Cosmic Background Explorer Guest Investigator Handbook

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1 OVERVIEW OF COBE

Since the discovery in 1964 of the Cosmic Microwave Background (CMB), interpreted as relic radiation from the Big Bang, scientists have tried to make accurate measurements of its spectrum and anisotropies. With the launch of COBE on November 18, 1989, major advances in our understanding of the very early universe have been achieved.

COBE was constructed and operated by the Goddard Space Flight Center. Essential to meeting the scientific objectives were an all-sky observing strategy, periodic absolute calibrations of the instruments, high sensitivity, and extensive care in the experimental design to minimize potential systematic errors.

COBE carried three scientific instruments to achieve its objectives: the Far Infrared Absolute Spectrophotometer (FIRAS), the Differential Microwave Radiometers (DMR), and the Diffuse Infrared Background Experiment (DIRBE). Both the FIRAS and the DIRBE were located inside a liquid helium cryostat that maintained a thermal environment of 1.5 K while the helium lasted. The DMR receivers were located around the outside of the cryostat.

The objective of the FIRAS was to measure the spectrum of the CMB over the wavelength range 0.1 to 10 mm, with an accuracy of 0.1% of the peak brightness. This instrument, a Michelson interferometer, had a spectral resolution of 0.2 cm^{-1} (6 GHz) and an angular resolution of 7 degrees. It measured small deviations in the shape of the CMB spectrum from that of a blackbody.

The DMR searched for spatial anisotropies at 31.5, 53, and 90 GHz using 2.6 degree pixels on the sky. These frequencies were selected to allow separation of the CMB signature from galactic synchrotron emission, free-free emission, and emission by interstellar dust in the data analysis process. There were two independent channels at each frequency.

The DIRBE was designed to search for the cosmic infrared background resulting from the cumulative emissions of the first galaxies and stars. The DIRBE objectives were to discern and measure the spectrum and angular distribution of this diffuse infrared background radiation to a sensitivity of 10^{-13} W cm^{-2} sr^{-1}, or 1% of the total background, whichever is greater, in 10 photometric bands from 1 to 300 micrometers. The instrument had a field of view of 0.7 degrees. DIRBE also measured linear polarization in the 1 to 3 micrometer channels to help distinguish astronomical foregrounds from the extragalactic components of the measured intensities.

COBE was launched into a 99 degree inclination, 900 km altitude circular orbit with a 6 PM ascending node. With this orientation, the spin axis of the satellite was always pointed away from the Earth and about 94 degrees away from the Sun. The orbital period was approximately 103 minutes. The satellite rotated at 0.8 rpm. This rotation helped reduce potential systematic errors in the DMR and provided DIRBE a range of solar elongation angles from which to view scattering and emission from interplanetary dust.

The cryostat cover was ejected three days after the COBE launch, and all three instruments began obtaining sky data. During the first month in orbit, various spacecraft maneuvers were undertaken to test the performance of the instruments and spacecraft, and to optimize instrument parameters. During this entire period the instruments were obtaining high quality data. All three instruments had completed their full sky coverage by mid-June 1990 and continued with a second survey.

On September 21, 1990, the 600 liters of liquid helium were depleted, ending over 10 months of cryogenic operation for FIRAS and DIRBE. After helium depletion, the FIRAS was turned off, since this instrument required operating at liquid helium temperatures; it had surveyed the sky 1.6 times. The DMR continued to operate normally in all of its six channels until the data taking was ended in December 1993. Two years after launch, the noise levels in the resulting sky maps were steadily decreasing, showing that the sensitivity limits of this instrument had not been reached. Following helium depletion, the four short wavelength bands of DIRBE continue working remarkably well, but the DIRBE long wavelength bands were turned off because of the diminished data quality at elevated temperatures. This continuation of data taking by these two instruments is expected to be important in further understanding any systematic errors and for complete closure on the sky as the Earth completes its annual cycle around the Sun. In particular, the interplanetary cloud in which we reside must be understood well enough to model and remove it from the data in order to search for a cosmic infrared background.

COBE has obtained several major cosmological results. FIRAS confirmed the Big Bang model's prediction that the CMB would have a thermal spectrum. Data analyzed by January 1993 showed no deviation from a perfect blackbody spectrum to 0.03% of the peak intensity. The temperature of the universe was found to be 2.726 ± 0.010 K, and it was found to be almost equally bright in all directions. The FIRAS instrument has also made the first all-sky infrared spectral line survey, in addition to mapping the spectra of the galactic dust distribution at wavelengths greater than 100 micrometers. Nine lines from interstellar [C I], [C II], [N II], and CO have all been clearly detected, and [C II] at 158 micrometers and [N II] at 205.3 micrometers have sufficient intensity to be mapped. These global data help us to understand the heating and cooling mechanisms in our galaxy.

The DMR experiment has obtained the most precise maps of the CMB anisotropy ever made. The observed anisotropy in CMB brightness on angular scales of about 10 degrees is of order $\Delta T/T \sim 10^{-5}$. This result supports standard dark matter scenarios of structure formation and inflation in the early universe, although the ruling out of more complex theories will have to await experiments with smaller angular resolution.

COBE has also obtained with DIRBE the most extensive infrared absolute sky brightness measurements and maps ever made, providing spectacular new views of the Milky Way Galaxy and permitting the search for cumulative light from the first objects in the universe. Spectra indicate that the faintest levels of emissions from our solar system and galaxy occur at wavelengths of 3.4, 140, and 240 micrometers. Careful modelling of these foreground emissions are now in progress, and the detection of the infrared cosmological background, or stringent limits, will be obtained.

2 INTRODUCTION TO THE COBE GUEST INVESTIGATOR (GI) PROGRAM

The data analysis facilities for the Cosmic Background Explorer (COBE) guest investigator program are located at the COBE Guest Investigator Facility (CGIF) at the NASA/Goddard Space Flight Center in Greenbelt, Maryland. Many of the principal investigators, deputy principal investigators, and Science Working Group members are resident at Goddard, which also houses a technical library. Most of the science support staff are located at the Cosmology Data Analysis Center (CDAC), one mile from Goddard.

Upon arrival at the CGIF, the guest investigator will work with a support scientist, who will be familiar with the guest's proposal and will be available during the guest's visits to help with technical information. Table 2-1 gives the names, phone numbers, and addresses of the guest investigator support staff.

Table 2-1. COBE Guest Investigator Support Staff

For...	Name	Location	Phone
User Support	Dave Leisawitz	GSFC 26/140A	286-0807
CGIF SPOC	Jeffrey Newmark	CDAC 120	513-7788
DIRBE Data Information	Janet Weiland	CDAC 150	513-7809
DMR Data Information	Chuck Bennett	GSFC 21/158	286-3902
FIRAS Data Information	Joel Gales	CDAC 120	513-7763
Systems Management	Jon Stokes	CDAC 135	513-7804
Documentation	Gayle Rawley	CDAC 120	513-7764

CONVENTIONS USED IN THIS HANDBOOK

There are several typographical conventions used in this document:

* The RETURN or ENTER key is indicated by <CR>.

* The left, center, and right workstation mouse buttons are <MB1>, <MB2>, and <MB3>, respectively, unless otherwise defined by the user.

* The CONTROL key is shown by a carat: ^. The user must keep the control key depressed while typing the following key stroke.

* The names of **software menu items** and **file names** are in bolded fixed-width (typewriter) font.

* Examples show the **computer display** in bolded fixed-width font, with literal USER'S ENTRIES in standard fixed-width font for clarity. User entries that are not meant to be taken as literal input, such as *username*, are shown in an italicized proportional-width font. Note that although the user's entries are usually shown in upper case letters, VMS is *not* case-sensitive; capital letters are used for better readability. Users are warned in the text where letter case is an issue (*i.e.*, UNIX and IRAF). For example, in the command line

  Local> C *node_name*

  the **Local>** prompt is put on the screen by the computer. The user enters C and a specific node name (ZWICKY, for instance).

* In the examples, we will show the system level prompts as follows:

  $ VMS
  % ULTRIX

3 DATA PROCESSING FACILITIES FOR GUEST USE

This chapter describes the data processing facilities available to guest investigators. Availability and accessibility of software packages is discussed in Chapter 6.

3.1 THE ULTRIX AND VAX/VMS WORKSTATIONS

The node name of the DECstation 5000/200 ULTRIX workstation is CUBA, and the node name of the VAXstation 4000/60 VMS workstation is ZWICKY; they are both located in the COBE Guest Investigator Facility (CGIF), Building 21, Room C129 at the Goddard Space Flight Center. The VMS workstation is a high-resolution, full-color display terminal capable of supporting imaging as well as basic plotting functions. It has 1280 × 1024 pixel resolution and supports 8-bit color. Because the workstation is running under Motif, the largest IDL display window is 1258 × 978. The ULTRIX workstation has the same imaging capability and resolution as the VAXstation, but it has 24-bit color instead of 8.

Working at the workstation consoles requires some familiarity with the DECwindows system running Motif, but for those users who are inexperienced, online help menus are found at the right of almost every menu line. A few general notes on using the mouse with the windows are listed below.

* The default labels for the mouse buttons are 1 through 3 from left to right and are commonly expressed as `<MB1>`, `<MB2>`, and `<MB3>` in help screens and the *CGIS Software User's Guide*.

* *Clicking* means pushing down a mouse button (usually the left one) and releasing it (unless otherwise instructed).

* *Double-clicking* means clicking twice in rapid succession.

* *Dragging* is accomplished by pressing and holding the mouse button down while moving the mouse pointer to the desired location.

* The menu line is the line in the window just below the title. Menu choices may be seen by pressing and holding the mouse button on the menu item. To make a selection, drag the pointer down until a box appears around the desired selection,

then release the button. If none of the selections are to be chosen, simply moving the pointer out of the menu allows a safe exit.

* The right hand side of most windows features a scroll bar with an up arrow above and a down arrow below. These control what text is seen in the window. To see previous items that have scrolled up out of the window, click on the fat part of the bar and drag it up a little. Release the button and the text will update. Clicking on the arrows lets you move up and down one line at a time.

To begin your session, enter your username and password. After a short while, a small window labeled **Session Manager** appears on the screen (see figure 3-1). A DECterm window should appear shortly after, displaying some login messages and then the system prompt (see figure 3-2). If it does not, start up a DECterm window by clicking on the **Application** menu in the **Session Manager** window and selecting **DECterm**.

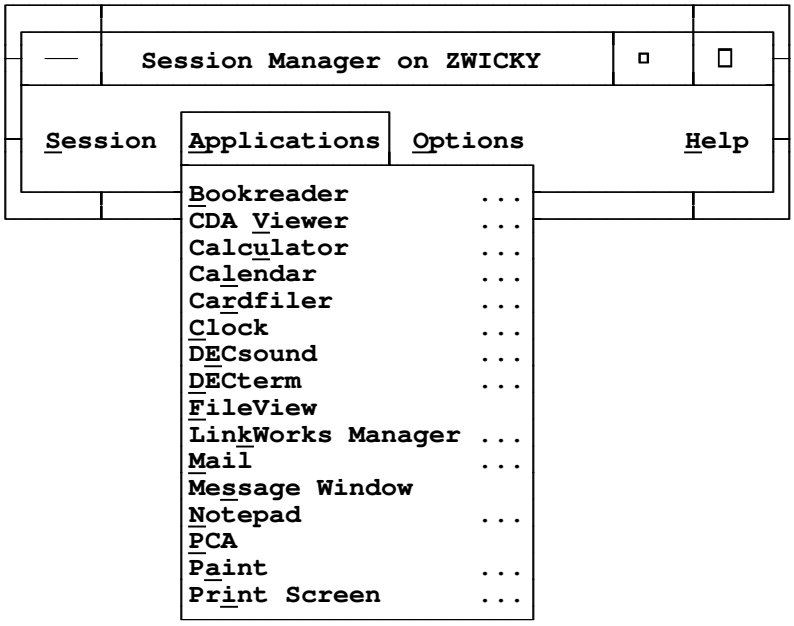


Figure 3-1. A VAX **Session Manager** window with **Applications** menu selected.

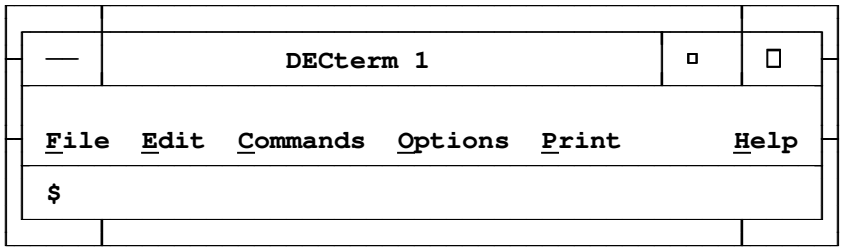


Figure 3-2. A typical DECterm window with **$** DCL prompt.

At this point in a session, the DECterm window behaves just like an ordinary terminal on the machine. When a session is complete, the standard logout (`LO` on VMS and `logout` on ULTRIX) will close and remove the DECterm window. Choosing **Quit** from the **Session** menu of the **Session Manager** ends the workstation session completely.

The default font for DECterm windows is a small font that some users may find difficult to read. To change the window font to a larger font, choose **Options** from the VMS DECterm menu line or **Customize** from the ULTRIX DECterm menu line. Now choose **Window...** and click on the button next to **Big font**. Click on **Apply** to see if the result is suitable; if so, click on **OK**. To make this font size the default for all subsequent VMS DECterms, choose **Options** again from the VMS DECterm menu and now select **Save options**. To make this font size the default for all subsequent ULTRIX DECterms, choose **Customize** again from the ULTRIX DECterm menu and now select **Save Current Settings**.

3.1.1 Automatic Start-up and Saving the Session Options

3.1.1.1 On the VMS Workstation

To have a DECterm or anything else (*e.g.*, a clock or calendar) brought up automatically at the beginning of a VMS session, first choose **Options** from the DECterm menu line. Now select **Automatic Startup...** from the VAX **Session Manager**. Click on the items in the left list that you would like to have started at the beginning of each session. When you have finished your selections, click on the **OK** box.

Once you have selected the applications, choose **Options** from the **Session Manager**. Select **Save Session Manager**. The next time that you begin a session, these applications will be started automatically.

3.1.1.2 On the ULTRIX Workstation

To have a DECterm or anything else (*e.g.*, a clock or calendar) brought up automatically at the beginning of a ULTRIX session, first choose **Customize** from the ULTRIX DECterm menu. Now select **Autostart** from the pull-down menu. Click on the items in the left box that you would like to have started at the beginning of each session, then click on **OK**.

To keep these settings for future sessions, choose **Customize** from the DECterm menu line. Then select **Save Current Settings**. The next time that you begin a session, these applications will be started automatically.

3.1.2 Printing the Screen

3.1.2.1 On the VMS Workstation

It is possible to capture a portion of the workstation screen for printing. To do this on ZWICKY, click on the **Applications** option on the **Session Manager** window. From this menu, choose the **Print Screen...** option. Soon a **Print Screen** window will appear. Then choose the appropriate options. Change most options by pressing <MB1> on the diamonds to the left of the option. An option is set when the diamond is darkened. Be sure that **PostScript** is marked under the **Output Type**. Give the output file a name by first clicking in the box labeled **Output File Name** and then typing in a file name.

Once all of the options have been set, click on **Print Screen** in the **Print Screen** window menu. **Print Portion of Screen**, **Print Entire Screen**, **Capture Portion of Screen**, and **Capture Entire Screen** are available. Because of the current configuration of the printers, you must use one of the *capture* options.

To write the entire screen to a file, click on **Capture Entire Screen**, and the screen will be written into the specified PostScript file. To get only a portion of the screen, click on **Capture Portion of Screen**. The workstation pointer turns into a large red plus (+) sign. Move the marker to one corner of the region to be captured. Press and hold down <MB1>, drag the mouse to stretch the box around the entire region, and then release <MB1>. The region inside the box will be written to the previously specified file name. (This may take a few minutes.)

To close the **Print Screen** window, click on **File** in the window menu and then choose **Exit**. Send your file to the appropriate printer (see section 3.3 for print queues).

3.1.2.2 On the ULTRIX Workstation

To print the entire screen or a portion of it on CUBA, first click on the **Customize** option on the **Session Manager** window. From this menu, choose the **Print Screen...** option. A **Customize Print Screen** window appears, and in it there are several options to mark appropriately. Change most options by pressing <MB1> on the squares to the left of the options. An option is set when the square is darkened. Be sure that **PostScript** is marked under the **Output Format**. Give the output file a name by first clicking in the box labeled **Output File Name** and then typing in a file name. Once all of the options have been set, click on the **OK** button in the window.

To print the screen or a portion of it, click on the **Print Screen** option on the **Session Manager** menu line. **Print Portion of Screen**, **Print Entire Screen**, **Capture Portion of Screen**, and **Capture Entire Screen** are available.

To print the entire screen, click on **Print Entire Screen**. A **Queue Options** window appears. Check and mark all of the options, including choosing a printer in the **Printer** box (see section 3.3 for print queues). When you are finished, click on **OK,** and the screen will be sent to the specified printer and to the file specified in the **Queue Options** box.

To print a portion of the screen to a file, click on **Print Portion of Screen**. The workstation pointer turns into a large red plus (+) sign. Move the marker to one corner of the region to be captured. Press and hold down <MB1>, drag the mouse to stretch the box around the entire region, and then release <MB1>. The region inside the box will be sent to the previously specified printer. (This may take a few minutes.)

Capturing all of the screen to a file is similar to printing all of the screen, except that you are also presented with a **Screen Dump Destination** window in which you may change the name of the file in which the screen capture is stored. Capturing a portion of the screen is similar to printing a portion of the screen, but the **Screen Dump Destination** window appears before the screen region to be printed is selected.

3.2 MACINTOSH

One Macintosh Centris 650 is available for guest investigator use and is also located at the CGIF. Manuals for many of the applications are kept on the desk to the left of the Mac keyboard. We ask that you do NOT remove any of this documentation from the CGIF area, as we cannot replace it.

We assume here that you are familiar with Macintoshes, so here we define only some of the terms we shall be using later:

* *Clicking* means pushing down the mouse button and releasing it.

* *Double-clicking* means clicking twice in rapid succession.

* *Dragging* is accomplished by pressing and holding the mouse button down while moving the mouse pointer to the desired location.

* The menu line is the line at the top of the window just below the title. Menu choices may be seen by pressing and holding the mouse button on the menu item. To make a selection, drag the pointer down until the desired selection is highlighted, then release the button. If none of the selections are to be chosen, simply move the pointer out of the menu.

* The right hand side of most windows features a scroll box with an up arrow above and a down arrow below. These control what text is seen in the window. To see previous items that have scrolled off of the window, click on the box and drag it up a little. Release the button and the text will update. Clicking on the arrows lets you move up and down one line at a time.

Using MacX

The `MacX` software package has been installed on the guest machine, allowing you to use the Mac as an X Window display. At this time, only service to the CUBA (ULTRIX) workstation (or other UNIX-type workstation) is operational.

To start the package, double-click on the icon for the hard disk in the upper right corner of the desktop. Open the **`MacX Application`** folder. Double-click on **`MacX`**. When `MacX` is

running, you will see that the choices in the top menu line have changed. Go to the **Remote** menu and choose **New Command**.

The resulting **New Remote Command** window has several boxes for you to complete. Start with **Remote Command** by clicking in the box. Enter the following command:

```
/usr/bin/X11/xterm -ls -title "®host xterm" -sb -display "®display"
```

You can make the ® symbol by holding down the OPTION key and pressing the letter `r`.

Fill in the rest of the boxes as indicated below:

Command Name	any name by which to identify your session
Display	**(0) Color Rootless** (The box is really a menu.)
Output	**Save**
Username	your username on CUBA
Password	your password on CUBA
Execute at Startup	click in the box; an `X` will appear there

Click on **Host**; this will open a whole new window. Choose **MacTCP Tool** from the **Method** menu. Enter `cuba.gsfc.nasa.gov` (or desired node name) in the **Host Name** box. Press <CR>, which will close the **Host** window and return you to the **New Remote Command** window.

Finally, click on **Execute**. If everything is working correctly, an `xterm` window will appear, with a prompt indicating that you are already logged onto the host computer.

When you have completed your session, log out of the host computer. If you have just completed your first `MacX` session, you will probably want to save your session setup for future use. To do this, go to the **File** menu and choose **Save As**. Enter a name for your setup file; it will appear in the **MacX Application** folder. Then click on **Save**. Choose **Quit** to close the application.

The next time you want to start a `MacX` session to the same computer, just double-click on your entry, not on the `MacX` icon. You will be prompted for your password on the remote host. Once that is entered, click on **OK**, and your session should start automatically.

In general, X Window terminals make use of a three-button mouse, rather than a one-button Macintosh mouse. Mappings between the X system and the Macintosh are as follows:

X terminal	Macintosh equivalent
<MB1>	mouse button
<MB2>	left arrow
<MB3>	right arrow
CONTROL	clover key
META	up arrow
arrow keys	hold down OPTION key and press arrow keys

You can find more detailed information in the *Apple MacX* binder near the machine; see especially the *User's Guide*, *Chapter 2: Getting Started*.

3.3 PRINTING AT THE CGIF

The CGIF laser printer is an HP LaserJet 4M, located near the main door to Room C129. It handles both ASCII and PostScript formats. Print files from the workstations using the commands

```
$ PRINT/QUEUE=CGIF$LASER filename          (VMS)
```

and

```
% lpr -Pcgiflaser filename                 (ULTRIX)
```

Color PostScript files may be printed on the Tektronix Phaser IISD in the International Ultraviolet Explorer (IUE) Regional Data Analysis Facility (RDAF) in Room G33 of Building 21. The corresponding print commands are

```
$ PRINT/QUEUE=TEKSD filename               (VMS)
```

and

```
% lpr -Pstars_teksd filename               (ULTRIX)
```

We offer several notes on color printing:

* Tektronix prints are expensive; please use them sparingly.

* You should check that the printer is loaded with the correct paper tray *before* sending your file.

Examine the print queues with the commands

```
$ SHOW QUEUE/ALL queue_name          (VMS)
```

and

```
% lpq -Pqueue_name                   (ULTRIX)
```

Removing a job from a print queue requires the job entry number, displayed by the command

```
$ SHOW QUEUE queue_name              (VMS)
```

or

```
% lpq -Pqueue_name                   (ULTRIX)
```

Print jobs may then be deleted with

```
$ DELETE/ENTRY=entry_number          (VMS)
```

or

```
% lprm -Pqueue_name job_number       (ULTRIX) (This may not be working yet.)
```

To set up printing from the Macintosh, go into the apple menu in the left corner and choose **Chooser**. A Chooser window appears. Click on **Laserjet 4M** in the panel in the upper left. Click on **!Goddard Backbone** from the list in the lower left. Click on **LASP Laserjet 4Si** from the list on the right, then click on **OK**. This printer is located in Room G33, next to the Tektronix color printer.

3.4 OFFLINE DATA INPUT/OUTPUT

The table below gives a quick summary of the external devices available on each machine. Explicit direction on using these drives are given in the following sections.

CUBA	CD ROM, 4mm tape, 3 1/2" floppy
ZWICKY	4mm tape
MAC	CD ROM, 3 1/2" floppy

The following list gives product sizes for those users planning to copy software or data:

Product	Approximate size(Mb)
UIMAGE/UIDL software	1
DIRBE, 10 photometry channels, ±10° galactic latitude	6
DMR, 1 channel, all-sky	0.3
FIRAS, Left High Fast scan mode, ±15° galactic latitude	3

3.4.1 Floppy Disks

The ULTRIX workstation CUBA is equipped with a 3 1/2" disk drive that uses 1.44 Mb PC floppies. Access to this disk drive is currently limited to superusers.

The Macintosh uses 3 1/2" floppies (double sided, high density) which have 1.44 Mb capacity. Note that the 3 1/2" Macintosh disks may NOT be used in CUBA.

3.4.2 Tape Drives

Both the VMS workstation ZWICKY and the ULTRIX workstation CUBA are equipped with 4mm tape drives. Some fundamental operations are discussed in the following sections.

3.4.2.1 On the VMS Workstation

VMS 4mm tapes may be one of two kinds: a *backup* tape or a *copy*. The use of backup tapes only is described here.

Listing Contents of a Backup Tape

To begin, insert the tape into the ZWICKY tape drive. (An arrow on the top side of the tape indicates which way to insert the tape.) Now type

```
$ MOUNT/FOREIGN ZWICKY$MKA500:
```

to mount the tape onto ZWICKY's tape drive whose device name is **ZWICKY$MKA500:**. If all goes well, you should see this message with the tape's label name in place of *labelname*:

```
%MOUNT-I-MOUNTED, LABELNAME mounted on _ZWICKY$MKA500:
```

To list everything that is currently on the tape, type

```
$ BACKUP/LIST/REWIND ZWICKY$MKA500:
```

This will list all of the files on the tape. (The **/REWIND** qualifier assures that the tape is rewound before the contents are listed.)

Creating a Backup Tape

To create a backup tape, begin by inserting the tape into the tape drive. (An arrow on the top side of the tape indicates which way to insert the tape.) Now type

```
$ INITIALIZE ZWICKY$MKA500: labelname
```

and type in a label for your tape which can be up to 6 characters long. Now mount the tape:

```
$ MOUNT/FOREIGN ZWICKY$MKA500:
```

To back up user Smith's entire account on ZWICKY, enter

```
$ BACKUP/LOG ZWICKY$DKA400:[SMITH...]*.*;*
_To:    ZWICKY$MKA500:saveset_name/LABEL=labelname
```

where *labelname* is the same labelname that was specified at the initialization step, *saveset_name* is the name of the backup save set, and **ZWICKY$DKA400:** is the device name for the disk serving all guest users on ZWICKY. The **/LOG** qualifier causes the filenames to be displayed as they are being written to the tape.

It may be handy to have a list of the contents of your tape to serve as a printed record. To write such a list to a file, execute this command:

```
$ BACKUP/LIST=filename/REWIND ZWICKY$MKA500:
```

If you do not specify an extension for the filename, *i.e.*, **.TXT** or **.DAT**, the extension will be **.LIS**.

To copy specific files from the tape to the disk, use the command

```
$ BACKUP/LOG/REWIND ZWICKY$MKA500:/SELECT=filename ZWICKY$DKA400:[dirname]
```

Dismounting a Tape

To dismount a 4mm tape from ZWICKY, type

```
$ DISMOUNT/NOUNLOAD ZWICKY$MKA500:
```

Omit the **/NOUNLOAD** qualifier if you would like the tape to be ejected. If you use the plain DISMOUNT command, the tape will be ejected automatically after a short pause.

3.4.2.2 On the ULTRIX Workstation

To read or write to a 4mm tape on CUBA, first insert the tape into the drive labeled **/dev/rmt0** in the direction indicated by the arrows on the top of the tape. Because the system default device is defined to be the device on CUBA, it will not be specified in the following command examples. The tape drive writes at high density by default.

To produce a listing of the files on the tape, use the command

```
% tar tv
```

To save a file onto the end of the tape, type

```
% tar rv filename
```

To produce a listing of tar options, type

```
% tar H
```

To create a new archive at the beginning of a tape, use

```
% tar cv filename_to_read
```

To extract a file from the tape and place it in the current directory, use the command

```
% tar xv filename_on_tape
```

Push the button to the right of the tape drive to eject the tape.

These are only a few of many functions available with the `tar` command. To view a complete list of the command's options, type `man tar` at the UNIX prompt to access the help file.

3.4.3 CD ROMs

Much computer system information and many astronomical databases are now available on CD ROM (compact disc, read only memory). CD ROM players are attached to both the CUBA DECstation and the Macintosh.

WARNING

Before loading a CD ROM into *ANY* machine, it *MUST* be placed into a caddy. Caddies are generally kept in or near the CD drive; contact a systems management staff member if a caddy is missing.

3.4.3.1 On the ULTRIX Workstation

The CD ROM player on CUBA is an RRD42 drive. The caddy for this type is opened by pressing the corner tabs as indicated on the caddy and lifting the lid. Insert the CD ROM with the label facing up, then close the caddy lid. Press the corners firmly.

Pushing the loaded caddy into the drive loads the CD.

Once the CD ROM is physically loaded, it must be mounted on the system:

```
% mountcd          (UNIX file systems)
```

You should get a message back saying that the CD has been mounted on directory **`/cdrom`**; if you do not, try the following command:

```
% mnt9660cd        (all other ISO 9660 format)
```

Once the CD is mounted, you can treat it like any other read-only directory.

> **Note:** If the files on the CD are in VMS format, *e.g.*, **`README.TXT;1`**, you will need to use single quotes around the file name:
>
> ```
> % cp 'README.TXT;1' cuba_c/giusers/your_dir/readme.txt
> ```

When you have finished, you must dismount the CD, first making sure that your working directory isn't pointing to the disk:

```
% unmountcd
```

BEFORE EJECTING THE CADDY, THE DISC MUST BE DISMOUNTED.

The CD is unloaded by pushing the disc eject button on the right side of the player, just below the disc slot.

3.4.3.2 On the Macintosh

The CD caddy for the Macintosh is usually stored in the overhead shelf to the left of the Mac keyboard and display. (The manuals for the CD ROM drive are also kept here.)

Begin by inserting your CD into the caddy. **DO NOT INSERT THE CD DIRECTLY INTO THE DRIVE!** To open the caddy, press in the corner tabs as indicated on the caddy and lift the lid. Insert the CD ROM with the label facing up, then close the caddy lid. Press the corners firmly.

Insert the caddy into the built-in drive in the unit to the right of the keyboard. After a few seconds, an icon with the name of your CD will appear below the icon of the hard disk in the upper right corner of the desktop.

You access files on the CD as you would files on the hard drive.

To retrieve your CD when you have finished, drag the icon of the CD into the **Trash** icon. (This sounds terrible, but really will not harm your CD.) The caddy will automatically eject.

3.5 DATA AND SOFTWARE AVAILABLE THROUGH NSSDC

The National Space Science Data Center (NSSDC) provides access to many data sets that may be of interest to COBE guest investigators, including COBE data. These are disseminated through the NODIS (NSSDC's On-line Data Information Services) account, accessed from the guest investigator machines with a SPAN address of NSSDCA (node number 15.188 or integer 15548) or Internet address NSSDCA.GSFC.NASA.GOV (node number 128.183.36.23). The user name for the account is NODIS; there is no password.

Six service categories are available through NODIS:

* Multi-disciplinary, including NSSDC online data (COBE and others), the Master Directory (describes and sets up links to remote data systems), CD ROMs available from NSSDC, requests for offline data, and the NSSDC Newsletter

* Astrophysics, including the Astronomical Data Center catalogs and FITS

* Space Physics, including the Space Physics Data System, Geophysical Models, and Near-Earth Heliosphere data (OMNI)

* Planetary sciences

* Earth sciences

* Life sciences/microgravity

3.6 ASTRONOMICAL DATABASES AT THE CGIF

A subset of the COBE Project Data Sets is available locally on both the CUBA and ZWICKY workstations. On ZWICKY (VMS), the data are stored in the **ADBDISK:[PDS_FITS]** directory; the logical **CGIS_FITS** points to the same area. On CUBA (ULTRIX), the data are

stored in the **/cuba_b/cgis/data/pds_fits** directory, which can also be accessed by the logical **$CGIS_FITS**.

Additional astronomical databases (ADBs) are available at the CGIF on ZWICKY. The main directory is **ADBDISK:[ADB]**; this and all subdirectories contain files called **AAA_README.TXT** that explain the directory contents. Two subdirectories are of particular interest to guest investigators:

* **ARCHIVE** contains external data sets that have been converted to COBE skymap form.

* **RAW** contains the external data sets in their native formats.

The contents of the ADB directories as of May 18, 1994 are given in the table below; an online version of the list is found in the file **ADBDISK:[ADB.RAW]AAA_DIR.LIS.**

Subdirectory in ADBDISK:[ADB.RAW]	Astronomical Database
3CR	3rd Cambridge Revised Catalog
4C	4th Cambridge Catalog
ABELL_ZWICKY	Abell and Zwicky catalogs of clusters of galaxies
AFGL	Air Force Geophysics Lab Infrared Sky Survey
BRIGHT_STARS	Yale-SAO Bright Star Catalog
CLAS	Combined List of Astronomical Sources
CO_CLEMENS	Massachusetts-Stony Brook CO survey of the first galactic quadrant.
CONDON1400MHZ	Condon-Broderick 1400 MHz Sky Survey
CONDON_4850MHZ	Condon, Broderick, Seielstad 4.85 GHz Sky Survey
COSB	COS-B FITS map
DEARBORN	Dearborn Observatory catalog of faint red stars
DIRBE_TIP	DIRBE Test Initial Product
DMR_TIP	DMR Test Initial Product
FIRAS_TIP	FIRAS Test Initial Product
GEZARI	Gezari “Catalog of Infrared Observations”
GREENBANK_87GB *	Greenbank “87GB” 4.85 GHz Source List
GREEN_SNR	Green Supernova Remnant list
HASLAM408MHZ *	Haslam 408 MHz Sky Survey
HAYNES5GHZ	Parkes 5 GHz maps (Haynes, *et al.*)

HCO_CFA_REDSHIFT	Center for Astrophysics Redshift Catalogs
HEILES_HABING_H1	Heiles and Habing HI (21cm) Sky Survey
IRAS_ALLSKY	IRAS All-sky maps
IRAS_2JY_Z	IRAS 2 Jansky redshift survey
IRAS_GAL_CTS	IRAS Galaxy Counts
IRAS_PS	IRAS Point Source Catalog
IRAS_SMALL_SCALE_STR	IRAS Small Scale Structure Catalog
IRAS_SSF_12	IRAS Super Sky Flux plates at 12 micrometers
IRAS_SSF_25	IRAS Super Sky Flux plates at 25 micrometers
IRAS_SSF_60	IRAS Super Sky Flux plates at 60 micrometers
IRAS_SSF_100	IRAS Super Sky Flux plates at 100 micrometers
IR_CROSS_INDEX	"Infrared Source Cross-Index" by Schmitz
KUEHR5GHZ_STRONG_SOURCE	5 GHz Strong Sources by Kuehr, *et al.*
LOCKMAN_H1 *	Lockman HI data
LUBIN_SMOOT_90GHZ	Berkeley 90 GHz balloon survey
MERCG	Merged Catalog of Galaxies, including IC, UGC, de Vaucoulers, MCG, Zwicky
NEUGEBAUER_TMSS	The Neugebauer Two Micron Sky Survey
PARKES_H1_UMD	Parkes HI line survey from Kerr, *et al.*, U. of Maryland
PARKES_CAT90	The Parkes Catalog of Radio Sources, version 1.01
PRINCETON_25GHZ	Princeton 25 GHz balloon survey
REDDENING	Burnstein-Heiles reddening maps
REICH1420MHZ *	Reich and Reich 1420 MHz Sky Survey
RESTRICTED_MIT_PRINCETON_19GHZ	MIT-Princeton 19 GHz balloon survey
RICH_GAL_CLUSTERS	Abell Catalog of rich clusters of galaxies
SAS2	SAS2 catalog of galaxies, pulsars, and other sources
SHAP_AMES	Revised Shapley-Ames catalog of bright galaxies
SHARPLESS_H2 *	Sharpless HII Source List
STARK_HI	Bell Labs/Stark HI sky survey
UGC	Uppsala General Catalog (included in MerCG)
WEAVER_WILLIAMS_H1_UMD *	Weaver and Williams HI Line Survey from University of Maryland tape -- has even 1 km/sec grid
WEAVER_WILLIAMS_H1_ADC *	Weaver and Williams HI Line Survey from Astronomical Data Center (ADC)

WHITE_BECKER_1400MHZ_NORTH	1.4 GHz Northern Sky Catalog of White and Becker
WISC_SOFT_X	Wisconsin soft x-ray data and maps
ZIP	Zodiacal Infrared Project data base

* Available in COBE skymap form

4 COMPUTER ACCESS

Guest users are given an account on the GI computer of their choice (see chapter 3 for available platforms). The account comes equipped with an appropriate login file (*e.g.*, **LOGIN.COM** file on the VMS workstation), which the user may further customize.

4.1 USING X WINDOWS FROM A REMOTE SITE

You may access the GI workstation remotely using DECnet or Telnet. Running image processing software (*e.g.*, UIMAGE) from your remote workstation requires the several additional steps given below. (Image processing over a modem line is extremely slow and not recommended.)

Before logging in to the guest investigator machine, you must set up your local session to allow it to be used as a remote X Window display. Exactly how you do this depends upon the platform you are using.

* From a VAXstation, choose **Options** from the **Session Manager** window menu, then choose **Security...**. Enter the full node name of the GI machine, *e.g.*., ZWICKY.GSFC.NASA.GOV. It is usually sufficient to enter * for the username. Enter DECNET or TCPIP as appropriate for transport. Then click on **Add**. The new entry should appear under **Authorized Users**. Click on **OK** when you have finished.

* From a DECstation, choose **Customize** from the **Session Manager** window menu, then choose **Security...**. If the remote node you are trying to reach is not on the **Authorized Hosts** list, click in the blank **Host Name** box and enter the full node name. Then click on **Add**; the authorized list should now contain the new node. Click on **OK** when you have finished.

* From a Sun or other X Window workstation running under UNIX, you should enter the following command at your local system prompt:

```
% xhost +gi_node_address
```

e.g.,

```
% xhost +zwicky.gsfc.nasa.gov
```

Now log into the guest investigator workstation of your choice. Before invoking any imaging software, type

```
$ SET DISPLAY/CREATE/NODE=your_full_home_node_address/TRANSPORT=xxx          (VMS)
```

where *xxx* is DECNET (if you connected using a SET HOST) or TCPIP (if you connected using TELNET), or

```
% setenv DISPLAY your_full_home_node_address:0.0                            (ULTRIX)
```

Now your local X Windows terminal should behave like the workstation console.

Note to ULTRIX users: Certain software packages check more than the **DISPLAY** environment variable to identify the terminal type. IDL, for example, uses the **IDL_DEVICE** variable (set it to x), while AIPS uses **TERM** (use xterm).

4.2 COMMUNICATIONS

4.2.1 Modem

The VMS and ULTRIX machines are accessible by dial-in modem at both 2400 [(301)286-9000] and 9600 baud [(301)286-4000]. The 2400 baud modem lines also support 1200 baud communications. The standard parameters are 8 bits, no parity, and 1 stop bit.

Once you are connected, you will see the following prompt, which you should answer as shown:

```
ENTER NUMBER: LASP
```

You should then see

```
CALLING 59721        (or some other number)

CALL COMPLETE
```

Respond by typing <CR><CR>. You should now get several lines of terminal server messages, followed by a prompt. Respond as shown:

```
Local> C CGIS                    (to connect to ZWICKY)
```

or

```
Local> telnet cuba               (to connect to CUBA)
```

When you have logged out of your host session, you will be returned to the server:

```
Local> LO
```

and then break your modem connection.

4.2.2 DECnet

4.2.2.1 To and from the VMS Workstation

To access another machine on DECnet from the VMS workstation, type

```
$ SET HOST node_name
```

For example, to reach the On-Line Data Information Services node at the National Space Science Data Center, type

```
$ SET HOST NSSDCA
```

If our system does not recognize the node name, you may have to provide the integer node address instead. This is typically a 4 or 5 digit number, and is used in place of the node name, as in this example for an alternate way of reaching NSSDC:

```
$ SET HOST 15548
```

Some tables of addresses provide a decimal number, such as 15.188 for NSSDCA above, instead of an integer. You compute the integer value by multiplying the units digit by 1024 and then adding the number after the decimal point. Thus, 6.29 becomes 6 × 1024 + 29 = 6173.

Your DECnet session is ended and control is returned to your original session when you log out of your remote session.

If your system does not recognize the ZWICKY node name, the DECnet numbers are 15.851 and 16211.

4.2.2.2 From the ULTRIX Workstation

The DECstation may be used to access remote nodes via DECnet using the dlogin command. At the ULTRIX system prompt, type

```
% dlogin node_name_or_number
```

On this system, the node number may be either the integer or the decimal form of the address.

You can access a local command shell by typing ~<CR>. This shell allows you to log your session to a file, suspend it, *etc.*, as explained in its internal help. To exit the local shell, type <CR> alone. As with the VMS workstation, the DECnet session ends when you log out of the remote session. Alternate ways to terminate the dlogin process are possible using the local command mode.

4.2.3 Telnet

4.2.3.1 To and from the VMS Workstation

The VMS machine will also allow you to attach to remote nodes using Telnet. You may specify either a node name or number. For example, the Internet address for a node at the NSSDC is 128.183.36.23. This machine can therefore be reached by either

```
$ TELNET NSSDCA.GSFC.NASA.GOV
```

or

```
$ TELNET 128.183.36.23
```

Telnet connections are closed when you end your remote session, or they can be broken from the VMS workstation by typing ^Z.

The full Telnet addresses for the VMS workstation are ZWICKY.GSFC.NASA.GOV and 128.183.87.26.

4.2.3.2 To and from the ULTRIX Workstation

Telnet connections from the ULTRIX workstation are made in the same way as for the VMS machine. Telnet connections are broken when you exit your remote session. Alternatively, typing ^] gives you a **telnet>** prompt; typing ?<CR> at the prompt gives you a list of commands, including close to close the connection.

The full Telnet addresses for the ULTRIX workstation are cuba.gsfc.nasa.gov and 128.183.87.27.

4.2.3.3 From the Macintosh

To start Telnet from the Macintosh, open the icon for the hard disk in the upper right corner of the desktop. Double-click on the **Telnet 2.6** folder. (**Note:** There are some bugs with Telnet version 2.6; version 2.5 is also available on the guest Macintosh.) Start the program by double-clicking on the **NCSA Telnet 2.6** icon. Choose **Open Connection** from the **File** menu. Click on the arrow to the right of the **Host/Session** box, and select the machine to which you want to connect. Click on **Connect**. This version is equipped with Tektronix 4105 emulation.

4.3 ELECTRONIC MAIL

4.3.1 On the VMS Workstation

The GI VAXstation supports the VAX MAIL facility. You can find online information about MAIL by typing

```
$ HELP MAIL
```

Additional (and more detailed) information is available by asking for help within MAIL:

```
$ MAIL
MAIL> HELP
```

MAIL may be used to communicate with any users with SPAN or Internet access. The protocol for addressees on SPAN is

node_name::*userid*

CDAC personnel have accounts on the COBECL cluster; their user names are typically their last names. To reach the documentation support person, for example, use the electronic address `COBECL::RAWLEY`. Many of the COBE group members working at the Goddard Space Flight Center also have accounts on the STARS cluster; thus the project scientist can be reached at `STARS::MATHER`.

In some instances the destination cluster for your message may not be recognized by the GI VAXstation, especially if it is located somewhere other than GSFC. There are several ways around this. One workaround is to use the STARS VAX at GSFC as an intermediate node, *i.e.*, use the protocol `STARS::`*node_name*`::`*userid*. This will also work for incoming mail; if the outside cluster does not recognize the GI VAXstation node, try

`STARS::ZWICKY::`*userid*

Another alternative is to use the equivalent cluster number *nnnnn*, as in `7120::RAWLEY`. (See section 4.2.2.1 for more information on DECnet addressing.)

The address protocol for Internet users is

`SMTP%"`*user_id*`@`*internet_or_arpanet_address*`"`

(**Note:** Double quotes rather than single quotes are required.) For example, if someone's network address is `SMITH@ABC.DEF.GHI`, you would address your mail message to

```
SMTP%"SMITH@ABC.DEF.GHI"
```

Please note: Do **NOT** address Internet mail for COBECL users to `COBECL.GSFC.NASA.GOV`; this is not a valid address, and the message will be lost. Instead, use the form

username`@cobecl.dnet.nasa.gov`

or

username`@`*CDAC_node_name*`.gsfc.nasa.gov`

You can also send messages to users on GSFCMAIL, NASAMAIL, and TELEMAIL. The protocol is similar to that above, with the address specified as

`SMTP%"`*user_id*`@`*mail_type*`.nasa.gov"`

e.g.,

```
SMTP%"SMITH@GSFCMAIL.NASA.GOV"
```

Send messages to BITnet users with the address

```
SMTP%"user@host.bitnet"
```

You receive BITnet mail at the address

```
user@zwicky.dnet.nasa.gov
```

4.3.2 On the ULTRIX Workstation

The GI DECstation supports the UNIX `mail` facility. You can find online information about `mail` by typing

```
% man mail
```

A list of commands is available by asking for help within `mail`:

```
% mail
& help
```

Note that you can only get help this way if you have unread mail messages.

`mail` may be used to communicate with users at the CDAC, the GSFC VAX clusters, and at any other facility with SPAN access. The protocol for the addressee is the same in either case:

```
% mail node_name::userid
```

CDAC personnel have accounts on the node COBECL; their user names are typically their last names. To reach the documentation support person, for example, use the electronic address `COBECL::RAWLEY`. Many of the COBE group members working at the Goddard Space Flight Center also have accounts on the STARS cluster; thus the project scientist can be reached at `STARS::MATHER`.

In some instances the destination cluster for your message may not be recognized by the GI workstation, especially if it is located somewhere other than GSFC. There are several ways around this. One workaround is to use the STARS VAX at GSFC as an intermediate node, *i.e.*,

use the protocol `STARS::`*node_name*`::`*userid*. This will also work for incoming mail; if the outside cluster does not recognize the GI workstation node, try

```
STARS::CUBA::userid
```

Another alternative is to use the equivalent cluster number *nnnnn*, as in `7120::RAWLEY`. (See section 4.2.2.1 for more information on DECnet addressing.)

`mail` can also be used to send electronic mail to users on Internet or Arpanet. The address protocol within mail is simply

```
% mail user_id@internet_or_arpanet_address
```

For example, if someone's network address is `SMITH@ABC.DEF.GHI`, you would send your message as

```
% mail smith@abc.def.ghi
```

Please note: Do **NOT** address Internet mail for COBECL users to `COBECL.GSFC.NASA.GOV`; this is not a valid address, so the message will be lost. Instead, use the form

username`@cobecl.dnet.nasa.gov`

or

username`@`*CDAC_node_name*`.gsfc.nasa.gov`

You can also use `mail` to send messages to users on GSFCMAIL, NASAMAIL, and TELEMAIL. The protocol is similar to that above, with the address specified as

```
% mail user_id@mail_type.nasa.gov
```

e.g.,

```
% mail smith@gsfcmail.nasa.gov
```

Send messages to BITnet users with the address format

user`@`*host*`.bitnet`

You receive BITnet mail at the address

user@cuba.dnet.nasa.gov

4.4 FILE TRANSFER

4.4.1 COPY (VMS Workstation)

The DCL COPY command can be used both for local file transfers (between directories on the GI VAXstation) and for transfers to and from the VAXstation to other machines using either the VMS or ULTRIX operating system. COPY supports all file types, including text, binary, and executable images.

Local file transfers from one user area to another require only that you have read access to the source file and write access to the destination directory. Use the standard DCL COPY syntax:

$ COPY *source_disk*:[*source_directory*]*source_file destination_file*

where the file destination is assumed to be your current default directory. If this is not the case, the destination file specification will also require the directory and (if not on your disk) the disk identifier.

You can also use the COPY command to copy files to and from your home DEC installation to the VAXstation if appropriate security arrangements have been made (*e.g.*, a proxy has been set up). If the source files have world read access, you just have to add the remote VAX node name to the source file specification:

$ COPY *source_node*::*source_disk*:[*source_directory*]*source_file* –
_$ *destination_file*

(The **–** is the VMS continuation character; VMS also provides the continuation prompt **_$**.)

If the source files do not have world read access, you must provide information to the remote system to authorize access to the files (assuming your ID account on the remote system has read privileges for the source files). (Because this involves displaying your password, we encourage you to use FTP, described in section 4.4.3, for this type of transfer if the remote node is also on the Internet.) If you must use COPY, you can use this generic call:

```
$ COPY s_node"s_user s_password"::s_disk:[s_dir]s_file d_file
```

For example,

```
$ COPY EREWHON"MORE UTOPIA"::THEDISK:[TOM]PARADISE.TXT -
_$ THE.END
```

will copy the file **PARADISE.TXT** from the directory **THEDISK:[TOM]** to the user **MORE** (password **UTOPIA**) on the node EREWHON to the local directory, under the name **THE.END**.

If you wish to split up some of the typing, or want to copy more than one file, you may define a logical symbol for the remote node that includes the source node, user's ID, and password. This is done using the DCL ASSIGN command as follows:

```
$ ASSIGN "remote_node""userid password""::" NODE
```

(The ASSIGN may be extended to include the disk name and directory; insert them between the last colon and the last double quote mark. You may also use the DCL command DEFINE; see the online system help for the correct syntax and examples.) Now use COPY as before, this time using the symbol NODE in place of the actual remote node name:

```
$ COPY NODE::source_disk:[source_directory] source_file -
 _$ destination_file
```

if the source file is at the remote VAX. The NODE symbol can also be used to copy files to a remote VAX, assuming that the user's ID at the remote installation has write access to the destination directory.

There are some caveats in any file transfer between installations. If there is a large distance between machines, you may want to use the /READ_CHECK qualifier for the DCL COPY. This will read each record twice in order to catch transmission errors. Also, the speed of file transmission depends both upon the speed of the line between the installation and the usage of the machines at each end. Transferring files larger than a few thousand blocks may be very slow during prime computing hours, so we advise you to transfer large files during off-hours whenever possible. You may wish to check the transmission speed with a small file before starting to copy large ones.

4.4.2 DCP (ULTRIX Workstation)

The dcp command is the ULTRIX equivalent of the VMS COPY command, allowing you to copy files between any two machines connected by DECnet.

To copy from a VAX node to the ULTRIX workstation, use the syntax

```
% dcp vax_node::'vax_disk:[vax_dir]vax_file' ultrix_file
```

For example, the transfer of the file **TESTING.123** from VAX node **EARTH**, disk **MISSION**, directory **CONTROL** to an ULTRIX file of the same name is done with the command

```
% dcp earth::'mission:[control]testing.123' .
```

where that final **.** indicates that the same filename should be used.

Writing into a directory requires the password for the account:

```
% dcp ultrix_file vax_node/vax_user_name/vax_password::'vax_disk:[vax_dir]vax_file'
```

If, for example, you want to write into the sample file above, you would use the command

```
% dcp test.roger earth/control/moon::'mission:[control]\
% testing.123'
```

(The \ is the ULTRIX continuation character.) More information on using dcp is available by typing man dcp at the ULTRIX system-level prompt.

As for DECnet COPY, if you do not wish to display your password, you may want to try FTP instead.

4.4.3 FTP

FTP (File Transfer Protocol) can be used for transferring files between the VMS and ULTRIX workstations and remote Internet nodes. The commands shown in the following examples are for the VAXstation; corresponding commands for each platform appear in a table at the end of this section. We use **$** to indicate the local system prompt and **FTP>** for the prompt within FTP.

To connect to a remote site, type

$ FTP *Internet_node_name*

The system may respond with an FTP prompt, at which you enter:

FTP> USER *user_name_on_remote_machine*

You will then be prompted for the corresponding password. A confirmation of login appears if all is well. For example, user **SMITH** might see something like

```
FTP>  USER SMITH
<Password required for smith.
Password:  POCAHONTAS                (Password is not echoed.)
```

Some remote nodes prompt directly for a user name and password; the USER command is not needed for these nodes.

To transfer a file from the remote site to the local site, type

FTP> GET *remote_file_name local_file_name*

If you do not specify the local file name, it will have the same name (or its closest translation) as the version on the remote machine. File and directory names must adhere to the conventions of the machine on which they reside. (UNIX operating systems are case-sensitive and define directories with **/**, for example.)

To transfer multiple files from the remote site to the local site, use the MGET command.

FTP> MGET JUNK.*

The * acts as a wildcard. In the above example, all files in the current directory of the remote node with the name **JUNK** and any extension (**JUNK.TXT**, **JUNK.DAT**, *etc*.) will be copied into the current local directory with the same names they had on the remote machine.

To transfer a file from the local site to the remote,

FTP> PUT *local_file_name remote_file_name*

There is also an MPUT command for transferring several files at once.

GET and PUT may also be entered without file names; the systems will respond with at least minimal prompting for the names, depending on the platform.

To change directories at the remote site, type

FTP> CD *directory_name*

or enter CD alone, and you will be prompted for the directory name.

Change your local site directory with the command

FTP> LCD *directory_name*

To see a listing of the remote site file directory, type DIR. A listing of the local site directory can be seen by typing LDIR.

Other local VMS commands may be issued by typing PUSH; when finished, LO returns the session to FTP at the remote site.

A list of valid commands may be obtained at any time by typing ? with no <CR> at the FTP prompt.

Type HELP *command* for a short description of any listed command.

To end the remote session, type

FTP> BYE

to disconnect from the remote session, then

FTP> QUIT

to return to the local session.

In general, you must have complete login information (user name and password) for the remote site in order to do file transfers with FTP. However, many hosts make available an *anonymous* FTP service. To use this service, log on in the usual way with the user name anonymous and an arbitrary password. Network etiquette demands that you use your e-mail address or at least your user ID as a password. This service, when available, usually does not gain access to all files on the host, but only to those that the host system administrator makes available for anonymous FTP.

Here is a table of the corresponding FTP commands for each of the operating systems:

Action	VMS	ULTRIX
Log in	USER, LOGIN	user
Get remote file	GET, RECEIVE	get, recv
Get multiple remote files	MGET, MULTIPLE GET	mget
Send a file	PUT, SEND	put, send
Send multiple files	MPUT, MULTIPLE PUT	mput
Change remote directory	CD, CPATH	cd
Change local directory	LCD, LOCAL-CD	lcd
List remote directory	DIR, LS(*)	dir, ls(*)
List local directory	LDIR, LOCAL-DIRECTORY	!ls
Other local commands	PUSH, SPAWN	!(**)
FTP command listing	?	?
FTP command description	HELP	help
Interactive prompting for MGET, MPUT	CONFIRM	prompt
Set file type for binary files	BINARY, TYPE IMAGE	binary, image
Disconnect from remote FTP server	BYE, CLOSE	close
Terminate FTP session	QUIT, EXIT	bye, quit

* File names only

** Type `exit` to return to `FTP`

4.5 EXAMPLE: REMOTE CONNECTION

The following example shows a remote user on a UNIX workstation how to set up their home node to run COBE image processing software, start a CGIS analysis session, and transport files for local printing. In the example, the UNIX workstation on which Jo User is working is called `SPACE.UNIV.EDU`, and `ZWICKY.GSFC.NASA.GOV` is the GI node to which Jo User will connect.

In the example, we use **`this font for computer prompts and replies`**, `this font for your keyboard entries`, and *this font for our side comments*. Menu choices are presented like this:

Menu title:	Select this item:
Title of menu	Choice from menu

Click on the menu to make the selection.

You will also see the following prompts:

- **`$`** when you are at the VMS system level (DCL)
- `%` when you are at the UNIX system level
- `<CR>` means to press the RETURN key

ON YOUR HOME NODE

```
%  xhost +zwicky.gsfc.nasa.gov <CR>
```

Add the GI node to your authorization list.

```
%  telnet zwicky.gsfc.nasa.gov <CR>
```

Log in to the GI machine.

ON THE GI NODE

```
$  SET DISPLAY/CREATE/NODE=SPACE.UNIV.EDU/ - <CR>
$  TRANSPORT=TCPIP <CR>
```

Send any displays to your home node (`space.univ.edu`). Note that the dash (-) is the VMS continuation character.

```
$  CGIS <CR>
```

Begin a CGIS analysis session.

Jo User has now successfully initiated a session with the CGIS software. (See the *CGIS Software User's Guide* for detailed information on the CGIS Executive, UIMAGE, and UIDL.)

Within this session, Jo User created a PostScript image to copy home for printing:

Menu title:	**Select this item:**	
CGIS Main Menu	Shell to Operating System	*Go to VMS.*

$ FTP SPACE.UNIV.EDU <CR>	*Begin* FTP *transfer.*
ZWICKY.GSFC.NASA.GOV MultiNet FTP user process 3.0(102) **Connection opened (Assuming 8-bit connections)** **<space FTP server (Version 4.1 Sun Mar 25 22:59:11 EST 1990) ready.**	FTP *start-up messages and prompt.*
SPACE.UNIV.EDU> USER JoUser <CR>	*Use your username here.*
<Password required for JoUser. **Password:**	*Type in your password.*
<User JoUser logged in.	*This message appears if the name and password were correctly entered.*
SPACE.UNIV.EDU> PUT ZWICKY.PS <CR> **To remote file:** HOME.PS <CR>	*Put the PostScript file* **ZWICKY.PS** *into the SPACE file* **HOME.PS**.
SPACE.UNIV.EDU> QUIT <CR>	*Quit the* FTP *session.*
$ LOGOUT <CR>	*Log out of the spawned VMS session and return to the* **CGIS Main Menu**.

4.6 EXAMPLE: READING A CD ROM ON CUBA FROM ZWICKY

This step-by-step example illustrates the process of reading a CD ROM mounted on the CUBA workstation.

$ TELNET CUBA	*Connect to the ULTRIX workstation.*

```
Trying... Connected to CUBA.GSFC.NASA.GOV
                    ⋮
              access warnings
                    ⋮
login: jouser                                        Login as usual; password
Password: Sec$ret                                    is not echoed.

                    ⋮
              login messages
                    ⋮
```

Insert the CD ROM into the caddy (see section 3.4.3).
Insert the caddy into the CD ROM drive on CUBA.

```
% mountcd                                           Mount the CD (UNIX file
Mounting CD-ROM on directory /cdrom                  system).

% cd /cdrom                                         Change the default
/cdrom                                               directory to the CD top-
                                                     level directory.

% ls                                                List the files.
readme/

% cd readme                                         Change to the readme
/cdrom/readme                                        subdirectory.

% ls
junk1.txt    junk2.txt    junk3.ps
% ftp zwicky                                        Now connect back to
                                                     ZWICKY.

Connected to zwicky.gsfc.nasa.gov
                    ⋮
              login messages
                    ⋮
Name(zwicky:jouser): <CR>                            Log in to ZWICKY.
       acknowledgement of username
Password: MORESEC$RET
       acknowledgement of login

ftp> put junk1.txt                                   Transfers junk1.txt to
                                                     your ZWICKY login
                                                     directory.

ftp> quit                                            End the FTP session.

% cd ~jouser                                        You must move off of the
                                                     CD ROM to dismount it.
```

```
% unmountcd
Unmounting CD-ROM from directory /cdrom
```

Eject the CD from the drive, and remove the disc from the caddy.

```
% logout
```

Leave CUBA and return to your original ZWICKY session.

```
$
```

4.7 MOSAIC

Mosaic is a point-and-click interface that makes obtaining information from the Internet relatively painless. It allows, among other things, the display and downloading of text, images, and data, and gives you access to the World Wide Web (WWW). A pared-down version of **mosaic** (no sound or movie player) is running on both the CUBA and ZWICKY workstations.

To spawn off a **mosaic** session, type

```
% mosaic &
```

Do not be alarmed by the warning messages about missing fonts. The NCSA home page should appear. Any text in blue, underlined type has been linked to further information; clicking on the word allows you to access these additional topics.

You can reach other sites over the Internet if you know their corresponding Uniform Resource Locator (URL) addresses. To enter a URL, click in the **Open** box at the bottom of the window; this opens an **Open Document** window. Place the cursor in the **URL to Open** box, and move the cursor pointer around until a small I-beam cursor appears on the line. Enter your new URL. If you make a mistake, use the mouse to highlight the offending text, then type in the correct characters. The backspace and delete keys do not work. Click in the **Open** box to open the connection to the new remote site.

Below are some URLs that you may find useful:

COBE home page	**http://www.gsfc.nasa.gov/astro/cobe/cobe_home.html**
Astrophysics Data System (ADS) Abstract Service	**http://adswww.harvard.edu/abs_doc/abstract_service.html**
Astronomy Conferences	**http://cadc.dao.nrc.ca/meetings/meetings.html**
NASA home page	**http://hypatia.gsfc.nasa.gov/NASA_homepage.html**
WebStars: Astrophysics on the Web	**http://guinan.gsfc.nasa.gov/WebStars.html**
GNN (Global Net Navigator) Directory	

	http://192.190.21.10/gnn/GNNhome.html
EINet Galaxy (net by topics)	**http://galaxy.einet.net/galaxy.html**
Planet Earth home page	**http://white.nosc.mil/info_modern.html**
Digital (DEC) FTP and WWW Archives	
	http://gatekeeper.dec.com
Gopher server	**gopher://wiretap.spies.com/11/Etext**

Note that these addresses are subject to change.

Click in the **Back** or **Forward** boxes at the bottom of the window to revisit sites at any time during your session without the need to re-enter the URL.

To end your session, click on the **File** item in the menu across the top of the **mosaic** window, and choose **Exit program**. Then click on **Yes** in the exit confirmation window that appears next.

5 PROJECT DATA SET OVERVIEW

More complete information about data format and quality is available in the *Proposer Information Package* or in the *Explanatory Supplement* for each instrument. Hardcopies are available from the documentation support contact. Online versions of the *Proposer Information Package* and the *Explanatory Supplements* are available by anonymous FTP from the NSSDC under **[COBE.PROJECT_DATA_SETS]**. Each *Explanatory Supplement*, when available, will be stored in the directory containing the corresponding data. You can scroll through the text of the *Proposer Information Package* using the **CGIS Main Menu**, **Documentation** branch.

5.1 DATA FORMATS AVAILABLE

The Project Data Sets are available in time-ordered data files and FITS binary tables (COBE skymaps). Guest investigators at the CGIF will have access to the files as well as the CGIS software for working with the skymaps. The software is equipped with a user-friendly interface that allows you to read in the COBE data sets quickly and to begin their analysis. The UIMAGE and UIDL packages were written specifically to handle the COBE skymap projection and provide several important analysis tools particular to COBE data analysis, including various model fitting, imaging, and plotting routines.

5.2 DIRBE PROJECT DATA SETS

5.2.1 DIRBE Product Description

The DIRBE Project Data Sets consist of:

1) absolutely calibrated time-ordered data (8 GB)

2) a set of 41 weekly-averaged sky maps (2.5 GB)

3) maps at fixed solar elongation (angle between the line-of-sight and the Sun) of 90° (0.13 MB)

4) annual-averaged sky maps (0.24 MB)

5) Galactic plane maps (0.04 MB)

6) beam profiles (small)

7) system spectral response function (ASCII - small)

8) color correction tables (ASCII - small)

The time-ordered data are binned into 32 second time intervals (1 Major Frame, MF) containing 10240 Bytes. Each MF includes the output from the 16 IR detectors (three each in bands 1-3 and one in all other bands), detector parameter settings, operating status and environment flags, outputs from all engineering sensors, attitude information, and selected data from the other instruments and the spacecraft. Each MF contains 256 samples of each detector's output, one for each 1/8th second (four chopper cycles). The time-ordered IR sensor data are exactly those used as the basis to construct the weekly-averaged maps.

All sky map Project Data Sets are presented in the COBE map format which divides the sky into pixels of approximately $0.32° \times 0.32°$ in size. The pixel locations are a fixed grid and each data sample is assigned to the center of the nearest pixel. Information provided for each pixel includes the pixel number, the sky brightness at each wavelength, the standard deviations of the mean values, the number of effective observations, the mean solar elongation angle, and time for the averaged observation, and ancillary data. In addition, at 1.25, 2.2, and 3.5 μm, the three detectors at each of these wavelengths measure the total intensity and orthogonal linearly polarized components of the signal. From these we have derived Stokes parameters Q and U, and these are also included for each pixel in the weekly-averaged maps.

It should be noted that when creating the sky maps, data taken when the Moon is within 10° of the line-of-sight (LOS) are excised. In addition, data following a Moon transit, which heavily saturates all of the detectors, are removed using different time cuts for different bands (30 seconds for all bands except the 12 - 100 μm bands, which have 3 minutes of data removed). Data are also removed if a planet or bright comet or a bright asteroid is near the LOS. All such data remain in the time-ordered data set.

5.2.2 DIRBE Data Records

Data fields (Time-Ordered Calibrated Intensities File):

Time
Attitude
Photometry for 16 detectors (MJy/sr)
Standard deviations of photometric values (MJy/sr)
Engineering sensors (data numbers)

Ancillary information includes the approach vector and a South Atlantic Anomaly (SAA) flag.

Data fields (Weekly-Averaged Sky Map Files):

DIRBE pixel number (resolution 9)
Sub-pixel containing the mean line-of-sight
Sub-pixel number of the average line-of-sight (bands 1A, 4, 7, 8)
Average time of observation
Difference between the average time of observation for each photometric band and the average time of all observations of the pixel
Mean solar elongation angle
Photometry for 10 full-intensity bands (MJy/sr)
Stokes' parameters Q and U for the polarization channels
Number of observations of the pixel for week
Sum of the applied observation weights for 10 photometric bands
Standard deviations for the full-intensity bands (MJy/sr)
Standard deviations for the Stokes' parameters Q and U
Solar system objects flag
Fraction of data used
Quality flag for polarization ratios in Stokes' parameters

Ancillary information includes ecliptic and Galactic coordinates of the pixel center.

Data fields (Annual-Averaged Sky Map Files):

DIRBE pixel number (resolution 9)
Sub-pixel containing the mean line-of-sight
Average time of observation

Photometry for full-intensity bands (MJy/sr)
Standard deviations for the full-intensity bands (MJy/sr)
Sum of the applied observation weights for photometric bands
Sum of the total number of observations available

Data fields (Elongation 90° Sky Map File):

DIRBE pixel number (resolution 9)
Time corresponding to observation of pixel at solar elongation = 90°
Photometry for full-intensity bands (MJy/sr)
Effective number of observations of the pixel over the mission
Standard deviations for the full-intensity bands (MJy/sr)
Fit quality flag
Fit χ^2 per degree of freedom

Ancillary information includes ecliptic and Galactic coordinates of the pixel center.

Data fields (Galactic Plane Sky Map Files):

DIRBE pixel number (resolution 9)
Photometry for full-intensity bands (MJy/sr)
Data quality flag - contains both quality flag and standard deviation
Time corresponding to observation of pixel
Ecliptic longitude
Ecliptic latitude
Galactic longitude
Galactic latitude

5.2.3 DIRBE Data Quality Summary

Spectral band	Wavelength (microns)	Effective bandwidth* (Hz)	Pixel noise (5 σ) (MJy/sr)	Minimum pt. source (Jy)
1	1.25	5.94e+13	0.1	30
2	2.2	2.28e+13	0.1	30
3	3.5	2.10e+13	0.1	30
4	4.9	8.61e+12	0.1	30
5	12	1.16e+13	0.6	170
6	25	4.41e+12	0.8	220
7	60	2.26e+12	1.3	360
8	100	1.15e+12	1.4	390
9	140	6.13e+11	40	11,200
10	240	4.99e+11	20	5,600

* Assumes source spectrum $\nu I(\nu)$ = constant

5.3 DMR PROJECT DATA SETS

5.3.1 DMR Product Description

The purpose of the 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 sorted by sky position to provide sky sampling information, and (iii) the time-ordered raw differential temperatures.

Smoot *et al.* (1990) and Bennett *et al.* (1992) provide detailed descriptions of the DMR instrument. The DMR experiment 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 (75 s period), orbit (103 m period) and orbital precession (~1°/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 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.

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 E-planes of linear polarization for all 53 and 90 GHz channels are directed radially outward from the spacecraft spin axis. A shield surrounds the aperture plane and shields all three instruments from solar and terrestrial emission. As the spacecraft spins, a point 30° from the spin axis is swept successively by the 31 GHz Horn 1, 31 GHz Horn 2, 53 GHz A and B Horns 1, 53 GHz A and B Horns 2, 90 GHz A and B Horns 1, and 90 GHz A and B Horns 2 respectively. See Figure 8 of Bennett *et al.* (1992) for a schematic of the COBE aperture plane.

Pixelized Differential DMR Data

The corrected, baseline-subtracted and calibrated 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 Project Data Set. 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 1,600,000 pixel permutations of the 6144 pixels. Section 5.3.2 describes the information given for each pixel permutation.

DMR Sky Maps

Within six months, each DMR channel repeatedly sampled well over a million pixel permutations (after that, the number of newly sampled pixel permutations grew much more slowly since

COBE's orbital plane had by then completed its initial sweep of the sky). These pixel permutations provide a highly redundant set of data in the form of differences between pairs of the pixel temperatures. By setting these differences up as equations, we effectively collapse the redundancy by forming the χ^2 sum of the measurements involving each pixel, and forcing its derivative with respect to the pixel temperatures to be zero. There are P normal equations in the pixel temperatures, where P is the number of pixels. Because of the 60° constraint of the horn separations, the $P \times P$ matrix of normal equation coefficients is only a few percent filled (hence it is a sparse matrix). By iterative techniques (see Janssen & Gulkis 1992), we solve for the sky temperature for each pixel simultaneously with coefficients of systematic error models. Since the instrument only measures temperature differences between different sky directions, these maps would be identical if the whole sky changed in temperature by a constant amount. Section 5.3.2 describes the information given for each pixel.

A higher order of pixelization has been used within 20° of the Galactic plane and those pixels were then averaged together in the Sky Maps Project Data Set so that the pixels are all of equal area, 6.7 square degrees.

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 (data is not used 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 also reduce coverage considerably for certain pixels.

Section 5.3.3 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.

References

Bennett, C. L., *et al.* 1992, ''*COBE* Differential Microwave Radiometers: Calibration Techniques,'' *Ap.J.*, **391**, 466-482.

Janssen, M. A., & Gulkis, S. 1992, ''Mapping the Sky with the *COBE* Differential Microwave Radiometers,'' in *The Infrared and Submillimeter Sky after COBE*, eds. M. Signore & C. Dupraz (Dordrecht: Kluwer).

Smoot, G., *et al.* 1990, ''*COBE* Differential Microwave Radiometers: Instrument Design and Implementation,'' *Ap.J.*, **360**, 685-695.

5.3.2 DMR Data Records

Pixelized Differential Data Project Data Sets

Field 1	Pixel number (0 to 6143) for Horn 1	
Field 2	Pixel number (0 to 6143) for Horn 2	
Field 3	Number of differential antenna temperatures, ΔT	
Field 4	T ΔT	
Field 5	T ΔT^2	
Field 6	T ΔT^3	
Field 7	T ΔT^4	
Noise level (per meas)	31A: 58.7 mK	31B: 60.5 mK
	53A: 23.2 mK	53B: 27.1 mK
	90A: 40.0 mK	90B: 30.3 mK

Sky Maps Project Data Set

Pixel number (0 to 6143)
Antenna temperature, dipole subtracted (mK)
Number of observations
Estimated pixel uncertainty (mK)
Ecliptic longitude
Ecliptic latitude
Galactic longitude

Galactic latitude
Right ascension
Declination

5.3.3 DMR Data Quality Summary

DMR Channel	31A	31B	53A	53B	90A	90B
Max obs per pixel	71145	62839	81271	81400	81490	81669
Noise level (mK)	0.206	0.233	0.079	0.087	0.141	0.099
Mean obs per pixel	29728	24484	35672	35681	35655	35643
Noise level (mK)	0.319	0.372	0.119	0.132	0.214	0.150
Min obs per pixel	11506	7988	21526	21471	21579	21557
Noise level (mK)	0.513	0.653	0.153	0.170	0.274	0.193

5.4 FIRAS PROJECT DATA SETS

5.4.1 FIRAS Product Description

The June 1994 data products consist of both calibrated sky maps and uncalibrated, time-ordered data. The former are of most interest to investigators. There are three types of calibrated maps: the calibrated complex spectra themselves, line emission maps, and continuum emission maps. For each type of map there are ten files, eight of which correspond to combinations of detector and instrument scanning state, and two of which are averaged master maps, one at low resolution covering the entire frequency range, and one at high resolution covering the range 1 - 20 cm^{-1}.

There are two high frequency and two low frequency FIRAS detectors, called, respectively Right High (RH), Left High (LH), Right Low (RL), and Left Low (LL). For each detector, there are four mirror scan modes corresponding to two speeds × two lengths. The mirror scan modes are thus called Long Slow (LS), Short Fast (SF), *etc*. The eight detector/scan mode combinations for which we have useful data are:

RHSS LHSS RHSF LHSF LLSS LLLF RLSS RLLF

where the first two letters designate the detector and the last two the mirror scan mode. All eight maps and their corresponding covariance matrices have also been combined into a grand average low spectral resolution map and matrix. (This is the ninth of the ten delivered maps.) The last map is a combination of the low frequency detector data taken with long mirror scans, *i.e.* LLLF and RLLF. This last map is a high spectral resolution map spanning the low frequency range only. These two average maps, and the associated line emission and dust continuum maps derived from them, are the products likely to be of most astrophysical interest.

The FIRAS data also consist of uncalibrated average interferograms for each pixel, averaged calibration interferograms, and the calibration models themselves. There is one such model for each of the eight detector/instrument state combinations.

Finally, there is Level 1 instrument data. This consists of raw interferograms and engineering data, pixel- and time-ordered indices of these data, instrument state information, and assorted reference data sets. More detail is given about each data set below.

5.4.2 FIRAS Data Record

The following table lists all of the data products.

DATA SET AND DISTRIBUTION MEDIUM[1]		NUMBER OF FILES[2]	TOTAL SIZE (MB)	TIME-ORDER OR SKY MAP	FORMAT[3]
	Calibrated data				
Sky spectra	F,C,T	10	400	map	FITS
Line emission maps	F,C,T	10	40	map	FITS
Line profiles	F,C,T	2	1	N/A[4]	FITS
Dust maps	F,C,T	10	40	map	FITS
Covariance matrices	F,C,T	10	25	map[5]	FITS
	Uncalibrated data				
Averaged sky interferograms	C,T	176	600	map	native
Averaged cal interferograms	C,T	40	80	time	native

Data Set and Distribution Medium[1]		Number of files[2]	Total Size (MB)	Time-order or sky map	Format[3]
Calibration models	F,C,T	8	20	time	FITS
Raw data and indices					
Raw interferograms	T	1224	3500	time	native
Engineering data	T	306	600	time	native
Sky interferogram index	T	88	85	map	native
Calibration interferogram index	T	1266	9	time	native
Housekeeping	T	328	250	time	native
Mirror scan data	T	328	170	time	native
Reference data sets	T	20	50	time	native

Notes: (1) Distribution media are *F* for anonymous FTP, *C* for CD-ROM, and *T* for tape. For calibrated sky maps, only the two channel and scan mode-averaged "master maps" will be available by `FTP`; the eight channel and scan mode maps are available via tape and CD-ROM.

(2) Number of files should not be confused with number of records in each file. For calibrated sky maps, there is one record per pixel in each file; for raw interferograms there is one file for each day of the mission, times the number of detectors (four).

(3) FITS files are in the binary table extension and are readable with the FITSIO package available via anonymous FTP from `legacy.gsfc.nasa.gov`. The files are written with one record per pixel, in pixel numerical order. Native format files are also written in pixel order but are not FITS: they are VAX binary files and require byte-swapping for IEEE conformance. Each file in native format is accompanied by a so-called Record Definition Language (RDL) file detailing the file record structure. The RDL is an ASCII file that gives data field names and byte offsets within each record.

(4) List of line profiles associated with each spectral line. One file applies to high resolution spectra, the other to low.

(5) Covariance matrices are not maps themselves, but each is associated with a map. Each matrix is a 167 × 167 matrix giving frequency-to-frequency variances of the calibrated spectra within each map.

Primary Data Sets

The following data sets are of primary interest to investigators:

Sky spectra are the ten sky maps consisting of complex calibrated spectra spanning the FIRAS frequency range. Each map contains all sky pixels. The record for each pixel includes the average spectrum, formal variances at each frequency point, the number of observations; the centroid of the data in Galactic, ecliptic, and equatorial coordinates; and the average value of engineering quantities (*e.g.*, bolometer temperatures) associated with the spectrum.

Line emission maps correspond to the sky maps, but have 16 data points in each pixel, consisting of the integrated line intensities (in units of W m^{-2} sr^{-1}) in the following lines:

Spectral Lines in FIRAS Data			
Species	ν (cm^{-1})	ν (GHz)	λ (μm)
CO (J=1-0)	3.84	115.27	2601.
CO (J=2-1) *	7.69	230.54	1300.
CO (J=3-2) *	11.53	345.80	867.0
O_2	14.17	424.75	705.8
CO (J=4-3) *	15.38	461.04	650.3
[C I] *	16.41	492.22	609.1
H_2O	18.58	556.89	538.3
CO (J=5-4) *	19.22	576.27	520.2
CO (J=6-5)	23.07	691.47	433.6
[C I] *	27.00	809.44	370.4
H_2O	37.13	1113.3	269.3
[N II] *	48.74	1461.1	205.2
[C II] *	63.40	1900.5	157.7

Spectral Lines in FIRAS Data			
Species	ν (cm^{-1})	ν (GHz)	λ (μm)
[O I]	68.71	2060.1	145.5
[Si I]	77.11	2311.7	129.7
[N II] *	82.04	2459.4	121.9

(Asterisks indicate detections that were published in Wright *et al.*, 1991.) Line maps corresponding to the high resolution scan modes contain data only for lines at frequencies below 20 cm^{-1}. In all maps a continuum has been subtracted from each line. The data set consists of the line intensities, the formal errors in those intensities, and the coefficients of a polynomial baseline subtracted from the spectrum after first removing a dust continuum.

Line profiles are in two files, each with a list of synthetic spectra. Each such spectrum contains a single spectral line convolved with the instrumental profile. There are 16 such spectra in one file corresponding to the 16 spectral lines listed above. Each spectrum is 167 points long, and corresponds in frequency scale and resolution to the low resolution calibrated maps. The other file contains profiles only for the six lines at frequencies below 20 cm^{-1}, and corresponds to the 36-point high resolution spectra.

Dust maps are maps of dust optical depth, temperature, and emissivity for a two-component dust model.

Covariance matrices are in units of MJy^2/sr^2. There is one such matrix for each sky map, of dimension $N \times N$, where N is the number of frequency points. (N=167 for low resolution spectra and 36 for high.) The matrices are symmetric, and the unique triangular elements are packed into the FITS file. The FIRAS *Explanatory Supplement* contains the algorithm and pseudocode for unpacking the data file into a square, symmetric matrix.

Secondary Data Sets

The following data sets require extensive data processing to be of astrophysical use but can in principal be used to reconstruct and reprocess the primary data sets. They can also be used to establish trends in instrument performance and identify periods of anomalous instrument behavior. Each data set comes with documentation that explains the utility of each field in the record.

Averaged sky interferograms are the coadded raw data in each pixel. These interferograms have undergone internal consistency checking and baseline and glitch removal but are not calibrated and have not been Fourier transformed into spectra. There may be more than one coadd per pixel. Each record consists of the data and its variance, the averaged sky position of the observations, the instrument scan mode, and the corresponding coadded engineering quantities such as detector voltages and mirror temperatures.

Averaged cal interferograms are analogous to the averaged sky interferograms, but are sorted by calibrator temperature instead of sky pixel.

Calibration models correspond to the eight delivered detector/mirror scan mode maps. Each model file gives the system optical efficiency; and the emissivities of the sky and reference antennas, the reference blackbody, the scanning mirrors, and the bolometers themselves. It also includes parameters for the bolometer responsivity model and coefficients for correcting for vibrational resonances in the mirror scan platform. Consult the *FIRAS Explanatory Supplement*, available via anonymous `FTP` from `nssdca.gsfc.nasa.gov`, for details.

Raw interferograms are stored as one file per detector per mission day. Each file contains roughly 1000 raw interferogram records, each in units of digital counts. Other information for each observation includes gain and mirror scan settings, attitude information, data quality flags, and onboard microprocessor status words.

Engineering data are also stored as one file per mission day, with about 1000 records per file. Engineering records consist of all instrument temperatures, voltages, and status bits, in appropriate units. Time tags of the engineering records, and the values within the records, have been interpolated to match up with raw interferogram collection times.

Sky interferogram index refers to a set of abbreviated raw interferogram records, sorted by sky pixel. Each record consists of the pixel number, instrument state, and time tags of the raw interferograms that match that pixel and state.

Calibration interferogram index is analogous to the sky interferogram index, but for calibration data. In this case the sorting is by calibrator temperature and instrument state, rather than pixel number and instrument state.

Housekeeping data are the raw engineering data, with all quantities expressed in digital counts rather than volts, kelvins, *etc*. Housekeeping records are asynchronous with raw interferograms.

Mirror scan data are synchronous with housekeeping data and give mirror scan speed, length, and direction at 0.25 sec intervals throughout the mission.

Reference data sets are small files containing various constants pertaining to instrument operation and performance, *e.g.*, mirror scan speeds and spectrum Nyquist frequencies.

References

Wright, E.L., Mather, J. C., Bennett, C. L., Cheng, E. S., Shafer, R. A., Fixsen, D. J., Eplee, R. E., Jr., Isaacman, R. B., Read, S. M., Boggess, N. W., Gulkis, S., Hauser, M. G., Janssen, M., Kelsall, T., Lubin, P. M., Meyer, S. S., Moseley, S. H., Jr., Murdock, T. L., Silverberg, R. F., Smoot, G. F., Weiss, R., and Wilkinson, D. T. 1991, ''Preliminary Spectral Observations of the Galaxy with a 7° Beam by the Cosmic Background Explorer (COBE),'' *Ap. J.*, **381**, 200.

5.4.3 FIRAS Data Quality Summary

FIRAS Calibrated Spectra Data Set

Sky coverage	95%
Frequency Range	20 - 95 cm^{-1}, 600 - 2850 GHz (channels RH and LH)
	2 - 20 cm^{-1}, 60 - 600 GHz (channels RL and LL)
Wavelength Range	105 - 5000 μm
Frequency Resolution	0.8 cm^{-1}, 24 GHz FWHM (low resolution spectra)
	0.2 cm^{-1}, 6 GHz FWHM (high resolution; low frequency channels only)
Frequency Step	0.56 cm^{-1}, 17 GHz, complex spectra (low resolution)
	0.14 cm^{-1}, 4 GHz, complex spectra (high resolution)
Pixelization	2.59°, ecliptic coordinates
Beamwidth	7° circular top hat
Motional smearing	2.6° perpendicular to ecliptic

The next table gives approximate errors and sensitivities for the best map, which is the low-resolution map combining all channels. Note that where "per pixel" numbers are given, the number refers to an "average" pixel: errors in individual pixels may vary by a large factor due to differences in number of observations per pixel. Frequency ν is in units of cm^{-1}.

FIRAS Errors and Sensitivity			
	2-18 cm^{-1}	18-24 cm^{-1}	24-95 cm^{-1}
Combined error per observation (MJy/sr)	2	≈8	0.8 exp(ν/16.6)
Combined error per pixel (MJy/sr)	.5	≈2	0.01 exp(ν/15.2)
Correlated error (MJy/sr)	0.02	≈0.08	0.004 exp(ν/15.3)
Gain error(1)	<0.25%	≈3%	0.6% (ν < 70)(2)

Notes: (1) Gain errors are estimated from fit residuals in the calibration and from comparison of observations made with different scan modes and detectors. Agreement with DIRBE calibration is 15%.

(2) Gain errors rise very steeply above 70 cm^{-1}, to ~25% at 95 cm^{-1}.

The spectral range of the high frequency channels includes the Wien region of the cosmic microwave background radiation, emission from interstellar dust, and the major far infrared cooling lines of the interstellar gas. The lines so far detected in the maps include the rotational sequence of CO for J=2-1 up to the J=5-4 transition. Most of the CO cascade is seen in the low frequency channels. There are also two lines of [C I], two of [N II], and one of [C II]. These lines are very widespread, and the [C II] line is highly correlated with the dust emission. The [N II] lines are also correlated with the dust emission but the trend is not always linear, presumably due to the higher ionization potential of the nitrogen, chemical abundance gradients, and differences in excitation conditions. Analyses of these data on dust and lines have been published by Wright *et al*. (1991) and by Petuchowski and Bennett (1993). The data sets include maps of these and other lines.

References

Wright, E.L., Mather, J. C., Bennett, C. L., Cheng, E. S., Shafer, R. A., Fixsen, D. J., Eplee, R. E., Jr., Isaacman, R. B., Read, S. M., Boggess, N. W., Gulkis, S., Hauser, M. G., Janssen, M., Kelsall, T., Lubin, P. M., Meyer, S. S., Moseley, S. H., Jr., Murdock, T. L., Silverberg, R. F., Smoot, G. F., Weiss, R., and Wilkinson, D. T. 1991, ‘‘Preliminary Spectral

Observations of the Galaxy with a 7° Beam by the Cosmic Background Explorer (COBE),'' *Ap. J.*, **381**, 200.

Petuchowski,S. J. and Bennett, C. L. 1993, ''Galactic Fine Structure Lines: Morphologies of the Warm Ionized Medium,'' *Ap. J.*, in press (March 10, 1993). (LASP preprint no. 92-1.)

6 CGIS SOFTWARE OVERVIEW

The CGIS Executive is designed to provide an interface to the COBE data and software so that guest investigators can begin working soon after their arrival. The software at the CGIF includes the software designed specifically for the COBE data, *i.e.*, the UIMAGE and UIDL packages, as well as some other commonly used software packages. All of these analysis tools can be accessed through the COBE Guest Investigator System (CGIS) Executive interface. For more extensive information on the CGIS software, consult the *CGIS Software User's Guide*.

6.1 THE CGIS EXECUTIVE

The CGIS Executive is a menu-driven interface which serves, among other things, as an entrance to UIMAGE, UIDL, IRAF, and SAOimage. The interface also contains online documents such as the *CGIS Software User's Guide* and this ***Handbook***. News items for all users concerning software changes are available for browsing in the Executive. Users who encounter any problems with the system or who have any comments they would like to share with us may do so easily within the Executive by simply choosing the **`Report Comments or Problems`** menu option. This will invoke the VMS editor (or an editor of your choosing). Upon completion of the edit session, your comments will be automatically mailed to the appropriate contact person. We urge all users to take advantage of this option. Be forewarned that you're not off the hook that easily -- all reports will be answered!

6.2 UIMAGE

UIMAGE is a menu-driven image analysis tool written in IDL by members of the COBE project so neophyte users can manipulate data without going to the IDL command line. Skymap data is easily read in and exported through UIMAGE data input/output. The software is also equipped with many fitting routines and other analysis tools that preserve the photometric accuracy of the data regardless of the projection chosen.

Chapter 4 of the *CGIS Software User's Guide* discusses UIMAGE functions thoroughly; in addition, each UIMAGE menu is equipped with a help option, explaining the choices available from that menu. Chapter 3 of the *CGIS Software User's Guide* presents a tutorial session using UIMAGE.

6.3 UIDL

IDL is a commercial interactive programming language widely used on the COBE project. It provides a broad range of general data I/O, array manipulation, mathematical, and display functions. Users who are unfamiliar with IDL should browse through the manuals *IDL Basics* and *IDL User's Guide*. The smaller *IDL Basics* illustrates various IDL capabilities through short cookbook examples, while the *User's Guide* is a comprehensive guide to IDL. An *IDL Reference Guide* is also available for detailed information on individual routines.

UIDL contains additional tools written specifically to support COBE-related analysis. The routines provide data imaging routines, fitting routines, various data input/output routines, and numerous utilities useful in COBE data analysis. Since UIDL contains all IDL routines, it is recommended that all IDL users use UIDL.

Chapter 3 of the *CGIS Software User's Guide* is a tutorial that demonstrates useful capabilities of UIDL. The *User's Guide* also includes detailed information about UIDL and standard IDL help facilities, as well as listing of the UIDL routines.

6.4 ADDITIONAL ANALYSIS PACKAGES

Besides UIMAGE and UIDL, several other public domain software packages are available at the CGIF. IRAF, AIPS, and SAOimage are most easily accessed through the CGIS Executive under the menu option **`Other Analysis Tools...`** (see Chapter 6 of the *CGIS Software User's Guide*) but can also be accessed as described below.

6.4.1 IRAF

6.4.1.1 On the VMS Workstation

If you are using IRAF for the first time on this system, type `IRAF` at the DCL prompt to set up the system logicals. Then type `MKIRAF` to create a **`LOGIN.CL`** file and a **`[.UPARM]`** subdirectory. Note that you need to execute the latter command only once during your stay here.

Now, to access IRAF from the DCL prompt, type `CL` at the DCL prompt, and your session will begin. Note that you must always use the `IRAF` command before typing `CL`.

If you plan to use SAOimage as your image display tool, enter the following commands at the system prompt:

```
$ SAOSETUP
$ SPAWN/NOWAIT SAOIMAGE
```

or spawn them from within IRAF.

Remember that IRAF is case-sensitive and that input data must be in FITS format.
To exit IRAF, type `logout` at the **`cl>`** prompt. You will have to end the SAOimage process separately by choosing **`etc`** and then **`QUIT`** from the SAOimage menu bars.

6.4.1.2 On the ULTRIX Workstation

To access IRAF for the first time on the ULTRIX machine, type `mkiraf` at the command prompt to create a **`login.cl`** file and a **`uparm`** subdirectory. Type `cl` to invoke IRAF.

Remember that IRAF is case-sensitive and that input data must be in FITS format.

If you would like to use SAOimage as your image display tool, you will have to spawn a separate process:

```
cl> !saoimage &
```

Alternatively, you may spawn the SAOimage process from the command line before you enter IRAF:

```
% saoimage &
```

To exit IRAF, type `logout` at the **`cl>`** prompt. You will have to end the SAOimage process separately (choose **`etc`**, then **`QUIT`**).

6.4.1.3 Getting Help in IRAF

For help while in IRAF, type `help` at a prompt for a one line description of the tools available at that level. (Typing a `?` is equivalent to the word `help` in IRAF.) For example, typing `help` at the **`cl>`** prompt gives you the following one-liners:

```
      dataio - Data format conversion package (RFITS, etc.)
        dbms - Database management package (not yet implemented)
      images - General image processing package
    language - The command language itself
       lists - List processing package
       local - Local (site dependent) tasks and packages
        noao - The NOAO optical astronomy packages
        plot - Plot package
    softools - Software tools package
      system - System utilities package
   utilities - Miscellaneous utilities package
```

The IRAF `help` command also accepts an argument, *e.g.*, `help utilities`. If a package or menu name, say `dataio`, is the argument, IRAF lists the routines available in that package/menu with a one line description for each (similar to the list shown above). If a routine name is given as the argument, say `bintxt`, a text file is shown with information such as a description of the routine, its usage and parameters, cross-references, and possibly an example. A status line at the bottom of the screen indicates how to move around in the help file. These commands include:

```
            q :  quit
            d :  down one-half of a screen
  f or space:  down one full screen
   j or <CR>:  down one line
```

If you scroll all the way down to the bottom of the file, IRAF automatically dumps you back to the IRAF command prompt.

6.4.2 AIPS

6.4.2.1 On the ULTRIX Workstation

First log in to the **`aips`** account. (See your science support person or systems management for the account password.) Change your working directory to the **`FITS`** subdirectory, and transfer any data that you want to use in AIPS into this area, using file names in all upper case letters.

Spawn an xterm window:

```
% xterm &
```

Switch over to the xterm window and start AIPS:

```
% aips
```

You will then be prompted for a printer; choose one, noting that all of these are located at the CDAC and not the CGIF.

The **X-AIPS TV-Screen-Server** soon appears on the screen as a small icon, probably behind one of your terminal screens. Click on it to restore it to its usual size.

AIPS then prompts you for your user ID number. You may choose any number greater than 1, but if you find that there is data already loaded in that area, please get out and choose another number.

While AIPS displays your image, messages about trackball buttons A, B, C, and D assignments will appear in your terminal window. These have been mapped into the keypad keys <PF1>, <PF2>, <PF3>, and <PF4>, respectively. To activate the screen cursor functions, press and hold <MB1> while moving the mouse.

To end your AIPS session:

```
> exit
```

6.4.2.2 Getting Help in AIPS

There are three ways to get help in AIPS. The first way is to type HELP. This brings up a four page description of AIPS help. A second method is to type HELP *taskname* for a more detailed description of a function. To find out the proper usage and syntax of a function, type EXPLAIN *taskname*. **Note:** The explanation will be sent to the default printer you selected at the beginning of your session, *none of which are at Goddard.*

If a help file is longer than one screen, press <CR> to move forward to the next screen. When you reach the bottom of a help file, AIPS automatically exits the file and brings you back to the command prompt.

6.4.3 SAOimage

SAOimage works as a standalone package only on the ULTRIX workstation. Invoke it by spawning a process:

```
% saoimage
```

6.5 PROGRAMMING LANGUAGE COMPILERS

Programs written in FORTRAN and C can be compiled on the ULTRIX or VMS workstations. The CGIF supports the widely used International Mathematics and Statistics Library (IMSL). To link to any IMSL routines, include the object library **IMSL$DIR:IMSL** in your LINK statement.

6.5.1 FORTRAN

6.5.1.1 On the VMS Machines

To compile and link a FORTRAN program *filename*.**FOR** on the VAX, simply type

```
$ FORTRAN filename
```

This creates a file *filename*.**OBJ**. Now enter

```
$ LINK filename
```

The result is a file named *filename*.**EXE**; to run this, type RUN *filename*. You do not need to enter the file name extension; the computer will automatically look for files with the default extensions given above.

To find information on any command qualifiers you might want to add, type HELP FORTRAN at the prompt.

6.5.1.2 On the ULTRIX Workstation

To compile and link a FORTRAN program on the ULTRIX workstation, type

```
% f77 -o filename filename.f subroutine_1.f subroutine_2.f
```

This produces a linked program called *filename*, which is executed by simply typing the filename at the % prompt.

To find help information on any command qualifiers you might want to add, type man f77 at the prompt.

6.5.2 C

6.5.2.1 On the VMS Workstation

The VMS workstation uses GNU C. You will need to create an options file called **VAXCRTL.OPT** consisting of the single line

```
SYS$SHARE:VAXCRTL/SHARE
```

To compile, link and run the C program **PROGRAM.C**, type

```
$ GCC PROGRAM
$ LINK PROGRAM, VAXCRTL.OPT/OPT, GNU_CC:[000000]GCCLIB/LIB
$ RUN PROGRAM
```

6.5.2.2 On the ULTRIX Workstation

The ULTRIX machine has two C compilers on it -- the standard DEC/ULTRIX C compiler and the GNU C compiler. We recommend the use of the latter. In the commands below, cc should be substituted for gcc to invoke the DEC C compiler.

To compile, link to the math library, and run a program **myprogram.c** on the ULTRIX workstation, type

```
% gcc -o myprogram myprogram.c -lm
% myprogram*
```

Further information can be obtained by typing manl gcc or (man cc) at the command line.

6.6 WORD PROCESSING PACKAGES

Several word processing packages are available at the CGIF. TeX and LaTeX are supported on the ULTRIX and VMS workstations. The Macintosh supports Microsoft Word.

6.6.1 TeX and LaTeX on the VMS Workstation

TeX and LaTeX files are compiled on the VAX via two commands:

$ TEX *filename* or **$** LATEX *filename*

for TeX and LaTeX, respectively. (Be sure to include the file extension if it is not **.tex**.) These commands create a *FILENAME*.**DVI** file. Now use the command

$ DVIPS *filename*.DVI

for both TeX and LaTeX to create a PostScript file (*filename*.**PS**).

6.6.2 TeX and LaTeX on the ULTRIX Workstation

TeX and LaTeX files are compiled on ULTRIX via two commands:

$ tex *filename* or **$** latex *filename*

for TeX and LaTeX, respectively. (Be sure to include the filename's suffix if it is different than **.tex**.) These commands create a *FILENAME*.**DVI** file. Now use the command

$ dvips -o *PS_filename filename*.dvi

for both TeX and LaTeX to create a PostScript file *PS_filename*.

6.6.3 Microsoft Word on the Macintosh

To use Microsoft Word, first double-click on the **hard disk** icon. Now double-click on the **MICROSOFT WORD** folder. Finally, double-click on **Microsoft Word**. This brings up a blank screen in which to begin your file.

7 OTHER PRINTED RESOURCES

Guest investigators may find the following documents helpful: the *Proposer Information Package*, the *Explanatory Supplement* for each instrument, the *CGIS Software User's Guide*, and the *COBE Software Catalog*. Each of these is described in more detail in subsequent sections.

All but the *Explanatory Supplements* may be viewed using the CGIS Executive (**`Documentation`** branch).

The fastest way to get a hardcopy at your remote site is to transfer the files from the appropriate anonymous FTP host listed for each below and print them on your local printer. If you would like a hardcopy and you are visiting the CGIF or if you do not have anonymous FTP capability, contact the documentation support person listed in Table 2-1.

7.1 PROPOSER INFORMATION PACKAGE

This document, intended for prospective guest investigators, provides details on the COBE data products as well as the computing hardware and software provided by the GI program.

FTP host: `nssdca.gsfc.nasa.gov`
File location: **`ANON_DIR:[000000.COBE.PROJECT_DATA_SETS]`**

File names:		
	`PROPOSER_INFO_FIG1.PS`	(PostScript figure)
	`PROPOSER_INFO_FIG2.PS`	(PostScript figure)
	`PROPOSER_INFO_FIG3.PS`	(PostScript figure)
	`PROPOSER_INFO_FIG4.PS`	(PostScript figure)
	`PROPOSER_INFO_PKG.DOC`	(ASCII version of document; does NOT include figures)
	`PROPOSER_INFO_PKG.PS`	(PostScript version of document; does NOT include figures)

7.2 EXPLANATORY SUPPLEMENTS

These documents describe the released data products in great detail, as well as discussing instrument calibration and limitations of the data products. They are intended for anyone interested in an in-depth description of the data processing.

FTP host: `nssdca.gsfc.nasa.gov`

DIRBE:

File location: **`ANON_DIR:[000000.COBE.PROJECT_DATA_SETS.DIRBE.DOC]`**

File names: not released as of 12/13/94. Files will use **`.DOC`** extension for ASCII versions, **`.PS`** for PostScript. PostScript documents do not include any figures, so any files containing the figures must be transferred separately.

DMR:

File location: **`ANON_DIR:[000000.COBE.PROJECT_DATA_SETS.DMR.DOC]`**

File names:		
	`DMR_PDS_EXPLANATORY_SUPPL.PS`	(PostScript)
	`DMR_PDS_EXPLANATORY_SUPPL.TEX`	(LaTeX)
	`DMR_PDS_PRODUCTS.DOC`	(ASCII)

FIRAS:

File location: **`ANON_DIR:[000000.COBE.PROJECT_DATA_SETS.FIRAS.DOC]`**

File names:		
	`FIRAS_PDS_PRODUCTS.DOC`	(ASCII)
	`FIR_APPDX_`*y*`.TEX`**	(LaTeX appendices; *y* is **`A`**, **`B`**, **`C`**, **`D`**, **`E`**, or **`F`**)
	`FIR_APPDX_C_FIG`*n*`.PS`**	(PostScript figures for appendix C, *n* is **`2`**, **`4`**, **`5`**, **`6`**, **`7`**, **`8`**, or **`9`**)
	`FIR_APPDX_D_FIG`*n*`.PS`**	(PostScript figures for appendix D; *n* is **`1`**, **`2A`**, **`2B`**, **`3`**, **`4`**, **`5`**, **`6`**, or **`7`**)
	`FIR_APPDX_`*y*`.TXT`**	(ASCII; *y* is **`G`**, **`H`**, or **`I`**)
	`FIR_EXP_SUP.PS`	(PostScript)
	`FIR_EXP_SUP.TEX`	(LaTeX)
	`FIR_EXP_SUP_FIG5-`*n*`.PS`**	(PostScript; *n* is **`1`**, **`2`**, or **`3`**)
	`FIR_MACRO.TEX`	(LaTeX macro file)

7.3 COBE GUEST INVESTIGATOR HANDBOOK

This document.

FTP host: `cuba.gsfc.nasa.gov`

File location: **`pub/cobe-gi/doc`**

File names:		
	`gihb21.asc`	(ASCII version; no figures)
	`gihb21.ps`	(PostScript version; no figures)
	`gihb21.wp`	(WordPerfect 5.1 version; no figures)
	`gihbfiga`*n*`.ps`**	(PostScript figures for appendix A; *n* is **`1`**, **`2`**, or **`3`**)
	`gihbfigc`*n*`.ps`**	(PostScript figures for appendix C; *n* is **`1`**, **`2`**, **`3`**, or **`4`**)

One figure for this document is available only in the hardcopy.

7.4 CGIS SOFTWARE USER'S GUIDE

You may find it helpful to have a copy of the *CGIS Software User's Guide* while using the COBE software. The guide will take you through the branches of the CGIS Executive, show you the many functions of UIMAGE, and walk you through examples in UIDL to acquaint you with its capabilities. It is also useful as a reference for UIMAGE and UIDL.

FTP host: `cuba.gsfc.nasa.gov`
File location: **`pub/cobe-gi/doc`**
File names:

`user22`*yy***`.asc`**	(ASCII version of the document; no figures. This document has been broken up into several files. *yy* is either a two-digit chapter/section number or a two-letter designation for title pages, index, *etc*.)
`user22`*yy***`.ps`**	(PostScript version; no figures; *yy* as above)
`user22`*yy***`.wp`**	(WordPerfect 5.1 version; no figures; *yy* as above)
`user22d`*n***`.ps`**	(PostScript figures for appendix D; *n* is **`1`**, **`2AB`**, **`2C`**, **`3`**, **`4`**, or **`5`**.)
`user22g`*n***`.ps`**	(PostScript figures for appendix G; *n* is **`1`**, **`2`**, **`3`**, or **`4`**.)

7.5 COBE SOFTWARE CATALOG

The *COBE Software Catalog* is a handy reference for anyone doing data analysis using the COBE UIDL tools. The catalog lists the help files for all of the UIDL routines, as well as listing and describing unconfigured routines used by the instrument teams. Note that these unconfigured routines are not available to the guest investigator community.

FTP host: `cuba.gsfc.nasa.gov`
File location: **`pub/cobe-gi/doc`**
File names:

`csc.asc`	(ASCII version)
`csc.ps`	(PostScript version)
`csc.wp`	(WordPerfect 5.1 version)

7.6 LIBRARIES AVAILABLE TO GUEST INVESTIGATORS

COBE preprints are available from Susan Adams at the CGIF. Preprints from other institutions are also available for browsing but not borrowing. In addition, guest investigators have access to the Goddard library, also located in Goddard Building 21. The GSFC library is open 8 AM to 6 PM, Monday through Friday.

APPENDIX A VISITING THE CGIF

AIRPORTS

Directions from local airports to the CGIF (see Figure A-1 for a map).

From Dulles Airport:

Follow signs for the Dulles Toll Road toward Washington until you reach I-495, the Capitol Beltway. Take I-495 North toward Baltimore. I-495 changes to I-95; take I-95 South. Do NOT take I-95 North to Baltimore. Get off at Exit 23, which is Route 193 (Greenbelt Road). Turn left (193 East) at the stop light. The Goddard Space Flight Center is on the left approximately 3 miles down Greenbelt Road, opposite the Cipriano Square Shopping center.

From Baltimore Washington International (BWI) Airport:

Follow the airport exit signs to I-295 South toward Washington. (I-295 is also known as the Baltimore Washington (BW) Parkway.) After about 18 miles, take the Greenbelt exit (Route 193). Turn left at the stop sign onto Southway. Turn left at the traffic light onto Route 193 (Greenbelt Road), heading east. The Goddard Space Flight Center is on the left 2 miles down Greenbelt Road, opposite the Cipriano Square shopping center.

There is also a limousine service from BWI based two miles from GSFC that runs approximately every hour for $10. Special dropoff is available for a higher rate. (See **Ground Transportation** below.)

From National Airport:

By car (the longer but easier way):
Follow the exit signs for the George Washington Memorial Parkway (I-66). Stay on I-66 for about 12 miles (keep right when it forks) until you reach I-495. Take I-495 North toward Baltimore. I-495 changes to I-95; take I-95 South. Do NOT take I-95 North to Baltimore. Get off at Exit 23, which is Route 193 East (Greenbelt Road). Turn left (193 East) at the stop light. The Goddard Space Flight Center is on the left, about 3 miles down Greenbelt Road, opposite the Cipriano Square shopping center.

By car (the shorter but harder way):
Follow the airport exit signs for the George Washington Memorial Parkway (I-395). Take I-395 North until it ends. Note that I-395 becomes Pennsylvania Avenue. After you cross the Anacostia Freeway and the Anacostia River on the 14th Street bridge, there is an unmarked left turn to the Anacostia Freeway heading north. Take that left and you will be on what will become the Baltimore Washington Parkway. Follow it north past the exits for the Beltway (I95). Take the next exit for Greenbelt Road (Route 193, also marked for NASA Goddard). Turn left at the traffic light. The Goddard Space Flight Center will be on your left, about a mile down Greenbelt Road and opposite the Cipriano Square shopping center.

By Metro rail (minimum operating hours are 10AM to midnight):
(See Figure A-2 for a map of the Metro rail lines.) Take the yellow line from National Airport toward Mount Vernon Square-UDC but get off at L'Enfant Plaza. Get on the orange line to New Carrollton. At New Carrollton, a taxi cab can be hired for about $10 to complete your trip to Goddard. Taxis line up at a staging area on the lower level of the Metro station. (See the "by car" instructions if the driver is unfamiliar with the GSFC area.)

The Greenbelt station on the green line is now open, although currently the entire green line is not. Change from the yellow line to the red line at Gallery Place, then change to the green line at Fort Totten. Local bus service is available.

GROUND TRANSPORTATION

BWI limo:

The Airport Connection II
Service to BWI airport from Greenbelt with connections to Dulles and National through their downtown Washington terminal.
(301) 441-2345

Metro rail:

Washington's Metro rail service provides an easy way to get around the downtown Washington area. A map of the metro service area can be found on page A-6. Metro fares are usually around $1.50 per trip.

Taxi services:

Checker/Takoma Langley Taxi Company
Serves Prince George's County / 24 Hours
(301) 270-6000
(301) 270-2200

Diamond Cab Company
Serves Prince George's County
(301) 499-4800

Dulles Airport Express Taxi
Serves entire Metro Area / 24 hours
(703) 406-0003
1 (800) 995-TAXI

Figure A-1. Schematic of the Washington metropolitan area, showing airports and major highways.

Figure A-2. Schematic of the Washington Metro routes.

LODGING

Room release can be avoided by confirming with a credit card. If you are a government employee, specify that you qualify for the government room rate. If you do book a hotel with the government rate, the hotels may require government ID when checking in. Letters in parentheses correspond to location on Figure A-3.)

Best Western Maryland Inn
8601 Baltimore Blvd.
College Park, MD
(301) 474-2800

The Courtyard by Marriott (B)
6301 Golden Triangle Drive
Greenbelt, MD
(301) 441-3311

The Courtyard by Marriott
8330 Corporate Drive
Landover, MD
(301) 577-3373

Days Inn of College Park
9137 Baltimore Blvd.
College Park, MD
(301) 345-5000

The Greenbelt Marriott (A)
6400 Ivy Lane
Greenbelt, MD
(301) 441-3700

Best Western - Capitol Beltway (D)
5910 Princess Garden Parkway
Lanham, MD
(301) 459-1000

Red Roof Inn (E)
9050 Lanham-Severn Road
Lanham, MD
(301) 731-8830

Ramada New Carrollton (F)
8500 Annapolis Road
New Carrollton, MD
(301) 459-6700

The Holiday Inn Greenbelt (C)
7200 Hanover Parkway
Greenbelt, MD
(301) 982-7000

RESTAURANTS

(Numbers correspond to locations on Figure A-3.)

Greenway Center (2):

Chesapeake Bagel Bakery (bagels) $3-$5
Chi Chi's (Mexican) $5-$10
Jasper's (variety) $5-$15
Wendy's (fast food) $1-$5
Safeway Market (salad/sandwiches) $3-$5

Cipriano Square (3):

Baskin Robbins (ice cream) $1-$3
Burger King (fast food) $1-$5
Gourmet Take-Away (deli) $3-$5
Hunan Village (Chinese) $5-$10
Maharaja (Indian) $8-$12
Osaka (Japanese sushi) $5-$10

Eastgate Shoppers World (4):

Kentucky Fried Chicken (fast food) $1-$5
McDonald's (fast food) $1-$5
Pizza Hut $4-$10

Beltway Plaza (1):

3 Brother's Pizza $3-$8
Bennigan's (variety) $5-$12
Chef's Secret (seafood) $10-$20
Chesapeake Bay Seafood $5-$15
Chi-Chi's (Mexican) $5-$10
Hardee's (fast food) $1-$5
Popeye's Chicken (fast food) $2-$5
Wendy's (fast food) $1-$5

Some other favorites...

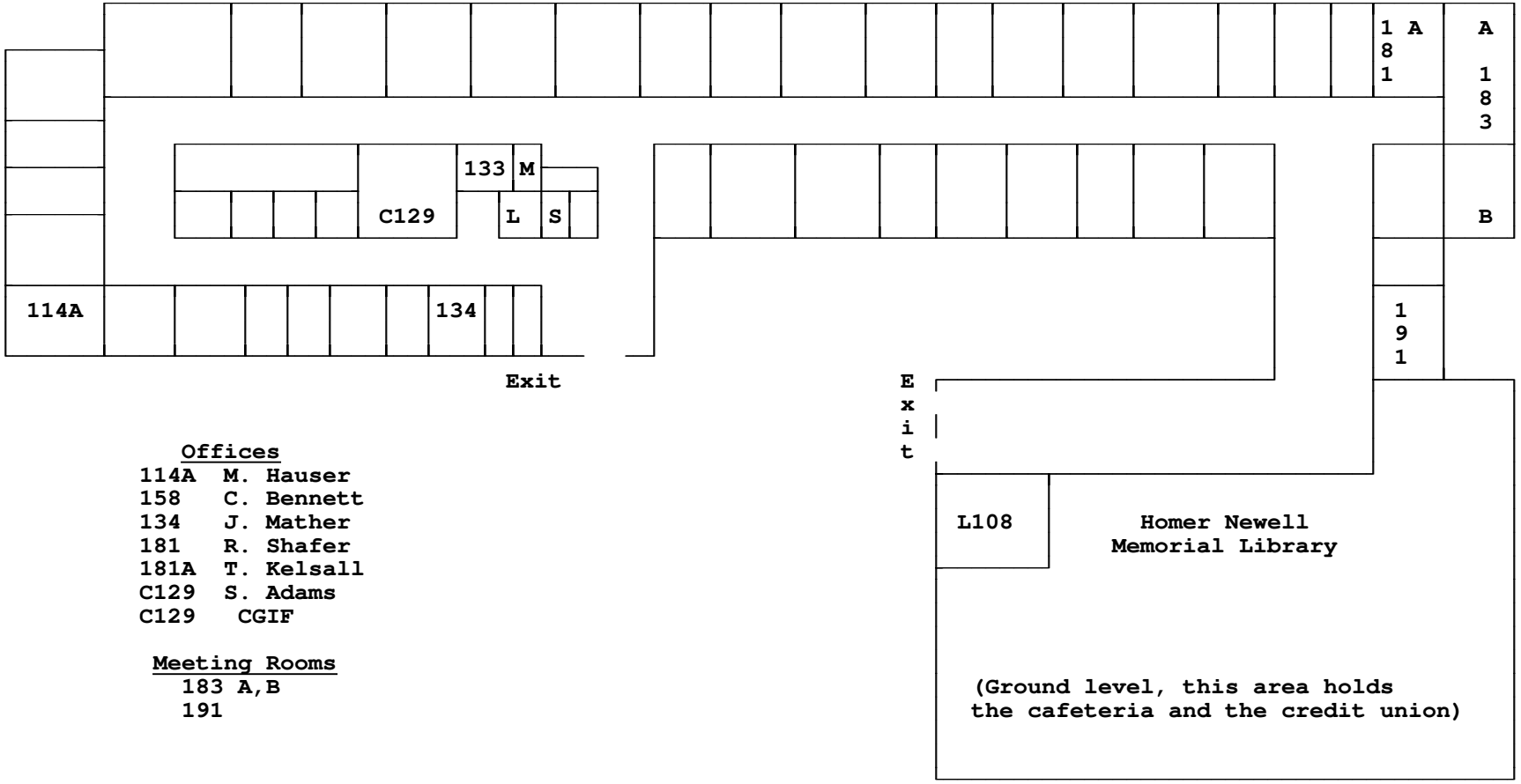
Beijing of Greenbelt (Chinese) $5-$15
131 Centerway (Located in Old Greenbelt) (6)
Sir Walter Raleigh's (steak & salad) $10-$20
6323 Greenbelt Road (Located between Greenway Center and Beltway Plaza) (5)
T.G.I. Friday's (variety) $5-$15
6460 Capitol Drive (Located between Greenway Center and Beltway Plaza) (7)

Figure A-3. Map of hotels and restaurants near Goddard. Circled letters and numbers refer to restaurants and hotels on preceding pages. Approximate distances are: F to 4, 5 miles; 1 to Goddard, 3 miles; CDAC to Goddard, 1 mile.

Figure A-4. Layout of the Goddard Space Flight Center.

MAIN GATE- OPEN 24 HOURS * 7 DAYS A WEEK
PARKWAY GATE & EAST GATE- OPEN 6 AM - 7 PM * MON-FRI ONLY

1 Space Projects Building- Cafeteria GEWA store, I.D., Personnel, Travel, Security
2 Research Projects Lab
3 Central Flight Control & Range Operations Bldg Information Technology Center
4 Plan Operations Bldg
5 Instrument Construction & Development Lab, Health Unit
6 Space Sciences Laboratory
7 Payload Testing Facility
8 Administration Building
9 Main Gate House
10 Environmental Testing Lab
11 Applied Sciences Lab
12 Tracking & Telemetry Lab
13 Network Control Center Facility
14 Spacecraft Operations Facility
15 High Capacity Centrifuge Facility
16 Logistic & Supply Facility- Shipping and Receiving
16W Logistic & Supply Facility
17 Administrative Support Bldg- Safety office, Facilities Engineering Division
18 Administrative Support Bldg- Information Technology Center
19 Technical Support Building
20 Technical Support Building- Mailroom
21 Meteorological Systems Installation Lab Cafeteria, Library, Credit Union
22 Space & Terrestrial Applications Facility
23 Data Interpretation Lab
24 Central Heating & Refrigeration Plant
25 NTTF and Hydromechanical Lab
26 NASA Space Science Data Center
27 Mobile Equipment Support Facility- Hazardous/waste Chemical Storage Facilities
28 Technical Processing Facility
29 Spacecraft Systems Development & Integration Facility
85 Center Management Facility
87 Gas Cylinder Storage Bldg.
88 Visitor's Center
89 Ordinance Building
90 Day Care Center
97 Plant Maintenance Support Facility
98 Center Management Facility
99 Center Management Facility



Offices

114A	M. Hauser
158	C. Bennett
134	J. Mather
181	R. Shafer
181A	T. Kelsall
C129	S. Adams
C129	CGIF

Meeting Rooms

183 A,B
191

BUILDING 21 FLOOR LAYOUT

APPENDIX B ACRONYMS USED IN THIS MANUAL

ADB	Astronomical Database
ADC	Astronomical Data Center
ADT	Absolute Date and Time (VAX time unit)
AIPS	Astronomical Image Processing System
CDAC	Cosmology Data Analysis Center
CD ROM	Compact Disc, Read-Only Memory
CGIF	COBE Guest Investigator Facility
CGIS	COBE Guest Investigator Support
CISS	COBE IDL Save Set
CMB	Cosmic Microwave Background
COBE	Cosmic Background Explorer
CPU	Central processing unit
CSDR	COBE Science Data Room
DCL	Digital Command Language
DIRBE	Diffuse Infrared Background Experiment
DMR	Differential Microwave Radiometer
FIRAS	Far Infrared Absolute Spectrophotometer
FTP	File Transfer Protocol
GHz	Gigahertz
GI	Guest Investigator
GSFC	Goddard Space Flight Center
I/O	Input/Output
IDL	Interactive Data Language
IMSL	International Mathematical and Statistical Libraries (replaced by just IMSL, Inc. now)
IP	Initial Product (first publicly released data)
IRAF	Image Reduction and Analysis Facility
IUE	International Ultraviolet Explorer

NDADS	NSSDC Near-Line Data Service
NOAO	National Optical Astronomical Observatories
NODIS	NSSDC's On-line Data Information Services
NSSDC	National Space Science Data Center
PDS	Project Data Sets
RPM	Revolutions Per Minute
SPoC	Single Point of Contact
SWG	Science Working Group
UIDL	Utility IDL (enhanced IDL)
URL	Uniform Resource Locator
WWW	World Wide Web

APPENDIX C THE COBE SKYCUBE AND PROJECTION EQUATIONS

THE COBE SKYCUBE

COBE data is pixelized using a variation of a quadrilateralized spherical projection that was originally developed for Earth science databases. In this scheme, the sky is projected onto a cube (also called a *skycube*), with faces numbered 0 through 5. Face 0 contains the North Ecliptic Pole and face 5 contains the South Ecliptic Pole. The Ecliptic plane spans the remaining faces. (See Figures C-1 and C-2.) The reference frame for the cube is defined by axes normal to faces 1 and 0. In Geocentric Ecliptic coordinates, these directions correspond to the vernal equinox and the North Ecliptic Pole. Additional details of the quad-sphere projection, including coordinate transformations, are found in the references.

The terminology used to indicate the level of resolution is resolution n, where $n-1$ is the number of subdivisions that were made to the face. For instance, a face with resolution 6 was subdivided 5 times, has $2^5 = 32$ pixels on a side, and has $4^5 = 1024$ total pixels.

The standard DIRBE pixel resolution is 256 × 256 per cube face (resolution 9), with a pixel size of approximately 0.32 × 0.32 degrees. For DMR and FIRAS, the standard resolution is 32 × 32 per cube face (resolution 6), corresponding to a pixel size of about 2.6 × 2.6 degrees. Figures C-3 and C-4 illustrate the pixel numbering for both DIRBE and FIRAS/DMR resolutions.

References

Chan, F. K. and O'Neill, E. M. *Feasibility Study of a Quadrilateralized Spherical Cube Earth Data Base*, EPRF Technical Report 2-75 (CSC), March 1975.

O'Neill, E. M. and Laubscher, R. E. *Extended Studies of a Quadrilateralized Spherical Cube Earth Data Base*, NEPRF Technical Report 3-76 (CSC), May 1976.

White, R. A. and Stemwedel, S. W. 1992, ''The Quadrilateralized Spherical Cube and Quad-Tree for All Sky Data,'' in *Astronomical Data Analysis Software and Systems I*, eds. D. M. Worrall, C. Biemesderfer, and J. Barnes (San Francisco: ASP), pp. 379-381.

Figure C-1. COBE skycube, ecliptic coordinates.

Figure C-2. COBE skycube, galactic coordinates.

Figure C-3. COBE skycube, resolution 6 pixel numbering.

Figure C-4. COBE skycube, resolution 9 pixel numbering.

SKYCUBE PROJECTION POLYNOMIALS

To create the skycube, the sky is projected onto a curvilinear grid ruled on the faces of a cube. The polynomial grid is chosen to minimize the variation in the projected area of any pixel on each face separately.

The projection polynomials used by COBE can be found in *Extended Studies of a Quadrilateralized Spherical Cube Earth Data Base*, O'Neill E.M. and Laubscher R.E., Computer Sciences Corporation, May 1976, NEPRF Technical Report 3-76 (CSC).

The polynomial coefficients used by COBE differ from those found in the reference above. The actual coefficients used by COBE are listed on the last page of this appendix.

Further information about the projection polynomials can be found in the *Feasibility Study of a Quadrilateralized Spherical Cube Earth Data Base*, Chen F. K. and O'Neill E. M., March 1975, EPRF Technical Report 2-75 (CSC).

The mapping function, also known as the direct function, is

$$f^*(\alpha,\beta) = r_o \left[x_1 + x_2 + x_3 \right]$$

where

$$x_1 = \gamma^* \alpha + (1-\gamma^*)\alpha^3$$

$$x_2 = \alpha\,\beta^2\,(1-\alpha^2)\,\left[M + (\Gamma - M)\,(1-\alpha^2) + (1-\beta^2) \sum_{\substack{i\geq 0 \\ j\geq 0}} C_{ij}\,\alpha^{2i}\,\beta^{2j}\right]$$

$$x_3 = \alpha^3\,(1-\alpha^2)\,\left[\,\Omega_1 + (1-\alpha^2) \sum_{i\geq 0} D_i\,\alpha^{2i}\,\right]$$

The rectangular coordinates (ξ, η) of the cube face points are related to the database coordinates (x, y) through these equations:

$$\xi = f(x, y)$$

$$\eta = f(y, x)$$

where the function $f(x,y)$, the inverse of $f^{*}(\xi, \eta)$, is given by

$$f(x,y) = \gamma x + \frac{(1-\gamma)}{r_o^2} x^3 + x y^2 \left(r_o^2 - x^2\right) \left[\delta + \left(r_o^2 - y^2\right) \sum_{\substack{i \geq 0 \\ j \geq 0}} c_{ij} x^{2i} y^{2j}\right]$$

$$+ x^3 \left(r_o^2 - x^2\right) \left[\omega + \left(r_o^2 - x^2\right) \sum_{i \geq 0} d_i x^{2i}\right]$$

The other important equations that relate the many variables are:

$$\delta = \frac{1}{4 r_o^4} \left[-(\mu + 2\gamma) + \sqrt{(\mu^2 - 4\mu\gamma + 4\gamma^2 + 16\sqrt{2}\,\gamma^2)}\right]$$

$$\omega = \frac{1}{2 r_o^4} \left(3 - 2\gamma - \mu - 2 r_o^4 \delta\right)$$

$$\Omega_1 = \frac{1}{2}(3 - 2\gamma^* - \mu_1^*) \qquad M = \frac{1}{2}(\mu_1^* - \mu^*)$$

$$C_{ij} = c_{ij}^* r_o^{2(i+j+3)} \qquad \gamma_1 = 1.0 - \gamma^*$$

$$D_i = d_i^* r_o^{2(i+3)} \qquad \Gamma = \gamma_1^* - \gamma^*$$

$$\delta^* = \frac{(\mu_1^* - \mu^*)}{2r_o^4} \qquad \delta_1^* = \frac{1}{r_o^2}\left((\gamma_1^* - \gamma^*) r_o^{-4} - \delta^*\right)$$

$$\gamma^* = 1/\gamma \qquad \gamma_1^* = \frac{1}{\gamma + r_o^4 \delta}$$

$$\mu^* = 1/\mu \qquad \mu_1^* = \frac{1}{\mu + 2 r_o^4 \delta}$$

$$\omega^* = \frac{1}{2r_o^4}\left(3 - 2\gamma^* - \mu^* - 2r_o^4 \delta^*\right)$$

The actual coefficients used in the COBE projections are:

$$\delta = 0.790486449\,1208 \qquad c_{00} = 0.141189631152$$

$$\omega = -1.225441487984 \qquad c_{10} = 0.0809701286525$$

$$\gamma = \sqrt{\pi/6} \qquad c_{01} = -0.281528535557$$

$$\mu = \sqrt{\sqrt{3}\,\pi/2} \qquad c_{11} = 0.15384112876$$

$$r_o = 0.577350269 \qquad c_{20} = -0.178251207466$$

$$M = 0.004869491981 \qquad c_{02} = 0.106959469314$$

$$\Omega_1 = -0.159596235474 \qquad d_0 = 0.0759196200467$$

$$\gamma^* = 1.37484847732 \qquad d_1 = -0.0217762490699$$

$$\Gamma = -0.13161671474$$

APPENDIX D NETWORK ADDRESSES

DECnet node name	Internet node name	IP Address System	DECnet numbers
ZWICKY	zwicky.gsfc.nasa.gov	128.183.87.26	15.851 = 16211
CUBA	cuba.gsfc.nasa.gov	128.183.87.27	15.852 = 16212
COBECL	tahiti.gsfc.nasa.gov	192.94.237.16	6.976 = 7120
STARS	stars.gsfc.nasa.gov	128.183.57.28	15.22 = 15382
NSSDCA	nssdca.gsfc.nasa.gov	128.183.36.23	15.188 = 15548

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