delivered Data sets for the first two years of operation of the Differential Microwave Radiometers (DMR) experiment on board the *COBE* spacecraft. It is intended as an overview of the delivered data sets and as a description of the specific quantities contained in the DMR time-ordered data. Detailed descriptions of the instrument and data reduction methods have been described in publications that are referenced in Section 4 of this document.

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1 DMR Project Data Sets Explanatory Supplement

1.1 The Differential Microwave Radiometers Experiment

The purpose of the Cosmic Background Explorer (COBE) Differential Microwave Radiometers (DMR) experiment is to measure large angular scale anisotropies of the cosmic microwave background (CMB) radiation. This release of the DMR Project Data Sets covers the first two years of instrument operation, specifically the time range from 1989 December 22 to 1991 December 21. The DMR Project Data Sets are (i) maps of the full sky at three microwave frequencies, (ii) the corresponding differential data coadded by sky position, and (iii) the time-ordered raw differential temperatures. Data sets (i) and (ii) are in the Flexible Image Transport System (FITS) format, and (iii) are in the DMR native data format.

Smoot et al. (1990) and Bennett et al. (1992a) provide detailed descriptions of the DMR instrument. The instrument consists of six differential microwave radiometers, two nearly independent channels (labelled A and B) at each of three frequencies: 31.5, 53, and 90 GHz (wavelengths 9.5, 5.7, and 3.3 mm). Each radiometer measures the difference in power, expressed as a differential antenna temperature, between two regions of the sky separated by 60° . The combined motions of spacecraft spin (73 s period), orbit (103 m period) and orbital precession ($\sim 1^\circ/\text{day}$) allow each sky position to be compared to all others through a highly redundant set of all possible difference measurements spaced 60° apart.

The DMR has three separate receiver boxes, one for each frequency, that are mounted 120° apart on the outside of the *COBE* cryostat containing the Far Infrared Absolute Spectrophotometer (FIRAS) and the Diffuse Infrared Background Experiment (DIRBE). There are ten horn antennas, all of which have an approximately Gaussian main beam with a 7° FWHM. The pair of horns for each channel are pointed 60° apart, 30° to each side of the spacecraft spin axis and are designated as Horn 1 and Horn 2. The differential temperature is always in the sense Horn 1 minus Horn 2. For each channel, the switching between Horns 1 and 2 is at a rate of 100 Hz, and the switched signals undergo amplification, detection, and synchronous demodulation with a 0.5 s integration period. Table 1 describes the noise level per measurement (0.5 sec being the duration of a measurement) for each DMR channel in units of antenna temperature.

Table 1: Noise Level (per 0.5 sec measurement) for Each DMR Channel

DMR Channel	31A	31B	53A	53B	90A	90B
Flight RMS (mK)	58.6	60.4	23.2	27.1	39.7	30.2

The 53 and 90 GHz channels use two separate linearly polarized horn pairs, while the 31 GHz channels receive opposite circular polarizations in a single pair of horns. The polarization of the 53 and 90 GHz receivers is such that the E-plane of each horn is perpendicular to the plane of the two horns of a given channel. A shield surrounding the aperture plane protects all three instruments from solar and terrestrial emission. As the spacecraft spins, a point 30° from the spin axis is swept successively, at about 12.5 second intervals, by 31 GHz Horn 1, by 90 GHz A and B Horns 2, by 53 GHz A and B Horns 1, by 31 GHz Horn

2, by 90 GHz A and B Horns 1, and 53 GHz A and B Horns 2 respectively. See Figure 8 of Bennett et al. (1992a) for a schematic illustration of the *COBE* aperture plane.

1.2 The Software System

The purpose of the DMR software system is to take the raw telemetry data from the instrument and produce calibrated maps of the sky that have systematic effects (instrumental and environmental) reduced below well specified levels. The techniques used and resulting systematic error limits for the initial product dataset release of July 1993, covering the first year of DMR data, are described by Kogut et al. (1992). A description of the more detailed analysis and lower systematic error limits that apply to the two years of data covered by this release is described by Bennett et al. (1994). The software system and data processing algorithms are also described by Janssen & Gulkis (1991) and Jackson et al. (1992).

1.2.1 Data Reduction

The DMR telemetry consists of uncalibrated differential temperatures, taken every 0.5 second for each of the six channels, plus housekeeping data (voltages, temperatures, relay states, etc). These are merged with spacecraft attitude data into a time-ordered dataset. Various algorithms are used to check data quality and flag bad data in this dataset (Keegstra et al. 1992). For these DMR datasets, the data from a channel are flagged as bad when either horn was within 21° of the Moon, or when the limb of the Earth was higher than 1° below the plane of the shield (3° at 31 GHz).

The instrumental offset was removed by fitting a smooth baseline to the uncalibrated time-ordered data. As a cross-check, baselines were routinely fitted three different ways: a running mean, a slowly varying cubic spline, and a more rapidly varying cubic spline fitted to the data after correction for magnetic susceptibility. The averaging period for the running mean is two orbit periods (the orbit period is 103 minutes); the slowly varying cubic spline has a knot every 52 minutes; and the fast spline has a knot every 9 minutes. The aim is to use the longest baseline consistent with instrument stability in order to reduce the influence of possible systematic errors. The fast baseline retains information only over the 73-second spin period; the slower spline retains information over the roughly 15-minute time period where the orbital motion is less than the 60° separation between the horns; and the mean baseline retains information over the *COBE* orbital period. The sky maps for this data release use the mean baseline.

Calibration of the data to antenna temperature is achieved by turning on noise sources of known antenna temperature for two minutes every two hours. Long-term stability of the noise sources is checked by observations of the Moon and by the amplitude of the modulation of the CMB signal over the course of a year caused by the Earth's 30 km/sec orbital motion. See Bennett et al. (1992a, 1994) for a detailed description of DMR calibration techniques.

In the preparation of the DMR Pixelized Differential Data and Sky Maps Project Data Sets, the calibrated time-ordered data were corrected for known instrumental and systematic effects: the Doppler effect from the *COBE* velocity about the Earth ("satellite velocity") and the Earth's velocity about the solar system barycenter ("Earth velocity"); the susceptibility of the instrument to the Earth's magnetic field; emission from the Moon in the antenna sidelobes; the slight 3.2% 'memory' of the previous observation (arising in the lock-in amplifier); and emission from the planets Jupiter, Mars, and Saturn. In order to

reduce the errors inherent in pixelizing over the non-uniformly sampled sky, the calibrated time-ordered data were also corrected for a nominal CMB dipole (“Sun velocity”) assuming a dipole of 3.35623 mK (in thermodynamic temperature) directed towards 2000 R.A. = $11^h 11^m 41^s.5$, Dec = $-7^\circ 30' 32''.5$.

1.2.2 Pixelization

The time-ordered data are pixelized according to the quadrilateralized spherical cube projection (White & Stemwedel 1992), which projects the entire sky onto six cube faces. Each face is pixelized into $2^{2(N-1)}$ approximately equal-area pixels. For these DMR Project Data Sets, we use $N = 6$, which divides the sky into 6144 pixels; each pixel subtends 6.7 square degrees. (For the actual solutions of the maps, we used a smaller pixel size of 1.7 square degrees, corresponding to $N = 7$, for all data within 20° of the Galactic plane in order to minimize the effects of gradients in the Galactic disk emission. These pixels were then block-averaged to form the $N = 6$ maps).

1.3 DMR Project Data Sets

1.3.1 Pixelized Differential Data

The baseline-subtracted, calibrated and corrected time-ordered data were sorted according to the pixel number seen by Horn 1, and then by the pixel number seen by Horn 2. All such data for a given pixel pair were then combined into four statistics: the sums of the first to fourth powers of the differential temperatures. These sums, the Horn 1 and 2 pixel numbers, and the number of occurrences of each pixel permutation comprise the DMR Pixelized Differential Data. Note that linear polarization information for 53 and 90 GHz is retained since the E-plane is perpendicular to the great circle joining the two pixels. For each channel, there are over a million pixel permutations of the 6144 pixels. Tables 2 and 3 describe, respectively, the parameters of the Data Set and the information given for each pixel permutation.

A simple program, PIXPRM, listed in Appendix A, can be used to read the FITS binary table from the DMR Pixelized Project Data set. This FORTRAN example uses the FITSIO library and should run, as written, on all platforms on which the library is supported. FITSIO was written by William Pence of NASA GSFC HEASARC, and is available by anonymous FTP from tetra.gsfc.nasa.gov. For illustrative purposes, the example calculates some simple statistics from the data sets; users may wish to substitute their own code to perform the calculations in which they are interested.

1.3.2 DMR Sky Maps

A sky temperature is derived for each pixel by simultaneously fitting (i.e. minimizing the chi-squared) a linear system of equations to the DMR observations and the coefficients of systematic error models (see Janssen & Gulkis 1992). Since the instrument only measures temperature differences between different sky directions, these maps of the sky only represent differences of the sky temperature. Tables 2 and 4 describe, respectively, the parameters of the Data Set and the information given for each pixel.

Table 2: DMR Pixelized Differential Data and Sky Maps Project Data Sets

Time range 53,90 GHz	0 UT Dec 22, 1989 to 0 UT Dec 22, 1991
31 GHz Channel A	0 UT Dec 22, 1989 to 0 UT May 21, 1990 plus 0 UT July 25, 1990 to 0 UT May 21, 1991 plus 0 UT July 25, 1991 to 0 UT Dec 22, 1991
31 GHz Channel B	0 UT Dec 22, 1989 to 0 UT May 21, 1990 plus 0 UT July 25, 1990 to 0 UT May 21, 1991 plus 0 UT July 25, 1991 to 0 UT Sept 23, 1991
Temperature Unit	milliKelvin antenna temperature
Ecliptic Latitude	-90° to + 90°
Ecliptic Longitude	0° to 360°
Frequencies	31.5, 53, and 90 GHz
Channels	two independent channels, A and B at each freq
Wavelengths	9.5, 5.7, and 3.3 mm
Pixelization	2.59°, ecliptic coordinates
Beamwidth	7° FWHM Gaussian, circular
Corrections	Satellite velocity, Earth velocity, Sun velocity, Magnetic susceptibility, Moon in sidelobes, Instrument Memory, Jupiter, Mars, Saturn

Table 3: Data Fields in DMR Pixelized Differential Data Project Data Set

Data field	Description
PIX_PLUS	Pixel number (0 to 6143) for horn 1
PIX_MINU	Pixel number (0 to 6143) for horn 2
N_OBS	Number of observations for differential temperatures ΔT
SUM	$\Sigma \Delta T$ (mK)
SUM.2	$\Sigma \Delta T^2$ (mK ²)
SUM.3	$\Sigma \Delta T^3$ (mK ³)
SUM.4	$\Sigma \Delta T^4$ (mK ⁴)

Table 4: Data Fields in DMR Sky Maps Project Data Set

Data field	Description
PIXEL	Pixel number (0 to 6143)
SIGNAL	Sky antenna temperature (mK)
N_OBS	Number of observations
SERROR	Estimate of uncertainty as RMS/SQRT(N_OBS) (mK)
ECLON	Ecliptic longitude of pixel center (degrees)
ECLAT	Ecliptic latitude of pixel center (degrees)
GALON	Galactic longitude of pixel center (degrees)
GALAT	Galactic latitude of pixel center (degrees)
RA	Right ascension of pixel center (degrees)
DEC	Declination of pixel center (degrees)

Table 5: DMR Sky Map Coverage and Sensitivity Limits

DMR Channel	31A	31B	53A	53B	90A	90B
Max obs/pixel	72499	63157	81890	82550	81247	81130
Noise level(mK)	0.218	0.241	0.081	0.094	0.139	0.106
Mean obs/pixel	29727	24484	35672	35681	35655	35643
Noise level(mK)	0.340	0.386	0.123	0.143	0.210	0.160
Min obs/pixel	11622	8108	21535	21489	21499	21560
Noise level(mK)	0.544	0.671	0.158	0.185	0.271	0.205

Table 6: DMR Time-Ordered Data Project Data Set

Time range	16 UT Nov 19, 1989 to 0 UT Jan 1, 1992
Temperature Unit	“Telemetry” units, integers from 0 to 4095
Ecliptic Latitude	-90° to + 90°
Ecliptic Longitude	0° to 360°
Frequencies	31.5, 53, and 90 GHz
Channels	two independent channels, A and B at each freq
Wavelengths	9.5, 5.7, and 3.3 mm
Beamwidth	7° FWHM Gaussian, circular
Data Rate	Every 0.5 sec for each of 6 DMR channels
Corrections available	Satellite velocity, Earth velocity, Sun velocity, Magnetic susceptibility, Moon in sidelobes, Instrument Memory, Jupiter, Mars, Saturn

The noise level of the DMR Sky Maps Project Data Set varies by more than a factor of two over the sky owing to differences in sky coverage during the mission. The greatest redundancy is on rings of 60° diameter centered at the North and South ecliptic poles since those regions are sampled on every orbit. The least redundancy is near the ecliptic plane owing to the presence of the Moon (we do not use data when either DMR horn is within 21° of the Moon). For channels 31A and 31B, the more stringent limits on the position of the limb of the Earth relative to the shield, and the rejection of data during the two months when there is an ‘eclipse’ of *COBE* by the Earth (see below) also reduce coverage considerably for certain pixels.

Table 5 gives the maximum, mean, and minimum coverages and the corresponding pixel-to-pixel rms noise levels. Note that since the DMR beam covers several pixels, the rms uncertainty in the determination of the strength of a point source is about 0.6 that of the pixel-to-pixel rms noise. Of course, the DMR was designed to be insensitive to point sources: a 1,000 Jy point source would yield peak antenna temperatures of 1.55 mK, 0.54 mK, and 0.19 mK at 31.5, 53, and 90 GHz respectively.

The DMR Sky Maps Project Data Set are in units of mK antenna temperature which have been calibrated to correct for any losses in the instrument and antenna system. To scale these to maps of the differential thermodynamic temperature of the cosmic microwave background, multiply by the frequency-dependent scaling factors given in Table 1 of Bennett et al (1992a), which are based on an assumed background thermodynamic temperature of 2.735K.

A simple program, SKYMAP, listed in Appendix B, can be used to read the FITS binary table from the DMR Sky Maps Project Data Set. This FORTRAN program also uses the FITSIO library described above.

1.3.3 DMR Time-Ordered Data

The DMR telemetry, merged with spacecraft attitude data, comprise the DMR Time-Ordered Data (TOD) Project Data Set. Included in the TOD are various warning flags and

indicators of data quality. Table 6 gives the basic parameters of the data set, Appendix C describes its structure, and Appendix D provides more details.

Before the DMR Sky Map and Pixelized data sets were made, the Time-Ordered Data were corrected for the following systematic effects:

- emission from the Moon when it lies between 21 and 90 degrees from the axis of either of the two DMR horns
- emission from Jupiter, Mars, and Saturn when they lie within 15 degrees of the axis of either of the two DMR horns
- susceptibility of the instrument to the ambient magnetic field
- instrument “memory”
- the Doppler velocities of *COBE* around the Earth and the Earth around the Sun, and
- a dipole of 3.356 mK thermodynamic temperature considered to be produced by the Doppler velocity of the Sun with respect to the cosmic microwave background.

Correction algorithms coded in VAX Fortran, and the reference datasets that they use, are available to Guest Investigators. An IDL routine, which converts the Time-Ordered Data from its native format to an IDL save set but does not apply the corrections, is also available.

1.4 Warnings and Limitations

Bennett et al. (1992a) present the DMR calibration and its uncertainties and Kogut et al. (1992) give a summary of upper limits on residual systematic errors affecting the DMR Initial Product (first year of data) released in July 1993. A summary of the calibration and systematic errors affecting the two-year Project Data Sets is described by Bennett et al. (1994). Our maps of systematic errors are available on request to the NSSDC. Scientific conclusions based on the DMR Project Data Sets should take proper account of the systematic error limits and the calibration uncertainties.

Near the time of the summer solstice, the *COBE* spacecraft enters the Earth’s shadow during a portion of each orbit and is thus ‘eclipsed’. This causes changes in the spacecraft temperature and electrical systems. Systematic errors during the eclipse season significantly affect the DMR 31 GHz channels. Hence, these DMR Project Data Sets do not include 31 GHz data for the period 0 UT on 1990 May 21 through 0 UT on 1990 July 25; and from 0 UT on 1991 May 21 through 0 UT on 1991 July 25.

On 1991 October 4, the 31B channel suffered an increase in receiver noise by more than a factor of 2. Data following this event are not included in the Sky Maps and Pixelized Differential Data Project Data Sets; however, these data are included in the Time-Ordered Data Project Data Set.

Scientific results based on the first year of DMR data have been published by Smoot et al. (1992, 1994), Bennett et al. (1992b, 1993), Wright et al. (1992, 1994a), Kogut et al. (1993), and Hinshaw et al. (1994). Smoot et al. (1992) review the overall results. Bennett et al. (1992b) analyze the Galactic emission and derive a value for the cosmic quadrupole.

Wright et al. (1992) interpret the DMR anisotropy in terms of cold dark matter cosmological models. Bennett et al. (1993) search for evidence of noncosmological source contributions. Kogut et al. (1993) analyze the dipole anisotropy and derive the Solar velocity, relative to the cosmic background radiation, implied by the observed dipole. Wright et al. (1994a) comment on the power spectrum normalization implied by the excess variance in the first-year maps. Hinshaw et al. (1994) analyze the 3-point correlation function to search for evidence of non-Gaussian fluctuations. Smoot et al. (1994) search for evidence of non-Gaussian fluctuations by analyzing the third and fourth moments and the genus of the first year maps. Scientific results based on the first two years of data have been published by Bennett et al. (1994), Wright et al. (1994b), and Kogut et al. (1994). Bennett et al. (1994) review the overall results of the first two years of data. Wright et al. (1994b) analyze the angular power spectrum. Kogut et al. (1994) search for unresolved point sources in the two-year maps.

2 DMR Analyzed Science Data Sets (ASDS) Explanatory Supplement

2.1 Introduction

The purpose of the *COBE* Differential Microwave Radiometers (DMR) experiment is to measure the large angular scale anisotropies of the cosmic microwave background (CMB) radiation. Smoot et al. (1990) and Bennett et al. (1992a) provide detailed descriptions of the DMR instrument. This release of the DMR Analyzed Science Data Sets covers the first two years of instrument operation, specifically the time range from 1989 December 22 to 1991 December 21. The data sets are in the Flexible Image Transport System (FITS) format. The detailed analysis and systematic error limits that apply to the two years of data covered by this release are described in Bennett et al. (1994).

2.2 DMR Analyzed Science Data Sets

The DMR Analyzed Science Data Sets consist of Galactic emission and cosmic emission maps. Bennett et al. (1992b) discuss the separation of the Galactic foreground emission from the cosmic emission. Four components are important at microwave wavelengths: CMB anisotropies, synchrotron emission, free-free emission, and thermal emission from dust. The latter three compose the Galactic foreground.

Tables 7 and 8 describe, respectively, the parameters of the Data Sets and the information given for each pixel.

Table 7: DMR Analyzed Science Data Sets

Time range	0 UT Dec 22, 1989 to 0 UT Dec 22, 1991
Temperature Unit	milliKelvin thermodynamic temperature for CMB maps milliKelvin antenna temperature for Galactic maps
Ecliptic Latitude	-90° to + 90°
Ecliptic Longitude	0° to 360°
Pixelization	2.59°, ecliptic coordinates
Beamwidth	7° FWHM Gaussian, circular
Corrections	Satellite velocity, Earth velocity, Sun velocity, Magnetic susceptibility, Moon in sidelobes, Instrument Memory, Jupiter, Mars, Saturn

2.2.1 Galactic Emission Maps

The 53 GHz synchrotron model, dust model and free-free maps are delivered in this release of the DMR Analyzed Science Data Sets (ASDS). The details about deriving these Galactic emission maps are described in Bennett et al. (1992b).

Synchrotron emission arises from relativistic electrons accelerated in the Galactic magnetic field. We use the observed local electron spectrum in conjunction with 408 MHz and 1420 MHz radio data to model the synchrotron radiation at the DMR frequencies.

Table 8: Data Fields in DMR Analyzed Science Data Sets

Data field	Description
PIXEL	Pixel number (0 to 6143)
SIGNAL	Sky temperature (mK)
N_OBS	Number of observations
SERROR	Statistical uncertainty (mK, 68% confidence level)
ECLON	Ecliptic longitude of pixel center (degrees)
ECLAT	Ecliptic latitude of pixel center (degrees)
GALON	Galactic longitude of pixel center (degrees)
GALAT	Galactic latitude of pixel center (degrees)
RA	Right ascension of pixel center (degrees)
DEC	Declination of pixel center (degrees)

Thermal emission from dust is also important at microwave wavelengths. We utilize the full sky measurements of the dust intensity and spectrum at higher frequencies from the *COBE*-FIRAS experiment and extrapolate these to the DMR frequencies.

Free-free emission occurs when free electrons are accelerated by interactions with ions. The free-free emission map is obtained by the simultaneous fitting of the DMR 31 and 53 GHz maps for the free-free and cosmic emission after subtracting the model synchrotron and dust maps. This is the first all-sky map of the Galactic free-free emissions.

2.2.2 DMR Cosmic Emission Sky Maps

Two techniques are used for separating the cosmic emission from the foreground Galactic emission. The details are described in Bennett et al. (1992b, 1994). The resulting cosmic emission maps from both techniques are delivered in this release of the DMR Analyzed Science Data Sets (ASDS). The combination factors for the three DMR channels are slightly different in the FITS headers than in Bennett et al (1992b, 1994) owing to the use of ecliptic coordinate maps for these ASDS Data Sets.

1. Subtraction technique. We first subtract the Galactic emission maps from the DMR maps, where Galactic emission is based on maps of synchrotron and dust emission derived from measurements at frequencies where these type of emissions are strong. The free-free galactic emission is then separated and subtracted from the remaining cosmic signal by making a linear combination, based on the assumed free-free spectral index, of the 31 GHz map with the 53 GHz map.
2. Combination technique. We form a linear combination of the DMR maps to 1) cancel the Galactic emission for $|l| > 30$ degrees and $|b| < 6$ degrees, 2) cancel the free-free emission based on the assumed free-free spectral index, and 3) normalize the cosmic emission map in thermodynamic temperature.

3 DMR Galactic Coordinate Data Sets Explanatory Supplement

3.1 Galactic versus Ecliptic Pixelization

The delivered Project Data Sets (PDS) and Analyzed Science Data Sets (ASDS) from all three instruments on the Cosmic Background Explorer (COBE) have been pixelized in ecliptic (J2000) coordinates. However, for the Differential Microwave Radiometers (DMR) experiment, the Milky Way Galaxy is the chief source of foreground emission. The accurate characterization of this galactic emission is the main challenge for the determination of the quadrupole and other largest-scale aspects of the cosmic microwave background (cmb) from the DMR data. When we select a portion of the skymap for analysis, based on a cut at a certain value of galactic latitude, the boundary of the selected portion of the sky will be smooth when we use galactic pixelization and jagged when we use ecliptic pixelization. For these reasons, the DMR team has consistently performed their primary analyses of the cmb structure based on maps and other datasets which are pixelized in galactic coordinates.

As other researchers have performed analyses on the PDS and ASDS, it has become apparent that some small differences between their analyses and those of the DMR team may arise from the different pixelizations (ecliptic vs galactic). In order for the scientific community to be able to more accurately estimate what the effects of a particular pixelization may be on their analyses, we have prepared DMR skymaps which are completely equivalent to the PDS and ASDS skymaps, except that they are pixelized in galactic coordinates.

3.2 DMR Two-year Galactic Coordinate Skymaps

These galactic coordinate skymaps are based on exactly the same time-ordered data (December 1989 to December 1991) as the PDS skymaps. All details of the observations and, except as otherwise described in this report, all details of the data reduction and analysis are the same as described in the 'DMR Project Data Sets (PDS) Explanatory Supplement'. Full details of the determination of the cmb structure based on the galactic skymaps are given in Bennett et al. (1994).

Owing to the different pixelization, there are slight modifications to Table 5 (DMR Sky Map Coverage and Sensitivity Limits) of the PDS Explanatory Supplement. A revised version of Table 5 which applies to these galactic skymaps is given in Table 9:

Table 9: DMR Galactic Sky Map Coverage and Sensitivity Limits

DMR Channel	31A	31B	53A	53B	90A	90B
Max obs/pixel	71145	62839	81271	81400	81490	81669
Noise level(mK)	0.220	0.241	0.081	0.095	0.139	0.106
Mean obs/pixel	29728	24484	35672	35681	35655	35643
Noise level(mK)	0.340	0.386	0.123	0.143	0.210	0.160
Min obs/pixel	11506	7988	21526	21471	21579	21557
Noise level(mK)	0.547	0.676	0.158	0.185	0.270	0.205

3.3 DMR Two-year Galactic Coordinate Analyzed Science Data Sets

These are analogous to the DMR Analyzed Science Data Sets (ASDS) which were released in ecliptic coordinates; and consist of three galactic emission maps (for 53 GHz synchrotron emission, free-free-emission, and thermal emission from dust) and (two) maps of the cosmic microwave background emission resulting from removal of the galactic foreground using two techniques - the subtraction technique and the combination technique. See the DMR Analyzed Science Data Sets (ASDS) Explanatory Supplement for more details.

Owing to the use of galactic versus ecliptic pixelization, there are small differences between the weights used to combine the 31, 53, and 90 GHz skymaps when forming the cosmic emission maps using the combination technique; and the weights for the corresponding map in the ASDS. See the FITS headers and Bennett et al 1994 for more details.

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A FORTRAN Source Code to Read the DMR Pixelized Differential Data

```
program pixprm

C      A simple program to read the FITS binary table from the DMR
C      Pixelized Project Data Set.

integer maxdim
parameter (maxdim = 20)
character*30 errtxt, extnam,
&          ttype(maxdim),
&          tform(maxdim),
&          tunit(maxdim)
logical simple,extend,anyflg
integer iunit,status,bitpix,naxis,naxes(maxdim),pcount,gcount
integer group,fpixel,nelm,nrows
integer i,j,nobs,nperm,npoint
integer tfield,rwstat,bksize,vardat
integer colnum,frow,felem
integer hdutyp,inull
real    sum,sum2,enull
doubleprecision sumsum,sum_sq

status=0
iunit=15
C      open the existing FITS file with readonly access
rwstat=0
call ftopen(iunit,'dmr_pixperm_31a.fits',rwstat,bksize,status)
if (status .ne. 0) goto 99

C      read the required primary array keywords
call ftghpr(iunit,maxdim,simple,bitpix,naxis,naxes,
&          pcount,gcount,extend,status)
if (status .ne. 0) goto 99

C      now move to the binary table extension
call ftmahd(iunit,2,hdutyp,status)
if (status .ne. 0) goto 99

C      get the binary table parameters
call ftghbn(iunit,maxdim,nrows,tfield,ttype,tform,tunit,
&          extnam,vardat,status)
if (status .ne. 0) goto 99

C      test that this is a DMR pixperm dataset, and its fields
```

```

C      are as expected.
      if (extnam .ne. 'DMR_PIXPERM' .or.
&         ttype(4) .ne. 'SUM' .or.
&         ttype(5) .ne. 'SUM_2' .or.
&         ttype(3) .ne. 'N_OBS') then
          print *, 'extnam = ', extnam
          print *, 'ttype(4) = ', ttype(4)
          print *, 'ttype(5) = ', ttype(5)
          print *, 'ttype(3) = ', ttype(3)
          stop 'Not a DMR pixperm dataset.'
      endif

C      initialize statistical accumulators
      nperm = 0
      npoint = 0
      sumsum = 0.0d0
      sum_sq = 0.0d0

C      read each pix-perm and process
      do 10 frow = 1, nrows
          felem=1
          nelelem=1
          inull=0
          colnum=4
          call ftgcve(iunit,colnum,frow,felem,nelem,enull,sum,
&                  anyflg,status)
          if (status .ne. 0) goto 99
          colnum=5
          call ftgcve(iunit,colnum,frow,felem,nelem,enull,sum2,
&                  anyflg,status)
          if (status .ne. 0) goto 99
          colnum=3
          call ftgcvj(iunit,colnum,frow,felem,nelem,inull,nobs,
&                  anyflg,status)
          if (status .ne. 0) goto 99

          if (nobs .gt. 0) then
              nperm = nperm + 1
              npoint = npoint + nobs
              sumsum = sumsum + sum
              sum_sq = sum_sq + sum2
          endif
10      continue

C      print out statistics
      print 1000, nperm, npoint, sumsum/dbble(npoint),
&          sqrt(sum_sq/dbble(npoint))

```

```

1000  format(' Pix-perms read in = ',i9/
      &      ' Total observations = ',i9/
      &      '          Data mean = ',2x,f14.6/
      &      '          Data RMS = ',2x,f14.6)

C      now close the table and quit
      call ftclos(iunit,status)

99      if (status .le. 0)then
          print *, '*** Program completed successfully ***'
      else
C          get the error text description
          call ftgerr(status,errtxt)
          print *, '*** ERROR - program did not run successfully ***'
          print *, 'status =',status,': ',errtxt
      end if

100      continue
      end

```


B FORTRAN Source Code to Read the DMR Sky Maps

```
program skymap

C      A simple program to read the FITS binary table from the DMR
C      Sky Maps Project Data Set.

integer maxdim
parameter (maxdim = 20)
real      d2r
parameter (d2r = 0.017453292e0)
character*30 errtxt, extnam,
&          ttype(maxdim),
&          tform(maxdim),
&          tunit(maxdim)
character*80 fname
logical simple,extend,anyflg
logical sunv
integer iunit,status,bitpix,naxis,naxes(maxdim),pcount,gcount
integer group,fpixel,nelam,nrows
integer i,j,nobs,npseen,tfield,rwstat,bksize,varstat
integer colnum,frow,felem
integer hdutyp,inull
real      temp,enull,tmax,tmin
real      dt,elat,elon,dtd,elatd,elond
doubleprecision sum,sum_sq,sumd,sumd_sq

status=0
iunit=15
C      open the existing FITS file with readonly access
rwstat=0

print *, 'Enter the name of the FITS sky map to read:'
read(*, '(a80)') fname
call ftopen(iunit,fname,rwstat,bksize,status)
if (status .ne. 0) goto 99

C      read the required primary array keywords
call ftghpr(iunit,maxdim,simple,bitpix,naxis,naxes,
&          pcount,gcount,extend,status)
if (status .ne. 0) goto 99

C      if dipole has been suppressed, get dipole to add back in.
call ftgkyl(iunit,'VEL_SUN',sunv,comment,status)
if (status .ne. 0) goto 99
```

```

if (sunv) then
  call ftgkye(iunit,'DIP_MAG', dtd, comment,status)
  if (status .ne. 0) goto 99
  call ftgkye(iunit,'DIP_ELAT',elatd,comment,status)
  if (status .ne. 0) goto 99
  call ftgkye(iunit,'DIP_ELON',elond,comment,status)
  if (status .ne. 0) goto 99
  elond = d2r*elond
  elatd = d2r*elatd
endif

C    now move to the binary table extension
call ftmahd(iunit,2,hdutyp,status)
if (status .ne. 0) goto 99

C    get the binary table parameters
call ftghbn(iunit,maxdim,nrows,tfield,ttype,tform,tunit,
&           extnam,varstat,status)
if (status .ne. 0) goto 99

C    test that this is a DMR sky map dataset, and its fields
C    are as expected.
if (extnam .ne. 'DMR_SKYMAP' .or.
&    ttype(2) .ne. 'SIGNAL' .or.
&    ttype(3) .ne. 'N_OBS') then
  print *, 'extnam   = ', extnam
  print *, 'ttype(2) = ', ttype(2)
  print *, 'ttype(3) = ', ttype(3)
  stop 'Not a DMR sky map.'
endif

C    initialize statistical accumulators
npseen = 0
sum     = 0.0d0
sum_sq  = 0.0d0
tmax    = -1e30
tmin    = 1e30

C    read each pixel and process
do 10 frow = 1, nrows
  felem=1
  nelelem=1
  inull=0
  enull=0.0
  colnum=2
  call ftgcve(iunit,colnum,frow,felem,nelem,enull,temp,
&             anyflg,status)

```

```

        if (status .ne. 0) goto 99
        colnum=3
        call ftgcvj(iunit,colnum,frow,felem,nelem,inull,nobs,
&                anyflg,status)
        if (status .ne. 0) goto 99
        colnum=5
        call ftgcve(iunit,colnum,frow,felem,nelem,enull,elon,
&                anyflg,status)
        if (status .ne. 0) goto 99
        elon = d2r*elon
        colnum=6
        call ftgcve(iunit,colnum,frow,felem,nelem,enull,elat,
&                anyflg,status)
        if (status .ne. 0) goto 99
        elat = d2r*elat

        if (nobs .gt. 0) then
            npseen = npseen + 1
            sum     = sum + temp
            sum_sq  = sum_sq + temp*temp
            tmax    = max(tmax,temp)
            tmin    = min(tmin,temp)

C      add dipole term
            if (sunv) then
                temp = temp
&            + dtd*( sin(elatd)*sin(elat) +
&            cos(elatd)*cos(elat)*cos(elond-elon) )
                sumd     = sumd + temp
                sumd_sq  = sumd_sq + temp*temp
                tmaxd    = max(tmaxd,temp)
                tmind    = min(tmind,temp)
            endif

        endif
10      continue

C      print out statistics
        if (sunv) then
            print 1020
            print 1010, npseen, npseen,
&            tmax, tmaxd,
&            tmin, tmind,
&            sum/dbl(npsen),
&            sumd/dbl(npsen),
&            sqrt( (dbl(npsen)*sum_sq - sum*sum)

```

```

&          /dbl(npsen)/dbl(npsen-1) ),
&          sqrt( (dbl(npsen)*sumd_sq - sumd*sumd)
&          /dbl(npsen)/dbl(npsen-1) )
else
    print 1000, npsen,
&          tmax,
&          tmin,
&          sum/dbl(npsen),
&          sqrt( (dbl(npsen)*sum_sq - sum*sum)
&          /dbl(npsen)/dbl(npsen-1) )
endif
1000    format(' Observed Pixels = ',2x,i5/
&          '          Max = ',f14.6/
&          '          Min = ',f14.6/
&          '          Avg = ',f14.6/
&          '          Sigma = ',f14.6)
1010    format(' Observed Pixels = ',2x,i5,12x,i5/
&          '          Max = ',f14.6, 3x,f14.6/
&          '          Min = ',f14.6, 3x,f14.6/
&          '          Avg = ',f14.6, 3x,f14.6/
&          '          Sigma = ',f14.6, 3x,f14.6)
1020    format(18x,'          Without          With'/
&          18x,'          Dipole          Dipole'/
&          18x,'          As Read          Restored')

C      now close the table and quit
      call ftclos(iunit,status)

99      if (status .le. 0)then
          print *, '*** Program completed successfully ***'
      else
C          get the error text description
          call ftgerr(status,errtxt)
          print *, '*** ERROR - program did not run successfully ***'
          print *, 'status =',status,': ',errtxt
      end if

100      continue
      end

```

C DMR Time-Ordered Data Project Data Set Structure

RECORD DT04_TOD/DURATION="00:00:32"

Offset Length Description

(Bytes)(Bytes)

```

!
! ***** DMR TIME ORDERED DATA (TOD) FILE STRUCTURE *****
!
!           Record Size 2048 Bytes [4 x 512 Byte Blocks]
!
!-----
0    8    Scalar/ADT           TIME
!-----
8    22    STRUCTURE           COBETRIEVE_HEADER
8    4    Scalar/Long          MAJOR_FRAME_NUMBER
12   4    Scalar/Long          ORBIT_NUMBER
16   1    Scalar/Byte          SPIKE_LEVEL
!                               ( x RMS X 10 for spike flagging )
17   1    Scalar/Byte          WRITE_HIST
!                               ( Last Write: 0=DSA,2=DT0,4=DCA )
18   1    Scalar/Byte          DSA_FLAG
!                               ( 1=Derived From a Simulated Archive )
19   2    Scalar/Word          FRAME_FLAG          !Bits 0 to 15 set for
!                               Not_clear, Gap, Eng, Dump, Bad_att, Prev_cal,
!                               Cal_up, Cal_dn, All_bad, 31A -> 90B_bad,spare
!                               ( Major-Frame Quality Flag )
21   1    Scalar/Byte          SEARCH_FLAG
22   1    Scalar/Byte          CELESTIAL_OBJECTS    !Bits 0 to 7 for
!                               Moon, Earth (31,53,90),
!                               Jupiter, Mars, Saturn, Galaxy
23   1    Scalar/Byte          ATTITUDE_TYPE
!                               ( 0=None, 1=SunEarth, 2=Definitive )
24   1    Scalar/Byte          Galaxy_Cut_Angle     ! Degrees
25   1    Scalar/Byte          Planet_Cut_Angle     ! Degrees
26   1    Scalar/Byte          Moon_Cut_Angle       ! Degrees
27   3    Array/Byte/Dim=3     Earth_Cut_Angle     ! Degrees for 31, 53, 90
ENDSTRUCTURE ! COBETRIEVE_HEADER
!-----
30  518    STRUCTURE           SPACECRAFT_INFORMATION
30  144    Array/Float/Dim=(4,9) ATTITUDE_QUATERNION
!                               ( 9 quaternions per frame to interpolate )
174 224    Array/Byte/Dim=(4,56) ATTITUDE_RESIDUAL

```

```

!                                     ( Residuals for the interpolator )
398 12   Array/Float/Dim=3   SPACECRAFT_VELOCITY ! meters / sec
410 12   Array/Float/Dim=3   SPACECRAFT_POSITION ! Celestial coord J2000
422 12   Array/Float/Dim=3   EARTH_VELOCITY      ! meters / sec
434  4   Scalar/Float        Orbit_Angle         ! Degrees
438  4   Scalar/Float        DIPDUATH_Orbit_Var    ! D.U.
442  4   Scalar/Float        DP28VRUA_Orbit_Var    ! D.U.
! MPA_BRACKET_THERM_31A Major frame average
446  4   Scalar/Float        MPA_BRACKET_THERMISTOR_31 ! DMT31MAA
! ABSOLUTE_PRT_53A and ABSOLUTE_PRT_90A Major frame averages
450  4   Scalar/Float        CRITICAL_REGION_53    ! DAP53MAA
454  4   Scalar/Float        CRITICAL_REGION_90    ! DAP90MAA
!
! Fields from spacecraft archive NSB_SCDB_CS
! Torquer bar currents
458  2   ARRAY /BYTE /DIM= 2   AMABI      !MODULO 64 MMA A BAR CURRENT
460  2   ARRAY /BYTE /DIM= 2   AMAXBI     !MODULO 64 MMA AX BAR CURRENT
462  2   ARRAY /BYTE /DIM= 2   AMBBBI     !MODULO 64 MMA B BAR CURRENT
464  2   ARRAY /BYTE /DIM= 2   AMBXBI     !MODULO 64 MMA BX BAR CURRENT
466  2   ARRAY /BYTE /DIM= 2   AMCBI      !MODULO 64 MMA C BAR CURRENT
468  2   ARRAY /BYTE /DIM= 2   AMCXBI     !MODULO 64 MMA CX BAR CURRENT
! Magnetometer field components, 4 per major frame in NSB_SCDB_CS
!(For each set of six values,the first value is the last value from
! NSB_SCDB_CS for the previous major frame, and the sixth value
! is the first value from NSB_SCDB_CS for the next major frame)
470  6   ARRAY /BYTE /DIM= 6   ATAMA      !MODULO 32 TAM A FIELD
476  6   ARRAY /BYTE /DIM= 6   ATAMAP     !MODULO 32 TAM AP FIELD(PERPENDICULAR)
482  6   ARRAY /BYTE /DIM= 6   ATAMAX     !MODULO 32 TAM AX FIELD
488  6   ARRAY /BYTE /DIM= 6   ATAMB      !MODULO 32 TAM B FIELD
494  6   ARRAY /BYTE /DIM= 6   ATAMP      !MODULO 32 TAM BP FIELD
500  6   ARRAY /BYTE /DIM= 6   ATAMBX     !MODULO 32 TAM BX FIELD
506  6   ARRAY /BYTE /DIM= 6   ATAMC      !MODULO 32 TAM C FIELD
512  6   ARRAY /BYTE /DIM= 6   ATAMCP     !MODULO 32 TAM CP FIELD
518  6   ARRAY /BYTE /DIM= 6   ATAMCX     !MODULO 32 TAM CX FIELD
! Momentum and Reaction Wheels
! (For each set of six reaction wheel values, the first value is the
! last value from NSB_SCDB_CS for the previous major frame, and the
! sixth value is the first value from NSB_SCDB_CS for the next major
! frame)
524  1   SCALAR/BYTE          AMW1WSP     !ACS MOMENTUM WHEEL 1 WHEEL SPEED.RPM.
525  1   SCALAR/BYTE          AMW1SPER    !ACS MOMENTUM WHEEL 1 SPEED ERROR.RPM.
526  1   SCALAR/BYTE          AMW2WSP     !ACS MOMENTUM WHEEL 2 WHEEL SPEED.RPM.
527  1   SCALAR/BYTE          AMW2SPER    !ACS MOMENTUM WHEEL 2 SPEED ERROR.RPM.
528  6   ARRAY/BYTE/DIM=6     ARWASP      !ACS REACTION WHEEL A SPEED. RPM.
534  6   ARRAY/BYTE/DIM=6     ARWBSP      !ACS REACTION WHEEL B SPEED. RPM.
540  6   ARRAY/BYTE/DIM=6     ARWCSP      !ACS REACTION WHEEL C SPEED. RPM.

```

```

546 2    ARRAY/BYTE/DIM=2 SPARE    !Spares
      ENDSTRUCTURE ! SPACECRAFT_INFORMATION
!-----
548 12   STRUCTURE      MOON_DATA
548 4    Scalar/Float    ANGLE_SPIN_MOON ! Degrees
552 4    Scalar/Float    PHASE           ! Radians
556 4    Scalar/Float    POLARIZATION    ! Radians
      ENDSTRUCTURE ! MOON_DATA
!-----
560 1392 STRUCTURE/Dim=(3,2)    SIGNAL    !Signal Name 6 x 232 bytes
560 128  Array/Word/Dim=64    DIFFERENTIAL_TEMPERATURE
688 8    Array/Word/Dim=4    TOTAL_POWER
696 16   STRUCTURE      AVERAGE
696 4    Scalar/Float    DIFFERENTIAL_TEMPERATURE
700 4    Scalar/Float    ABSOLUTE_STEP
704 4    Scalar/Float    LOCK_IN_AMP_THERM
708 4    Scalar/Float    LOCAL_OSC_THERM
      ENDSTRUCTURE ! AVERAGE
712 4    Scalar/Float    DIODE_GAIN              ! (du/mK)
      UNION
      MAP
716 12   Array/Float/Dim=3 BASELINE              ! Alias for baselines
      ENDMAP
      MAP
716 4    Scalar/Float    MEAN_BASELINE    !Long time constant running mean
720 4    Scalar/Float    SPLINE_BASELINE   !Medium time constant baseline
724 4    Scalar/Float    FAST_CTD_BASELINE !Short time constant corrected
      !baseline
      ENDMAP
      ENDUNION
728 64   Array/Byte/Dim=64    FLAG          ! Bits 0 to 7 set for
!      Bad_data, Moon, Spike, Offscale,
!      Planet, Galaxy, (spare), Bad_att
!      (Minor-Frame (Science) Quality Flag)
!
      ENDSTRUCTURE ! SIGNAL
!-----
1952 96  STRUCTURE      HOUSEKEEPING_DATA    ! 96 bytes
!From SUBCOM_99
1952 1   Scalar/Byte    DSCRBY              !S/C REG BUS VOLT
1953 1   Scalar/Byte    DNESBI              !S/C NON-ES BUS CURR
1954 1   Scalar/Byte    DP28VRUA            !IPDU +28 V MON
1955 1   Scalar/Byte    DP5VMRUA            !IPDU +5 V MON
1956 1   Scalar/Byte    DP15VRUA            !IPDU +15V MON
1957 1   Scalar/Byte    DN15VRUA            !IPDU -15V MON
1958 1   Scalar/Byte    DIPDUVMA            !IPDU BUSV MON

```

1959	1	Scalar/Byte	DIPDUIMA	!IPDU BUSI MON
1960	1	Scalar/Byte	DIICBIMA	!IPDU CONV BUSI
1961	1	Scalar/Byte	DIPHBVMA	!IPDU HEAT BUSV
1962	1	Scalar/Byte	DIPHBIMA	!IPDU HEAT BUSI
1963	1	Scalar/Byte	DPR10VMA	!IPDU PR1V MON
1964	1	Scalar/Byte	DPR20VMA	!IPDU PR1V MON
1965	1	Scalar/Byte	D31MIVMA	!31 MPA/IFA PRVM
1966	1	Scalar/Byte	D531PRTA	!53 GHz 1K PRT
1967	1	Scalar/Byte	D901PRTA	!90 GHz 1K PRT
1968	1	Scalar/Byte	DIPDUTHA	!IPDU BOX THERM
1969	1	Scalar/Byte	DIPLMTHA	!IPWR LMAC THERM
1970	1	Scalar/Byte	DHPLMTHA	!HPWR LMAC THERM
1971	1	Scalar/Byte	DPRGTH1A	!PRE-REG 1 THERM
1972	1	Scalar/Byte	DPRGTH2A	!PRE-REG 2 THERM
1973	1	Scalar/Byte	DINTCTHA	!IPDU INT CONV T
1974	1	Scalar/Byte	D53NSVMA	!53 GHz NSIV MON
1975	1	Scalar/Byte	D90MIVMA	!90 MPA/IFA PRVM
1976	1	Scalar/Byte	D90NSVMA	!90 GHz NSIV MON
1977	1	Scalar/Byte	DDEP5VMA	!DE +5V IV MON
1978	1	Scalar/Byte	D31TCM1A	!31 GHz TCVM #1
1979	1	Scalar/Byte	D53TCM1A	!53 GHz TCMV #1
1980	1	Scalar/Byte	D90TCM1A	!90 GHz TCMV #1
1981	1	Scalar/Byte	DDEUTCMA	!DATA ELEC TCVM
1982	1	Scalar/Byte	D31NSVMA	!31 GHz NSIV MON
1983	1	Scalar/Byte	D53MIVMA	!53 MPA/IFA PRVM
1984	1	Scalar/Byte	DP28VRUB	!+28 IPDU IV MON
1985	1	Scalar/Byte	DP5VMRUB	!+5 IPDU IV MON
1986	1	Scalar/Byte	DP15VRUB	!+15 IPDU IV MON
1987	1	Scalar/Byte	DN15VRUB	!-15 IPDU IV MON
1988	1	Scalar/Byte	DIPDUVMB	!IPDU I BUSV MON
1989	1	Scalar/Byte	DIPDUIMB	!IPDU I BUSI MON
1990	1	Scalar/Byte	DIICBIMB	!IPDU IC BUSI MON
1991	1	Scalar/Byte	DIPHBVMB	!IPDU HBUSV MON
1992	1	Scalar/Byte	DIPHBIMB	!IPDU HBUSI MON
1993	1	Scalar/Byte	DPR10VMB	!IPDU PR1 OV MON
1994	1	Scalar/Byte	DPR20MVB	!IPDU PR2 OV MON
1995	1	Scalar/Byte	D31MIVMB	!31 MPA/IFA PRVM
1996	1	Scalar/Byte	D531PRTB	!53 GHz 1K PRT
1997	1	Scalar/Byte	D901PRTB	!90 GHz 1K PRT
1998	1	Scalar/Byte	DIPDUTHB	!IPDU BOX THERM
1999	1	Scalar/Byte	DIPLMTHB	!IPWR LMAC THERM
2000	1	Scalar/Byte	DHPLMTHB	!HTRP LMAC THERM
2001	1	Scalar/Byte	DPRGTH1B	!PRE-REG 1 THERM
2002	1	Scalar/Byte	DPRGTH2B	!PRE-REG 2 THERM
2003	1	Scalar/Byte	DINTCTHB	!IPDU INT CONV T
2004	1	Scalar/Byte	D53NSVMB	!53 GHz NSIV MON

2005	1	Scalar/Byte	D90MIVMB	!90 MPA/IFA PRVM
2006	1	Scalar/Byte	D90NSVMB	!90 GHz NSIV MON
2007	1	Scalar/Byte	DDEP5VMB	!DE +5V INSV MON
2008	1	Scalar/Byte	D31TCM2B	!31 GHz TCVM #2
2009	1	Scalar/Byte	D53TCM2B	!53 GHz TCVM #2
2010	1	Scalar/Byte	D90TCM2B	!90 GHz TCVM #2
2011	1	Scalar/Byte	DDEUTCMB	!DATA ELEC TCVM
2012	1	Scalar/Byte	D31NSVMB	!31 GHz NS IVM
2013	1	Scalar/Byte	D53MIVMB	!53 MPA/IFA PRVM
2014	1	Scalar/Byte	DIPDUATH	!IPDU-A BOX S/CT
2015	1	Scalar/Byte	DIPDUBTH	!IPDU-B BOX S/CT
2016	1	Scalar/Byte	DDEUABTH	!DEU-A BOX S/CT
2017	1	Scalar/Byte	DDEUBBTH	!DEU-B BOX S/CT
2018	1	Scalar/Byte	DI8NSCA	!NS CALIBRATE
2019	5	Array/Byte/Dim=5	DRELA99A	!RelayA group

!Byte 1

!Bit0 = DI7DEVRA	Bit1 = D69OLIAA	Bit2 = DI590DSA	Bit3 = D453LIAA
!DE VOLT REG	90 GHz LI AMP	90 GHz DK SW	53 GHz LI AMP
!Bit4 = DI353DSA	Bit5 = D231LIAA	Bit6 = DI131DSA	Bit7 = DK831CCA
!53 GHz DK SW	31 GHz LI AMP	31 GHz DK SW	31 GHz CH CNV

!Byte 2

!Bit0 = D7DETG5A	Bit1 = D69ONSDA	Bit2 = DK590MIA	Bit3 = D453NSDA
!DE TIM GEN +5	90 GHz NS DIS	90 MPA/IFA	53 GHz NS DIS
!Bit4 = DK353MIA	Bit5 = D231NSDA	Bit6 = DK131MIA	Bit7 = D853FMHA
!53 MPA/IFA	31 GHz NS DIS	31 MPA/IFA	53 FAIL M HTR

!Byte 3

!Bit0 = D731FMHA	Bit1 = D69OWBCA	Bit2 = D590CRCA	Bit3 = D453WBCA
!31 FAIL M HTR	90 CASE T CNT	90 CRIT T CNT	53 CASE T CNT
!Bit4 = D353CRCA	Bit5 = DH231CCA	Bit6 = D131CRCA	Bit7 = D1290LOA
!53 CRIT T CNT	31 CASE T CNT	31 CRIT T CNT	90 GHz LO CNV

!Byte 4

!Bit0 = D1153LOA	Bit1 = D10DETC A	Bit2 = D990FMHA	Bit3 = DK12DECA
!53 GHz LO CNV	DE TEMP CNT	90 FAIL M HTR	DATA ELEC CNV
!Bit4 = D1131LOA	Bit5 = D1090CCA	Bit6 = DK953CCA	Bit7 = D31MODEA
!31 GHz LO CNV	90 GHz CH CNV	53 GHz CH CNV	31A INST MODE

!Byte 5

!Bit0 = D53MODEA	Bit1 = D90MODEA	Bit2 = D90GAINA	Bit3 = D53GAINA
!53A INST MODE	90A INST MODE	90 GHz GAIN	53 GHz GAIN
!Bit4 = D31GAINA	Bit5 = D31BWTHA	Bit6 = DILMACOA	Bit7 = DHLMACOA
!31 GHz GAIN	31 GHz BANDWD	LMAC OVTP OVR	HPWR OVTP OVR

2024	1	Scalar/Byte	D31NSSTA	!31A NS STATUS
2025	1	Scalar/Byte	D53NSSTA	!53A NS STATUS
2026	1	Scalar/Byte	D90NSSTA	!90A NS STATUS
2027	1	Scalar/Byte	D31NSSTB	!31B NS STATUS

2028	1	Scalar/Byte	D53NSSTB	!53B NS STATUS
2029	1	Scalar/Byte	D31SCBTH	!31 GHz BOX TH
2030	1	Scalar/Byte	D90NSSTB	!90B NS STATUS
2031	1	Scalar/Byte	D53SCBTH	!53 GHz BOX TH
2032	1	Scalar/Byte	D90SCBTH	!90 GHz BOX TH
2033	1	Scalar/Byte	DI8NSCB	!NS CALIBRATE
2034	5	Array/Byte/Dim=5	DRELA99B	!RelayB group

!Byte 1

!Bit0 = DI7DEV RB	Bit1 = D690LIAB	Bit2 = DI590DSB	Bit3 = D453LIAB
!DE VOLT REG	90 GHz LI AMP	90 DICKE SW	53 GHz LI AMP
!Bit4 = DI353DSB	Bit5 = D231LIAB	Bit6 = DI131DSB	Bit7 = DK831CCB
!53 DICKE SW	31 GHz LI AMP	31 DICKE SW	31 GHz CH CNV

!Byte 2

!Bit0 = D7DETG5B	Bit1 = D690NSDB	Bit2 = DK590MIB	Bit3 = D453NSDB
!DE TIM GEN +5	90 GHz NS DIS	90 MPA/IFA	53 GHz NS DIS
!Bit4 = DK353MIB	Bit5 = D231NSDB	Bit6 = DK131MIB	Bit7 = D853FMHB
!53 MPA/IFA	31 GHz NS DIS	31 MPA/IFA	53 FAIL M HTR

!Byte 3

!Bit0 = D731FMHB	Bit1 = D690WBCB	Bit2 = D590CRCB	Bit3 = D453WBCB
!31 FAIL M HTR	90 CASE T CNT	90 CRIT T CNT	53 CASE T CNT
!Bit4 = D353CRCB	Bit5 = DH231CCB	Bit6 = D131CRCB	Bit7 = D1290LOB
!53 CRIT T CNT	31 CASE T CNT	31 CRIT T CNT	90 GHz LO CNV

!Byte 4

!Bit0 = D1153LOB	Bit1 = D10DETCB	Bit2 = D990FMHB	Bit3 = DK12DECB
!53 GHz LO CNV	DE TEMP CNT	90 FAIL M HTR	DATA ELEC CNV
!Bit4 = D1131LOB	Bit5 = D1090CCB	Bit6 = DK953CCB	Bit7 = D31MODEB
!31 GHz LO CNV	90 GHz CH CNV	53 GHz CH CNV	31B INST MODE

!Byte 5

!Bit0 = D53MODEB	Bit1 = D90MODEB	Bit2 = D90GAINB	Bit3 = D53GAINB
!53A INST MODE	90A INST MODE	90 GHz GAIN	53 GHz GAIN
!Bit4 = D31GAINB	Bit5 = D31BWTHB	Bit6 = DILMACOB	Bit7 = DHLMACOB
!31 GHz GAIN	31 GHz BANDWD	LMAC OVTP OVR	HPWR OVTP OVR

2039	1	Scalar/Byte	Spare
------	---	-------------	-------

!

!From SUBCOM_98

2040	1	Scalar/Byte	DRELA98	!Relay group
------	---	-------------	---------	--------------

!Byte1

!Bit0 = DIPIC28A	Bit1 = DIPIC28B	Bit2 = DHSC28VA
!+28V IPDU INT CONV A	+28V IPDU INT CONV B	+28V HEATER SWITCH A
!Bit3 = DHSC28VB	Bit4 = DIPPR28A	Bit5 = DIPPR28B
!+28V HEATER SWITCH B	+28V IPDU PRE REG A	+28V IPDU PRE REG B

2041	1	Scalar/Byte	D31BOXSH	!31 GHz BOX SURV HEATER
------	---	-------------	----------	-------------------------

2042	1	Scalar/Byte	D53BOXSH	!53 GHz BOX SURV HEATER
2043	1	Scalar/Byte	D90BOXSH	!90 GHz BOX SURV HEATER
2044	1	Scalar/Byte	DDEUABSH	!DEU-A BOX SURV HEATER
2045	1	Scalar/Byte	DDEUBBSH	!DEU-B BOX SURV HEATER
2046	1	Scalar/Byte	DIPDUBSH	!IPDU BAY SURV HEATER
2047	1	Scalar/Byte	DBUSVOLT	!DMR BUS VOLTAGE

!

ENDSTRUCTURE ! HOUSEKEEPING_DATA

!

2048 END_RECORD

TOTAL LENGTH OF RECORD: 2048 BYTES

TOTAL NUMBER OF FIELDS: 161

D Comments for the Related Data Fields in DMR Time-Ordered Data Project Data Set

Offset	Length	Description
-----	-----	-----
0	8	Scalar/ADT TIME

This time field is of primary use by the COBE archiving database system (COBETRIEVE). In VAX ADT format, it is defined as the number of 100 nanosecond intervals that have elapsed since 0 UT on November 17, 1858 (not counting leap-seconds), and so currently has values of order 4×10^{16} . It is conceptually an 8-byte signed integer, and can be handled as such on certain 64-bit systems, e.g. DEC Alpha with OSF/1. For systems without such luxuries it may be thought of as (e.g., in C) a structure combining a signed long and an unsigned long. Unfortunately, VAX Fortran does not provide unsigned integer types, so using ADT times in Fortran is quite cumbersome.

It is evaluated in VAX Fortran as two INTEGER*4 numbers, but the sign bit of the first number is used so that it is not straightforward to reconstruct the value. Here is a method of evaluating the ADT time as a REAL*8 number:

```

INTEGER*4 ADT(2)
REAL*8 I4MAX/4.294967296D+9/, TADT
      IF (ADT(1) .GE. 0)
&      TADT = DBLE(ADT(1)) + I4MAX*DBLE(ADT(2))
      IF (ADT(1) .LT. 0)
&      TADT = I4MAX + DBLE(ADT(1)) + I4MAX*DBLE(ADT(2))

```

In the COBE ingest system, the ADT time is calculated from the UTC (Coordinated Universal Time) for each major frame. Hence, the ADT time increases by exactly 320,000,000 for each 32 second major frame, except for those major frames which follow a 'leap second', in which case the ADT time increases by exactly 310,000,000 from the previous frame. Hence, to convert ADT time back to UTC or to T81 (seconds of UTC or IAT that have elapsed since 0 UTC on Jan 1, 1981), specialized routines are necessary that can make the adjustments at the leap-second times, and these routines will be available to the COBE guest investigators. In case this documentation survives the availability of such routines, the following table will allow a user to make the conversion. The table gives values of UTC, TADT, and T81 for the four leap-seconds that occurred during the COBE mission (UTC times are expressed in the format YYDDDHHMMSS):

Leap-second number	1	(Dec 31, 1989)		
		Previous Second	Leap Second	Following Second
	UTC	89365235959	89365235960	90001000000
	T81	283,996,804	283,996,805	283,996,806
	TADT/10**7	4,137,868,799	-----	4,137,868,800

Leap-second number	2	(Dec 31, 1990)		
		Previous Second	Leap Second	Following Second

UTC	90365235959	90365235960	91001000000
T81	315,532,805	315,532,806	315,532,807
TADT/10**7	4,169,404,799	-----	4,169,404,800

Leap-second number 3 (June 30, 1992)

	Previous Second	Leap Second	Following Second
UTC	92182235959	92182235960	92183000000
T81	362,793,606	362,793,607	362,793,608
TADT/10**7	4,216,665,599	-----	4,216,665,600

Leap-second number 4 (June 30, 1993)

	Previous Second	Leap Second	Following Second
UTC	93181235959	93181235960	93182000000
T81	394,329,607	394,329,608	394,329,609
TADT/10**7	4,248,201,599	-----	4,248,201,600

Note that since the ADT time is not definable for leap-seconds, TADT can be thought of as being 'frozen' during the entire leap-second.

Each of the records of this time-ordered data set spans 32 seconds and is called a 'Major Frame'. The major frame contains data for 64 half-second DMR integration periods, called 'DMR Minor Frames'. The TIME field of the major frame corresponds to the time at the end of the first of these 64 integration periods. (The times in the DMR time-ordered dataset are one-eighth second [0.125 sec] less than the times in the ingested COBE telemetry in order to compensate for a time delay in the DMR instrument).

Offset	Length	Description
-----	-----	-----
8	4	Scalar/Long MAJOR_FRAME_NUMBER

Integer giving the current major frame number. This number was reset to zero at the beginning of each new ingest tape. Normally each tape had more or less one day's data or 2700 frames and started between 0900 and 1000 UTC.

Offset	Length	Description
-----	-----	-----
12	4	Scalar/Long ORBIT_NUMBER

Integer giving the current orbit number. The origin of this number was apparently arbitrary and the COBE mission starts at about orbit number 7232. There are slightly more than 14 orbits per day. A new orbit begins near orbit angle 310° which is between the South Pole and the equator moving northward.

Offset	Length	Description
-----	-----	-----
16	1	Scalar/Byte SPIKE_LEVEL

Individual data points beyond a certain threshold from the mean are flagged as spikes [see comments for data field DTO4_TOD.SIGNAL(frequency,channel).FLAG(1:64)]. DMR used the threshold of 5.0 times the daily RMS value, so that SPIKE_LEVEL has the value of 50.

Offset	Length	Description	
-----	-----	-----	
17	1	Scalar/Byte	WRITE_HIST
		!	(Last Write: 0=DSA,2=DT0,4=DCA)

The delivered DMR time-ordered data was produced by the DCA (CALibrate time-ordered data) facility, so that WRITE_HIST has the value of 4.

Offset	Length	Description	
-----	-----	-----	
18	1	Scalar/Byte	DSA_FLAG
		!	(1=Derived From a Simulated Archive)

For the real, non-simulated data, DSA_FLAG = 0.

Offset	Length	Description	
-----	-----	-----	
19	2	Scalar/Word	FRAME_FLAG
		!	Bits 0 to 15 set for Not_clear, Gap,
		!	Eng, Dump, Bad_att, Prev_cal, Cal_up,
		!	Cal_dn, All_bad, 31A -> 90B_bad, spare
		!	(Major-Frame Quality Flag)

Determines whether the major frame has usable data. Evaluated as a number FRAME_FLAG can have values from 0 to 65535. If all 6 channels have at least some minor frames with usable data, then FRAME_FLAG, evaluated as a number will be 0 or 1.

Offset	Length	Description	
-----	-----	-----	
21	1	Scalar/Byte	SEARCH_FLAG

This is a bit-by-bit logical OR of the 384 (6 channels by 64 minor frames) minor frame science FLAGS. See comments for data field DTO4_TOD.SIGNAL(frequency,channel).FLAG(1:64).

Offset	Length	Description	
-----	-----	-----	
22	1	Scalar/Byte	CELESTIAL_OBJECTS
		!	Bits 0 to 7 set for Moon,
		!	Earth(31,53,90), Jupiter, Mars,
		!	Saturn, Galaxy

This flag tells the user whether to search the individual minor-frame science FLAGS for occurrence of the particular celestial object. Data flagged as Moon or Earth close are not considered usable. Data flagged for planets were corrected for those planets in the DMR Sky Maps and Pixelized Project Data Sets. The Galaxy flag is a warning only. If bits 0, 4, 5, 6, or 7 were set, then the data for at least one minor frame for at least one channel were affected. If bits 1, 2, or 3 were set, then the data for the respective frequency or frequencies were not used for the entire major frame.

Offset	Length	Description
-----	-----	-----
23	1	Scalar/Byte ATTITUDE_TYPE !
		(0=None, 1=SunEarth, 2=Definitive)

Usable DMR data must have attitude types of 1 or 2. The Definitive attitude is usually of higher quality and was obtained from analyzing DIRBE observations of stars.

Offset	Length	Description
-----	-----	-----
24	1	Scalar/Byte Galaxy_Cut_Angle ! Degrees

DMR data within 15° of the galactic plane are flagged as Galaxy_close (see comments on DTO4_TOD.COBETRIEVE_HEADER.CELESTIAL_OBJECTS). Such data are usable with this caveat.

Offset	Length	Description
-----	-----	-----
25	1	Scalar/Byte Planet_Cut_Angle ! Degrees

DMR data from within 15° of Mars, Jupiter, or Saturn are flagged (see comments on DTO4_TOD.COBETRIEVE_HEADER.CELESTIAL_OBJECTS). Data so flagged were corrected for planetary emission in the DMR Sky Maps and Pixelized Project Data Sets.

Offset	Length	Description
-----	-----	-----
26	1	Scalar/Byte Moon_Cut_Angle ! Degrees

DMR data from within 21° of the Moon are flagged and were not used in the production of DMR Sky Maps or Pixelized Project Data Sets.

Offset	Length	Description
-----	-----	-----
27	3	Array/Byte/Dim=3 Earth_Cut_Angle ! Degrees

Data obtained when the Earth's limb was too close to the COBE ground shield (less than 3° below the shield for 31 GHz data and less than 1° below for 53 and 90 GHz data) were flagged (see comments on DTO4.TOD.COBETRIEVE_HEADER.CELESTIAL_OBJECTS), and not used in the production of DMR Sky Maps or Pixelized Project Data Sets.

Offset	Length	Description
-----	-----	-----
30	144	Array/Float/Dim=(4,9) ATTITUDE_QUATERNION

These are the four quaternions describing the spacecraft attitude for nine of the DMR integration periods (DMR minor frames). These are integration periods 1,9,17,25,33,41,49,56, and 65 (which corresponds to the first integration period of the next record or major frame).

Offset	Length	Description
-----	-----	-----
174	224	Array/Byte/Dim=(4,56) ATTITUDE_RESIDUAL

These are residuals so that attitude interpolation routine in the DMR software could accurately reconstruct the spacecraft attitude quaternions for the remaining 56 DMR integration periods. The actual pointings for the ten DMR horns were constructed from the quaternions by adding the vectors defining the offsets of the horns from the spacecraft spin axis.

Offset	Length	Description
-----	-----	-----
398	12	Array/Float/Dim=3 SPACECRAFT_VELOCITY ! meters/sec

This field contains the Cartesian components (x,y,z) of the spacecraft velocity around the earth in J2000 equatorial coordinates. It is evaluated at the center of the major frame, specifically, at the time 16 seconds later than the timestamp of the frame. (Note that this is the boundary between DMR integration periods 33 and 34.)

Offset	Length	Description
-----	-----	-----
410	12	Array/Float/Dim=3 SPACECRAFT_POSITION ! Celestial coord

This field contains the Cartesian components (x,y,z) of the spacecraft position in J2000 equatorial coordinates. It is evaluated at the center of the major frame, specifically, at the time 16 seconds later than the timestamp of the frame. (Note that this is the boundary between DMR integration periods 33 and 34.)

Offset	Length	Description
-----	-----	-----
422	12	Array/Float/Dim=3 EARTH_VELOCITY ! meters / sec

For the preparation of the Sky Maps and Pixelized Project Data Sets, the DMR time-ordered data were corrected for the velocity of the spacecraft around the Earth, the Earth around the Sun, and 'Sun Velocity' (velocity which would produce a nominal CMB Dipole). This field contains the Cartesian components (x,y,z) of the earth velocity about the solar system barycenter in J2000 equatorial coordinates.

Offset	Length	Description
-----	-----	-----
434	4	Scalar/Float Orbit_Angle

The spacecraft orbit angle is defined as the angle between the spacecraft and the ascending node of the orbit with vertex at the center of the Earth. Thus the orbit angle is 0 at the ascending node, 90° over the North Pole, 180° at the descending node, and 270° over the South Pole.

Offset	Length	Description
-----	-----	-----
438	4	Scalar/Float DIPDUATH_Orbit_Var ! D.U.

Residual of DIPDUATH (IPDU-A box thermistor) for this frame after subtracting mean value from 2 orbits centered on this frame. See Appendix E for conversion to Kelvin.

Offset	Length	Description
-----	-----	-----
442	4	Scalar/Float DP28VRUA_Orbit_Var ! D.U.

Residual of DP28VRUA (IPDU +28 Voltage monitor) for this frame after subtracting mean value from 2 orbits centered on this frame. See Appendix E for conversion to Volts.

Offset	Length	Description
-----	-----	-----
548	4	Scalar/Float ANGLE_SPIN_MOON ! Degrees

The angle between the spacecraft spin axis and the direction to the moon as seen from COBE at the middle of the major frame.

Offset	Length	Description
-----	-----	-----
552	4	Scalar/Float PHASE ! Radians

The phase of the moon as seen from the COBE satellite. Full = 0, Last Quarter = $\pi/2$, New = π , and First quarter = $-\pi/2$.

Offset	Length	Description	
-----	-----	-----	
556	4	Scalar/Float	POLARIZATION ! Radians

Always zero (not used).

Offset	Length	Description	
-----	-----	-----	
560	128	Array/Word/Dim=64	DIFFERENTIAL_TEMPERATURE

Differential temperature telemetry. Each point is an unsigned integer between 0 and 4095 data units (du) representing the difference in input power between the two horns averaged over a half-second. Each half-second interval is called a “minor frame”. See DIODE-GAIN (below) to correct to antenna temperature in mK.

Offset	Length	Description	
-----	-----	-----	
688	8	Array/Word/Dim=4	TOTAL_POWER

Total power telemetry. Each point is an unsigned integer between 0 and 4095 data units (du) representing the total radiometer output over an eight-second integration period. Note that four 8-second total power samples are taken for every 64 half-second differential temperature samples.

Offset	Length	Description	
-----	-----	-----	
696	4	Scalar/Float	DIFFERENTIAL_TEMPERATURE

Average of the differential temperatures measured during this frame. The average is over minor frames 3 to 64 to avoid transients during calibration.

Offset	Length	Description	
-----	-----	-----	
700	4	Scalar/Float	ABSOLUTE_STEP

Absolute step is defined as the average absolute difference between successive differential temperatures. It is computed on a frame by frame basis and used as an alternative to the standard deviation because of its greater computational efficiency. It is computed only for minor frames 3 to 64 to avoid transients during calibration.

Offset	Length	Description	
-----	-----	-----	
704	4	Scalar/Float	LOCK_IN_AMP_THERM

Average of the lock-in amplifier thermistor telemetry for this frame (du). See Appendix E (DLTH31A) for conversion to Kelvin.

Offset	Length	Description
-----	-----	-----
708	4	Scalar/Float LOCAL_OSC_THERM

Average of the local oscillator thermistor telemetry for this frame (du). See Appendix E (DLOT31A) for conversion to Kelvin.

Offset	Length	Description
-----	-----	-----
712	4	Scalar/Float DIODE_GAIN ! (du/mK)

Gain pertaining to this major frame derived from a noise source measurement. Divide the baseline-subtracted differential temperatures in data units by this number to obtain the uncorrected measurement in milliKelvin antenna temperature.

Offset	Length	Description
-----	-----	-----
716	4	Scalar/Float MEAN_BASELINE ! Long time constant running mean

Mean baseline value pertaining to this major frame. This value may be subtracted from the differential temperatures in data units to remove the instrument offset.

Offset	Length	Description
-----	-----	-----
720	4	Scalar/Float SPLINE_BASELINE ! Medium time constant baseline

Spline baseline value pertaining to this major frame. This value may be subtracted from the differential temperatures in data units to remove the instrument offset.

Offset	Length	Description
-----	-----	-----
724	4	Scalar/Float FAST_CTD_BASELINE ! Short time constant corrected baseline

Fast corrected baseline value pertaining to this major frame. This value may be subtracted from the differential temperatures in data units to remove the instrument offset.

Offset	Length	Description
-----	-----	-----
728	64	Array/Byte/Dim=64
		FLAG
	!	Bits 0 to 7 set for Bad_data, Moon,
	!	Spike, Offscale, Planet, Galaxy,
	!	(Spare), Bad_att
	!	(Minor-Frame (Science) Quality Flag)
	!	

Determines whether the corresponding minor frame datum is usable. Each bad data flag is a single byte whose interpretation is given in the following table.

DTO4.TOD.COBETRIEVE_HEADER.FRAME_FLAG

Bit	Hex	Set Condition	Comments
0	0001	Any bad data	If clear, entire frame is clean (all channels)
1	0002	Gap	If set, frame is gap (data unusable)
2	0004	Engineering	If set, data were taken in engineering mode
3	0008	Dump	If set, frame is in dump mode (data unusable)
4	0010	Bad attitude	If set, no attitude available for this frame
5	0020	Prev Cal	If set, previous frame was calibration and current is not
6	0040	Cal up	If set, calibrating with UP noise source
7	0080	Cal down	If set, calibrating with DOWN noise source
8	0100	Unusable frame	If set, entire frame is unusable (all channels)
9	0200	31A Unusable	If set, there is no usable data for 31A channel
10	0400	31B Unusable	If set, there is no usable data for 31B channel

Bit	Hex	Set Condition	Comments
11	0800	53A Unusable	If set, there is no usable data for 53A channel
12	1000	53B Unusable	If set, there is no usable data for 53B channel
13	2000	90A Unusable	If set, there is no usable data for 90A channel
14	4000	90B Unusable	If set, there is no usable data for 90B channel
15	8000	Spare	(not used)

DTO4.TOD.COBETRIEVE_HEADER.CELESTIAL_OBJECTS

Bit	Hex	Set Condition	Comments
0	01	Moon close	If set, the Moon is within the cut angle of spin axis
1	02	Earth, 31 GHz	If set, the Earth is above the 31 GHz cut angle
2	04	Earth, 53 GHz	If set, the Earth is above the 53 GHz cut angle
3	08	Earth, 90 GHz	If set, the Earth is above the 90 GHz cut angle
4	10	Jupiter close	If set, Jupiter is within cut angle of at least 1 channel
5	20	Mars close	If set, Mars is within cut angle of at least 1 channel
6	40	Saturn close	If set, Saturn is within cut angle of at least 1 channel
7	80	Galaxy close	If set, the Galactic plane is within cut angle

DTO4_TOD.SIGNAL(frequency,channel).FLAG(1:64)

Bit	Hex	Significance of bit value = 1	Comments
0	01	Unusable datum	This datum is unusable. This usually means that there were bad quality flags set in the raw data telemetry for this major frame or that the time range and channel were specified in the 'bad data log' (DQU4_BAD.LOG)
1	02	Moon	Moon is within cut angle of beam center. These data were not used.
2	04	Spike	Datum deviates from local mean by more than threshold. These data were not used.
3	08	Off-scale	Datum is off scale (0 or 4095). These data were not used.
4	10	Planet	One or more planets (Jupiter, Mars, and Saturn) are within cut angle of beam center. These data were used after correction.
5	20	Galaxy	Galaxy is within cut angle of beam center. This is a warning only and the data were used.
6	40	Spare	Not used.
7	80	Bad attitude	Residual too large to interpolate attitude for this datum. These data were not used.

E Conversion of DMR Housekeeping Signals and Spacecraft Signals from Telemetry Digital Units to Physical Units

Some of the DMR housekeeping signals and spacecraft signals specified in the Time-Ordered Data Project Data Set are given in Telemetry Digital Units (DU's). For purposes of converting data in Telemetry Digital Units into Physical Units, one of the following type of conversions is applied.

1. Polynomial conversion:

$$Y = C(1) + C(2)X + C(3)X^2 + C(4)X^3 + C(5)X^4 + C(6)X^5$$

2. Reciprocal Logarithm conversion:

$$Y = \frac{1.0}{C(1) \cdot \log[C(4)X + C(5)] + C(2)} + C(3)$$

Where X is given in Telemetry Digital Units (DU) and Y is the corresponding value in Physical Units (Kelvin, Volts or Amps); C(0), C(1),...,and C(5) are coefficients whose values are given in the following table.

Note:

- The type of conversion (given in the table) depends on the type of signal (temperature, voltage or current). Type "0" represents the case where no conversion is applied.
- All mnemonics beginning with the letter "D" denote DMR signals, and letter "A" spacecraft signals.
- No conversion is applied for Differential Temperatures, Total Powers, Gains and Baselines.

Signal Name	Coefficients						Type of Conv.
	C(1)	C(2)	C(3)	C(4)	C(5)	C(6)	
AMABI	-2.00000E+05	1.60000E+03	3.39897E-02	-2.64241E-04	1.01191E-06	-1.51852E-09	1
AMAXBI	-5.00000E+04	4.00000E+02	3.39897E-02	-2.64241E-04	1.01191E-06	-1.51852E-09	1
AMBBBI	-2.00000E+05	1.60000E+03	3.39897E-02	-2.64241E-04	1.01191E-06	-1.51852E-09	1
AMBXBI	-5.00000E+04	4.00000E+02	3.39897E-02	-2.64241E-04	1.01191E-06	-1.51852E-09	1
AMCBI	-2.00000E+05	1.60000E+03	3.39897E-02	-2.64241E-04	1.01191E-06	-1.51852E-09	1
AMCXBI	-5.00000E+04	4.00000E+02	3.39897E-02	-2.64241E-04	1.01191E-06	-1.51852E-09	1
ATAMA	6.39260E-01	-5.15996E-03	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	1
ATAMAP	6.39300E-01	-5.15597E-03	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	1
ATAMAX	6.39920E-01	-5.14403E-03	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	1
ATAMB	6.37350E-01	-5.09684E-03	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	1
ATAMBP	6.38690E-01	-5.19247E-03	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	1
ATAMBX	6.39260E-01	-5.13479E-03	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	1
ATAMC	6.39920E-01	-5.16796E-03	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	1
ATAMCP	6.39510E-01	-5.14272E-03	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	1
ATAMCX	6.40290E-01	-5.15730E-03	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	1
AMW1WSP	2.03446E+00	-1.28926E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	1
AMW1SPER	1.27000E+02	-1.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	1
AMW2WSP	2.03446E+00	-1.28926E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	1
AMW2SPER	1.27000E+02	-1.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	1
ARWASP	-2.75000E+03	2.20000E+01	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	1
ARWBSP	-2.75000E+03	2.20000E+01	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	1
ARWCSP	-2.75000E+03	2.20000E+01	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	1
DMBT31A	2.09805E-04	1.41211E-03	-3.18000E+01	-1.19150E+01	4.92328E+04	-2.98106E-09	2
DPRT31A	2.02037E+01	-9.86502E-03	2.83949E-08	-3.75715E-04	1.68846E-06	-2.98106E-09	1
DPRT53A	1.89732E+01	-9.26421E-03	2.83949E-08	-3.75715E-04	1.68846E-06	-2.98106E-09	1
DPRT53B	1.89732E+01	-9.26421E-03	2.83949E-08	-3.75715E-04	1.68846E-06	-2.98106E-09	1
DPRT90A	1.89732E+01	-9.26421E-03	2.83949E-08	-3.75715E-04	1.68846E-06	-2.98106E-09	1
DPRT90B	1.89732E+01	-9.26421E-03	2.83949E-08	-3.75715E-04	1.68846E-06	-2.98106E-09	1
DASP31B	3.15214E+02	-9.92608E-03	1.48992E-08	-3.75715E-04	1.68846E-06	-2.98106E-09	1
DASP53A	1.54213E+02	-9.38283E-03	2.83949E-08	-3.75715E-04	1.68846E-06	-2.98106E-09	1
DASP53B	1.54213E+02	-9.38283E-03	2.83949E-08	-3.75715E-04	1.68846E-06	-2.98106E-09	1
DASP90A	1.54213E+02	-9.38283E-03	2.83949E-08	-3.75715E-04	1.68846E-06	-2.98106E-09	1
DASP90B	1.54213E+02	-9.38283E-03	2.83949E-08	-3.75715E-04	1.68846E-06	-2.98106E-09	1
DLTH31A	2.09805E-04	1.41211E-03	-3.18000E+01	-1.19150E+01	4.92328E+04	-2.98106E-09	2
DLTH31B	2.09805E-04	1.41211E-03	-3.18000E+01	-1.19150E+01	4.92328E+04	-2.98106E-09	2
DLTH53A	2.09805E-04	1.41211E-03	-3.18000E+01	-1.19150E+01	4.92328E+04	-2.98106E-09	2
DLTH53B	2.09805E-04	1.41211E-03	-3.18000E+01	-1.19150E+01	4.92328E+04	-2.98106E-09	2
DLTH90A	2.09805E-04	1.41211E-03	-3.18000E+01	-1.19150E+01	4.92328E+04	-2.98106E-09	2
DLTH90B	2.09805E-04	1.41211E-03	-3.18000E+01	-1.19150E+01	4.92328E+04	-2.98106E-09	2
DLOT31A	2.09805E-04	1.41211E-03	-3.18000E+01	-1.19150E+01	4.92328E+04	-2.98106E-09	2
DLOT31B	2.09805E-04	1.41211E-03	-3.18000E+01	-1.19150E+01	4.92328E+04	-2.98106E-09	2
DLOT53A	2.09805E-04	1.41211E-03	-3.18000E+01	-1.19150E+01	4.92328E+04	-2.98106E-09	2
DLOT53B	2.09805E-04	1.41211E-03	-3.18000E+01	-1.19150E+01	4.92328E+04	-2.98106E-09	2
DLOT90A	2.09805E-04	1.41211E-03	-3.18000E+01	-1.19150E+01	4.92328E+04	-2.98106E-09	2
DLOT90B	2.09805E-04	1.41211E-03	-3.18000E+01	-1.19150E+01	4.92328E+04	-2.98106E-09	2

Signal Name	Coefficients						Type of Conv.
	C(1)	C(2)	C(3)	C(4)	C(5)	C(6)	
DSCRBY	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0
DNESBI	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0
DP28VRUA	0.00000E+00	1.60000E-01	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	1
DP5VMRUA	0.00000E+00	4.00000E-02	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	1
DP15VRUA	0.00000E+00	8.00000E-02	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	1
DN15VRUA	-2.04000E+01	8.00000E-02	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	1
DIPDUVMA	0.00000E+00	1.60000E-01	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	1
DIPDUIMA	0.00000E+00	2.00000E-02	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	1
DIICBIMA	0.00000E+00	4.00000E-03	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	1
DIPHBVMA	0.00000E+00	1.60000E-01	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	1
DIPHBIMA	0.00000E+00	2.00000E-02	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	1
DPR10VMA	0.00000E+00	1.60000E-01	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	1
DPR20VMA	0.00000E+00	1.60000E-01	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	1
D31MIVMA	0.00000E+00	8.00000E-02	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	1
D531PRTA	7.52052E+01	9.69722E-01	2.18727E-04	0.00000E+00	0.00000E+00	0.00000E+00	1
D901PRTA	7.52052E+01	9.69722E-01	2.18727E-04	0.00000E+00	0.00000E+00	0.00000E+00	1
DIPDUTHA	3.80965E+02	-2.72743E+00	4.18229E-02	-3.75715E-04	1.68846E-06	-2.98106E-09	1
DIPLMTHA	3.80965E+02	-2.72743E+00	4.18229E-02	-3.75715E-04	1.68846E-06	-2.98106E-09	1
DHPLMTHA	3.80965E+02	-2.72743E+00	4.18229E-02	-3.75715E-04	1.68846E-06	-2.98106E-09	1
DPRGTH1A	3.80965E+02	-2.72743E+00	4.18229E-02	-3.75715E-04	1.68846E-06	-2.98106E-09	1
DPRGTH2A	3.80965E+02	-2.72743E+00	4.18229E-02	-3.75715E-04	1.68846E-06	-2.98106E-09	1
DINTCTHA	3.80965E+02	-2.72743E+00	4.18229E-02	-3.75715E-04	1.68846E-06	-2.98106E-09	1
D53NSVMA	0.00000E+00	1.60000E-01	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	1
D90MIVMA	0.00000E+00	8.00000E-02	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	1
D90NSVMA	0.00000E+00	1.60000E-01	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	1
DDEP5VMA	0.00000E+00	4.00000E-02	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	1
D31TCM1A	0.00000E+00	1.60000E-01	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	1
D53TCM1A	0.00000E+00	1.60000E-01	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	1
D90TCM1A	0.00000E+00	1.60000E-01	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	1
DDEUTCMA	0.00000E+00	1.60000E-01	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	1
D31NSVMA	0.00000E+00	1.60000E-01	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	1
D53MIVMA	0.00000E+00	8.00000E-02	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	1
DP28VRUB	0.00000E+00	1.60000E-01	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	1
DP5VMRUB	0.00000E+00	4.00000E-02	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	1
DP15VRUB	0.00000E+00	8.00000E-02	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	1
DN15VRUB	-2.04000E+01	8.00000E-02	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	1
DIPDUVMB	0.00000E+00	1.60000E-01	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	1
DIPDUIMB	0.00000E+00	2.00000E-02	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	1
DIICBIMB	0.00000E+00	4.00000E-03	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	1
DIPHBVMB	0.00000E+00	1.60000E-01	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	1
DIPHBIMB	0.00000E+00	2.00000E-02	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	1
DPR10VMB	0.00000E+00	1.60000E-01	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	1
DPR20VMB	0.00000E+00	1.60000E-01	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	1

Signal Name	Coefficients						Type of Conv.
	C(1)	C(2)	C(3)	C(4)	C(5)	C(6)	
D31MIVMB	0.00000E+00	8.00000E-02	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	1
D531PRTB	7.52052E+01	9.69722E-01	2.18727E-04	0.00000E+00	0.00000E+00	0.00000E+00	1
D901PRTB	7.52052E+01	9.69722E-01	2.18727E-04	0.00000E+00	0.00000E+00	0.00000E+00	1
DIPDUTHB	3.80965E+02	-2.72743E+00	4.18229E-02	-3.75715E-04	1.68846E-06	-2.98106E-09	1
DIPLMTHB	3.80965E+02	-2.72743E+00	4.18229E-02	-3.75715E-04	1.68846E-06	-2.98106E-09	1
DHPLMTHB	3.80965E+02	-2.72743E+00	4.18229E-02	-3.75715E-04	1.68846E-06	-2.98106E-09	1
DPRGTH1B	3.80965E+02	-2.72743E+00	4.18229E-02	-3.75715E-04	1.68846E-06	-2.98106E-09	1
DPRGTH2B	3.80965E+02	-2.72743E+00	4.18229E-02	-3.75715E-04	1.68846E-06	-2.98106E-09	1
DINTCTHB	3.80965E+02	-2.72743E+00	4.18229E-02	-3.75715E-04	1.68846E-06	-2.98106E-09	1
D53NSVMB	0.00000E+00	1.60000E-01	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	1
D90MIVMB	0.00000E+00	8.00000E-02	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	1
D90NSVMB	0.00000E+00	1.60000E-01	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	1
DDEP5VMB	0.00000E+00	4.00000E-02	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	1
D31TCM2B	0.00000E+00	1.60000E-01	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	1
D53TCM2B	0.00000E+00	1.60000E-01	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	1
D90TCM2B	0.00000E+00	1.60000E-01	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	1
DDEUTCMB	0.00000E+00	1.60000E-01	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	1
D31NSVMB	0.00000E+00	1.60000E-01	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	1
D53MIVMB	0.00000E+00	8.00000E-02	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	1
DIPDUATH	3.80965E+02	-2.72743E+00	4.18229E-02	-3.75715E-04	1.68846E-06	-2.98106E-09	1
DIPDUBTH	3.80965E+02	-2.72743E+00	4.18229E-02	-3.75715E-04	1.68846E-06	-2.98106E-09	1
DDEUABTH	3.80965E+02	-2.72743E+00	4.18229E-02	-3.75715E-04	1.68846E-06	-2.98106E-09	1
DDEUBBTH	3.80965E+02	-2.72743E+00	4.18229E-02	-3.75715E-04	1.68846E-06	-2.98106E-09	1
DI8NSCA	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0
DRELA99A	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0
D31NSSTA	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0
D53NSSTA	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0
D90NSSTA	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0
D31NSSTB	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0
D53NSSTB	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0
D31SCBTH	3.80965E+02	-2.72743E+00	4.18229E-02	-3.75715E-04	1.68846E-06	-2.98106E-09	1
D90NSSTB	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0
D53SCBTH	3.80965E+02	-2.72743E+00	4.18229E-02	-3.75715E-04	1.68846E-06	-2.98106E-09	1
D90SCBTH	3.80965E+02	-2.72743E+00	4.18229E-02	-3.75715E-04	1.68846E-06	-2.98106E-09	1
DI8NSCB	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0
DRELA99B	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0
D31BOXSH	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0
D53BOXSH	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0
D90BOXSH	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0
DDEUABSH	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0
DDEUBBSH	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0
DIPDUBSH	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0
DBUSVOLT	0.00000E+00	2.00000E-02	4.18229E-02	-3.75715E-04	1.68846E-06	-2.98106E-09	1