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PC-SEAPAK User's Guide

Version 4.0

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National Aeronautics and Space Administration

Goddard Space Flight Center
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Preface to the Goddard DAAC Edition

Dear CZCS customer,

In response to your request for documentation for the SEAPAK CZCS processing software, we have sent you the attached Users Manual. Although this Manual was written specifically for users of the PC version of SEAPAK, it is the best available documentation for all versions and it is the ONLY documentation on SEAPAK available from the Goddard DAAC. (This document is also available on-line on the Ocean Color Data & Resources website:
http://daac.gsfc.nasa.gov/CAMPAIGN_DOCS/OCDST/ob_main.html.)

If you have any questions about the contents of this Manual or the specifics of the SEAPAK software, please contact the authors, Gary Fu and Brian Schieber. They may be reached at the following phone numbers, emails and postal addresses:

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If you need further assistance or have any questions about the Goddard DAAC's products and services, please contact our Helpdesk at the numbers and addresses below.
Sincerely,

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INTRODUCTION

PC-SEAPAK is a user-interactive satellite data analysis package that is being developed at NASA/Goddard Space Flight Center (GSFC) and is designed to operate on an IBM PC-AT class micro-computer. Its primary applications are for the processing and interpretation of satellite imagery data from the Nimbus-7 Coastal Zone Color Scanner (CZCS) and the TIROS-N/NOAA satellite series' Advanced Very High Resolution Radiometer (AVHRR). It is a subset of the SEAPAK analysis system (Darzi et al., 1989; McClain et al., 1989 and 1991; Fuh et al, 1990; Firestone et al, 1990 and 1991) that runs on a DEC VAX-based system at the Oceans Computing Facility at GSFC. PC-SEAPAK is designed to provide the user with a user-friendly standardized interface that provides flexibility and allows the user to truly work with the data. The user interface is a modified version of an interface developed by General Sciences Corporation under another federal government contract. SEAPAK development activity is being supported by the Ocean Processes Branch at NASA/Headquarters.

The system described in this document is the fourth version of PC-SEAPAK. The original design of the system was completed in November, 1987 (Firestone and Chen, 1987; Firestone et al., 1989). The actual software development began in March, 1988. Certainly, there will be enhancements to the hardware configuration and to the software in the future. The structure of this manual is designed to be updated periodically as new versions are released, so sections are numbered independently of other sections and the manual is in a loose-leaf form. The manual includes sections which describe in some detail the various hardware and software components of the system, some discussions on particular data processing scenarios, an explanation of the PC-SEAPAK menu and the programs it contains, a reference section containing detailed descriptions of all the SEAPAK programs, references and a glossary.

The CZCS was the first spaceborne sensor designed specifically to measure the concentration of photosynthetic pigments and their degradation products in the ocean. It had six co-registered bands (5 visible and one in the thermal IR) with a swath and resolution (2200 km and 825 meters at nadir, respectively) similar to the NOAA AVHRR. The CZCS IR band did not work after about the first year and was only useful for thermal feature delineation when it did work. The derived products generated by the CZCS level-2 programs are upwelled water radiance at 443, 520 and 550 nm, aerosol radiance at 670 nm, pigment concentration, diffuse attenuation at 490 nm and Rayleigh radiance at 443 nm. A variety of programs have been developed which allow the user to derive and evaluate the input parameters required by the level-2 generation programs.

Since sea surface temperature (SST) is an important oceanographic parameter, a capability for handling SST fields from the AVHRR was developed. Many of the analysis tools developed for the CZCS derived product fields are also useful in analyzing SST fields. The algorithm for calculating the SST values from the AVHRR brightness temperatures varies depending on the satellite (TIROS-N or NOAA-6, 7, 8, 9, 10, 11, 12). PC-SEAPAK supports most of the SST algorithms that have been published for different satellites. In addition, PC-SEAPAK also allows the user to enter coefficients for a generalized SST equation.

PC-SEAPAK is organized into several categories of programs in menus that include level-1 data ingest, CZCS level-2 analyses, statistical analyses, data extraction, remapping to standard projections, graphics manipulation, image board memory manipulation and general utilities. Most programs allow user interaction not only through the menu and command modes, but also allow the user to work within a program by using the mouse cursor to define pixels or areas of interest and the function keys from which subprocesses may be executed in any order and any number of times without exiting the main program. Most programs provide for ASCII file generation for further analysis in spreadsheets, graphics packages, etc.

Obtaining PC-SEAPAK and User Support: PC-SEAPAK is available from the website of the Distributed Active Archive Center at NASA Goddard Space Flight Center, Code 902, Greenbelt, MD 20771; http://daac.gsfc.nasa.gov; tel., 301-614-5224). Support provided to the user community by the GDAAC Helpdesk includes assistance with obtaining the software and documentation and with the hardware and software configuration requirements. For assistance with known PC-SEAPAK software errors and useage restrictions, or, if you need assistance with PC-SEAPAK software functionality, please contact Gary Fu (tel., 301-286-7107; gfu@shark.gsfc.nasa.gov).

Obtaining CZCS Data: The following types of CZCS data may be obtained from the CZCS archive at NASA/GSFC Distributed Active Archive Center:

- Level 1 — Full resolution, swath projection (unmapped), calibrated radiance data for all six CZCS bands in a single scene.
- Level 1b — Subsampled (every fourth pixel and line) level-1 data for bands 1 to 5; about 4km resolution.
- Level 2 — Derived geophysical parameters for a single, unmapped CZCS scene at 4km resolution.
- Level 3 — Level-2 composited, Earth-gridded (binned) data.

Table 1. Data formats available for 9-track and 8mm tapes.

Format	Data	Procedure to Create Tape under VAX/VMS
CRT	Level 1	Special program
VAX backup	Levels 1,1b,2,3	BACKUP command
Archive foreign	Levels 1,1b,2,3	MOUNT/FOREIGN and COPY
Archive labeled	Levels 1,1b,2,3	MOUNT/LABEL & COPY (ANSI)

Format options for these products are summarized in Table 1:

Table 2 identifies the proper PC-SEAPAK programs to use for the various formats and media of the data products. The Cipher M990 tape drive with the Flagstaff Engineering tape utilities may be used for 9-track tapes; the Summus drive with its Gigasafe utilities may be used for the 8mm tapes. **Note that these Summus utilities do not handle "foreign" tapes.** (Summus is no longer in business, although many PC-SEAPAK users may own this drive.) For the M990, we recommend that 1,600 bit/inch tapes be requested since problems with reading tapes of higher densities have been reported.

Obtaining CZCS data: In order to evaluate CZCS coverage, a WWW browse capability has been developed which allows the user to query a data base using latitude and longitude ranges and time interval parameters to visually examine the CZCS scenes available which satisfy the query criteria. THE WWW CZCS Browser can be found on the Goddard DAAC’s Ocean Color website at

http://daac.gsfc.nasa.gov/CAMPAIGN_DOCS/BRS_SRVR/czcsbrs_main.html

For information about the CZCS archive, contact the Goddard DAAC Ocean Color Data Support Team, Code 902, NASA/GSFC, Greenbelt, MD 20771 (301-614-5224 voice,301-614-5268 fax, ocdst@daac.gsfc.nasa.gov). All products orderable from the Goddard DAAC website and Browser are available at no charge.

Progra				
PSTIMG	3	ANSI,foreign	9-track,8mm	disk
TPCZCS,TP				
DKCZCS,DSK2DSK	1	CRT	9-track	disk
DKCZCS,DSK2DSK	1	ANSI,foreign	9-track,8mm	disk
DSPIMG	1b,2	ANSI,foreign	9-track,8mm	disk

Obtaining AVHRR Data: To obtain NOAA AVHRR level-1b data, contact Will Gould, Room 100, NOAA/Satellite Data Service Division, 5627 Allentown Road, Camp Spring, MD 20746 (tel., 301-763-8400). Also, one should refer to Brown et al. (1985), Kidwell (1988), Planet (1988), and Weinreb et al. (1990) regarding AVHRR data formats and calibration. The JPL DAAC offers a CDROM product containing co-registered CZCS and AVHRR SST data. To request this product and other AVHRR SST products, contact the JPL Physical In Oceanography DAAC User Services Office, NASA/Jet Propulsion Laboratory, MS 300-320, 4800 Oak Grove Drive, Pasadena, CA 91109, (818-354-9890 voice, 818-393-2718 fax, jpl@eos.nasa.gov)

SYSTEM ENVIRONMENT: HARDWARE

1. SYSTEM CONFIGURATION

The updated configuration for the original PC-SEAPAK development is shown in Figure 1. (The availability, price, and performance of hardware components are subject to frequent changes. The user should contact vendors directly to obtain the most current product information. See Appendix for recommended hardware and vendor information.) The main computational engine is a COMPAQ 386 (20, 25, or 30 MHz) which uses the Intel 80386 microprocessor. An Intel 80387 and a Weitek floating-point coprocessors, a 60 megabyte hard disk, and two floppy disk drives (a 5.25 inch with 1.2 MB capacity and a 3.5 inch with 1.44 MB capacity) are included in the system. The 80387 coprocessor is necessary in this system since it can greatly increase the speed of floating-point calculations and all the PC-SEAPAK software is built around it. The Weitek coprocessor is 2 to 3 times faster than the 80387.

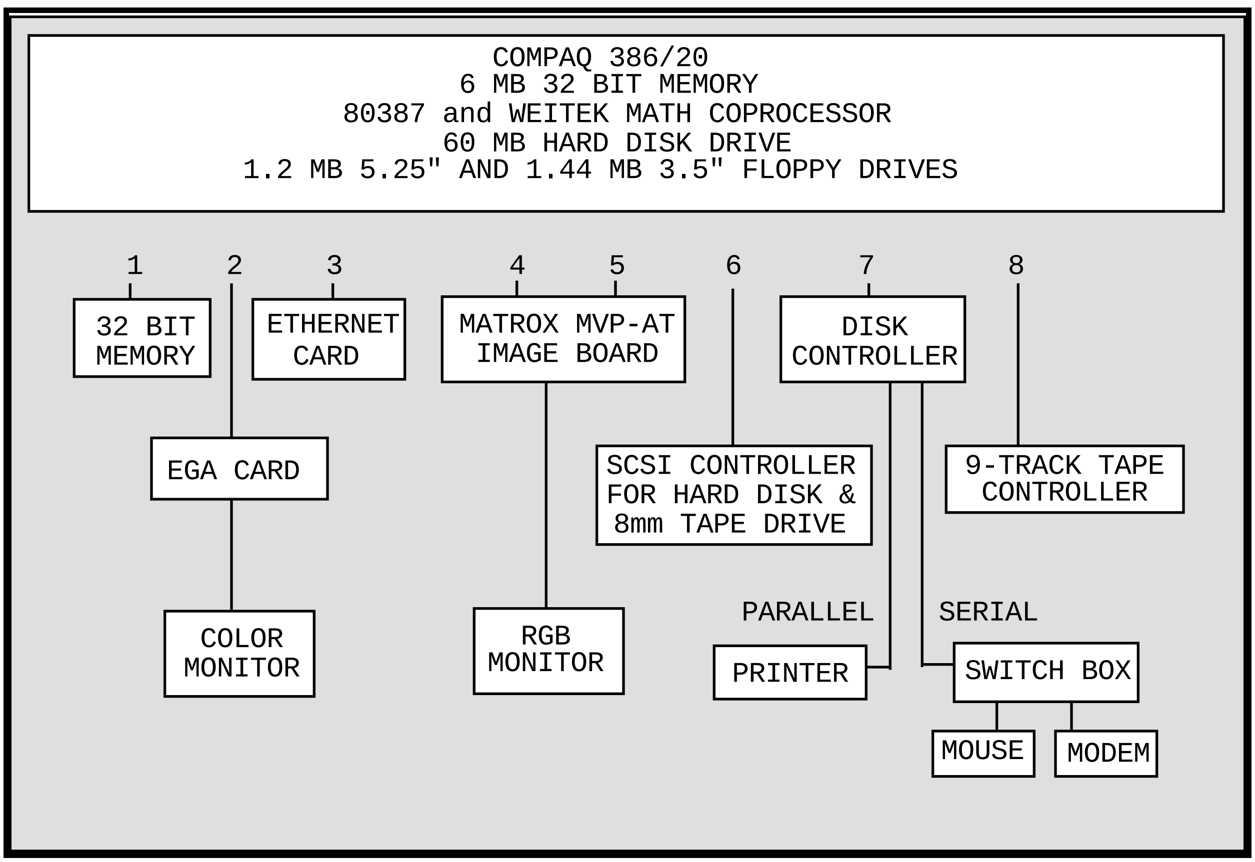

Figure 1. System Configuration 1

It is an option to the PC-SEAPAK configuration and only a few programs in PC-SEAPAK are available to run with this coprocessor. The hard disk normally is used for storing files of PC-SEAPAK and files associated with any additional software development. The floppy drives are used for transferring files to and from other sources.

There are eight slots available for industry-standard expansion boards: one 32-bit memory slot, five full-sized 8-/16-bit slots, one full-sized 8-bit slot, and one half-size 8-bit slot. Currently, all the slots are used in this configuration.

In slot 1, on the 32-bit memory board, there are 6 MB of memory installed. Up to 16 MB memory may be put on the memory board. The extra memory (greater than the DOS 640 KB range) may be used as a virtual disk to improve the I/O throughput or may be used to run multi-tasking under expanded memory management applications like Quarterdeck's DESQview and QEMM. Also, it can be used for application programs that have been developed using Phar Lap's DOS-Extender and MicroWay's NDP Fortran-386 compiler to directly access the memory up to the limit.

In slot 2, the AST-3G EGA controller card is installed. A serial and a parallel port are supported by this card. However, this card requires another slot for these two ports and, since none are available, the two ports are not used in this configuration.

In slot 3, the 3Com EtherLink board 3C501 is installed. This board, combined with the DECnet-DOS network software, allows the workstation to be directly linked to the VAX cluster of the NASA/GSC Oceans Computing Facility through a thin-wire Ethernet.

In slots 4 and 5, the Matrox MVP-AT image board is installed This is a two-board image processing set with one megabyte of memory which is configured as four 512x512x8-bit frame buffers under PC-SEAPAK.

In slot 6, the Summus SCSI controller card is installed. The SCSI interface allows up to seven device drives to be daisy-chained into the same port. Summus supports a number of Imprimis WREN disk drives (capacities ranging from 100 MB to 1 GB), an 8mm tape drive and an erasable optical disk, all of which can be daisy-chained on the same SCSI interface. This is an excellent solution for unlimited storage, data backup and data exchange.

In slot 7, the Compaq's Multipurpose Fixed Disk Drive Controller card is installed. This card is included with the COMPAQ 386/20 system. It controls the 60 MB hard disk drive and the 5.25 and the 3.5 inches floppy diskettes drives. A parallel and a serial port are included in this card. In this configuration, the parallel port is connected to the printer and the serial port is used to connect to the modem and the mouse input device via a switch box.

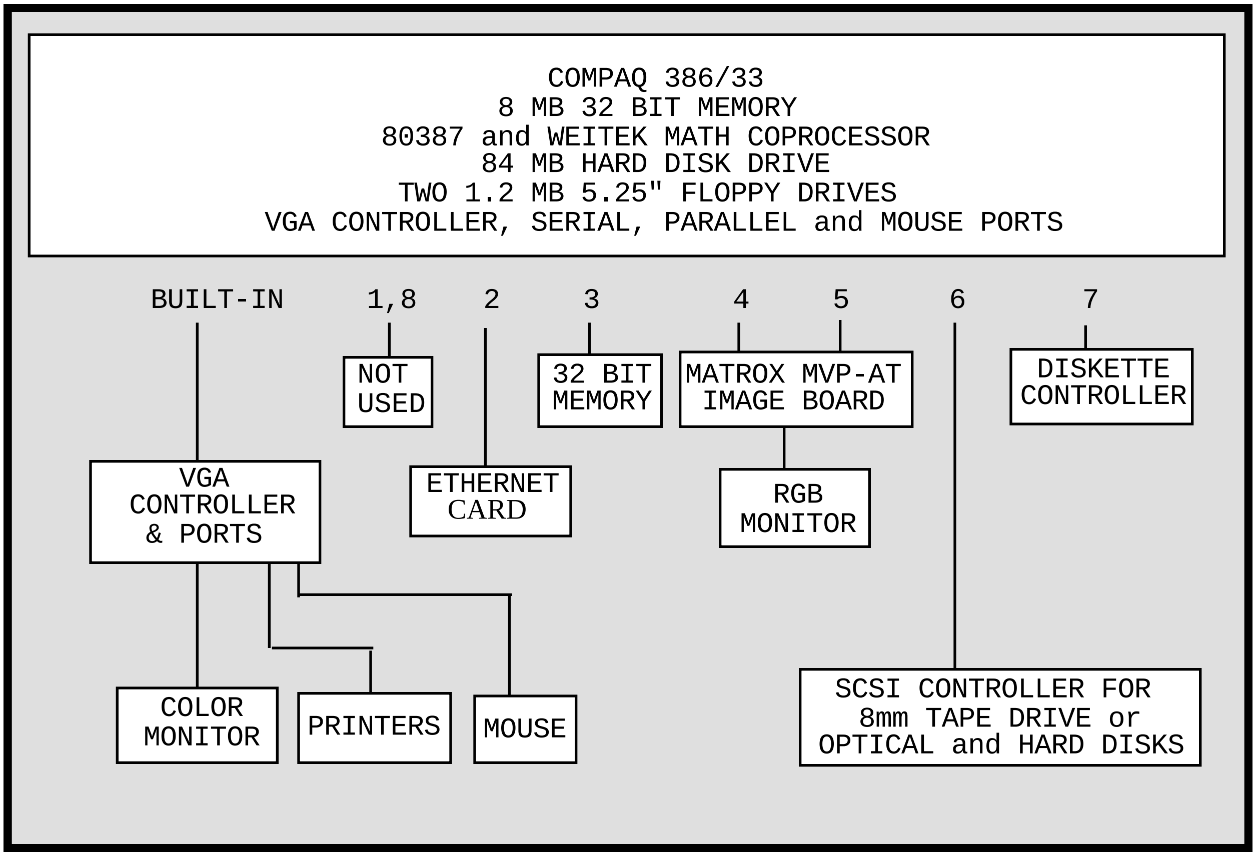

Figure 1. System configuration 2.

In slot 8, the Flagstaff Engineering Tape Controller card is installed. This is used to control the 9-track M990 tape drive from Cipher Data Products, Inc.

Two new systems, the configuration of which is shown in Figure 2, have also been installed for running PC-SEAPAK at t
he NASA/GSFC Oceans Computing Facility. The new configuration is
similar to that shown in Figure 1, except for the upgraded CPU and floating-point coprocessors, the built-in serial, parallel, and mouse ports, the VGA instead of the EGA controller, and the lack of a 9-track tape drive.

2. EXTERNAL PERIPHERALS

NEC Multisync II or 3D Color Monitor - This is a monitor which has a 14-inch diagonal display and a 13-inch viewing area. It is connected to and controlled by the AST-3G EGA control card or VGA controller and is used to display text and graphics and accept user input for all the utilities and applications.

Mitsubishi HA-3905L9 ADK Monitor - This is a 20-inch diagonal monitor which was connected to the MVP-AT image board. It is used for image and graphics display under PC-SEAPAK.

Imprimis WREN V Disk Drive - This is a high capacity, full-height, 5.25" Winchester disk drive. Its formatted capacity is 600 MB with an average seek time of 16 ms and a data transfer rate of 9-15 Mbits/sec on the SCSI interface. With the high capacity and fast access time of this disk, all the software utilities can be installed and all the software development can be done on it.

Summus GigaTape - This is an 8mm tape drive which is capable of backing up 2.33 gigabytes of data on one 8mm data cartridge. The GigaSAFE from Summus is a menu-driven software utility for backups or data interchange between PC and other host systems. The utility also supports two file formatting options, ANSI standard or Summus proprietary.

Summus LightDisk - This is a 5.25" erasable optical disk with an unformatted capacity of 650 MB (594 MB formatted) on one double-sided optical disk. The average access time is 90 ms and the data transfer rate is 620 KB/sec. This device can supply unlimited storage and is a good supplement to the storage on the hard disk and for backups.

Cipher M990 Tape Drive - This is a 9-track reel-to-reel tape drive. It is connected to and controlled by the Flagstaff tape controller card. Both 1600 and 6250 bpi tapes are supported by this system. For PC-SEAPAK, it is used to ingest the data from the CZCS level-1 and AVHRR level-1b tapes.

Hewlett Packard PaintJet Printer - This is a color graphics printer. It is connected to the parallel port on the multipurpose controller card. It can be used as the regular output device for text and graphics and is supported by the leading graphics and word processing software packages. The dithering methodology with the four ink cartridges (black, cyan, magenta, yellow) allows up to 330 colors. In PC-SEAPAK, there is a driver program which can print an image using 16 colors for the displayed image and 7 colors for the graphics overlay.

Microsoft Mouse - This is a two button mouse device. In the first (20 MHz CPU) configuration, it is connected to the serial port on the multipurpose controller card through a switch box; the second configuration has a built-in port for the mouse. The mouse is primarily used for controlling the cursor in PC-SEAPAK.

3. INSTALLATION CONFLICTS

Most of the controller cards and peripherals can be installed and connected easily with default setups by following the instructions in their manuals. The only problems with the Figure 1 and 2 configurations are conflicts by the default setups among the Ethernet card, the MVP-AT image board, and the SCSI host adapter.

The first conflict is between the Ethernet card and the MVP-AT board where they both use the I/O address 300H. The second conflict between the MVP-AT board and the SCSI host adapter results from the fact that they both access the memory addresses D000 to DFFF.

To overcome these problems, the I/O address on the Ethernet card was changed to 200 and the memory address on the SCSI host adapter was changed to CC00. Since the MVP-AT image board is a two-board set with the dip switches for the I/O and memory addresses located inside, one needs to unscrew the board connections and divide two multiple pin connectors between the two boards in order to change its setups. This is not an easy task and should be done only if necessary.

There are always potential conflicts between controller cards. Normally, they occur on the I/O address or memory address setup, but they can also occur with the DMA or interrupt channel selections. Usually, when there is a conflict, it will hang up the machine or fail to run some applications without any warning or error messages. To avoid potential conflicts between boards, especially when installing a new board or changing the setups of an existing board, always check the setups of the I/O address, the memory address, the DMA, and the interrupt channels. It is useful to keep a record of this information for each board.

4. MONITOR FOR MVP-AT

The MVP-AT image board can be configured through software to send different signals to the display monitor. Basically, the MVP-AT can send out two types of signals, interlaced and non-interlaced. For the interlaced signal, the frequency of the horizonal synchronization from the MVP-AT is 15.75 KHz and for the non-interlaced signal it is 31 KHz. The horizonal synchronization frequency determines the pixel resolution. For the MVP-AT, both the interlaced and non-interlaced options have a 512 pixel resolution. As for the frequency of the vertical synchronization from the MVP-AT, there are the 60-Hz American standard and the 50-Hz European standard options. For the American standard, only 480 lines can be displayed on the monitor, but for the European standard, 512 lines can be displayed.

To determine what kind of monitor and display format can be used with the MVT-AT, the frequency ranges for both horizontal and vertical syncs should be obtained from the monitor's manual. For example, the C-3920 from Mitsubishi Electric Corporation has a horizontal frequency range of 15.5 KHz to 23.5 KHz and a vertical frequency range of 40 Hz to 70 Hz. In this case, only the interlaced mode from MVP-AT can be selected since the non-interlaced mode needs a horizontal frequency of 31 KHz, which is out of the monitor's range. The vertical frequency in this monitor allows the MVP-AT to display 480 lines or 512 lines since its 40 Hz to 70 Hz range covers both 60 Hz and 50 Hz.

The default setup for the C-3920 is 60 Hz and 480 lines. To change it to 50 Hz and 512 lines, the standard line number for all PC-SEAPAK images, an adjustment must be made. The program SPKSETUP under the PC-SEAPAK directory is used to change the configuration file for MVP-AT setups. If the vertical frequency from MVP-AT does not match the vertical frequency on the monitor, the image will jiggle and will be unclear. The vertical synchronization can be adjusted by turning the V-HOLD knob until a steady display is obtained. Depending on the monitor, the V-HOLD knob may be located inside or outside of the monitor box. Unfortunately, the V-HOLD knob of the C-3920 is located inside the monitor box and the cover must be removed for the adjustment.

Another example is the Multisync II monitor from NEC. This monitor automatically adjusts the horizontal frequency from 15.5 KHz to 35 KHz and the vertical frequency from 50 Hz to 80 Hz. Tests on the interlaced and non-interlaced as well as with 480 and 512 line displays were successful. The only adjustment that may be required is with the vertical screen size so that the full image can be displayed within the screen range. This is easy to do for this monitor, since the V-SIZE knob is inside the front control box located just under the screen.

The new model HA3905L9 from Mitsubishi Electric corporation has a horizontal frequency range from 15.7 KHz to 35.5 KHz and a vertical frequency range from 45 Hz to 80 Hz as well as the auto-tracking capability. This monitor can be used on both interlaced and non-interlaced modes to display 480 or 512 lines on the screen without any adjustment.

SYSTEM ENVIRONMENT: SOFTWARE

1. PC-SEAPAK INSTALLATION

PC-SEAPAK should be installed on the hard disk with enough available storage space. The current version of PC-SEAPAK requires about 20 Mbytes of storage of which 94% are executable files for individual application programs and the rest are parameter files, configuration files and help files in text or binary format. In addition, 4.1 Mbytes of the CIA World Data Base, 3.7 Mbytes of the NASA Total Ozone Mapping Spectrometer (TOMS) data files and 4 Mbytes of the Navy bathymetry data base also need to be installed on the hard disk. In addition, HALO88 fonts are supplied on a separate disk through a licensing agreement with Media Cybernetics. These fonts are described in the Appendix. Also see Appendix for additional information on software and vendors.

PC-SEAPAK may be installed onto a hard disk from the distribution diskettes by following a simple series of steps. The installation procedure is as follows:

1. Create a SEAPAK directory (e.g., D:\SEAPAK) on the hard disk.
2. Copy all files except the HALO88 font and driver files, the CIA World Data base files, the Navy bathymetry data base file and the NASA TOMS data files from the PC-SEAPAK distribution diskettes to the SEAPAK directory on the hard disk.
3. Select or create a directory (D:\HALO88) and copy all HALO88's font and driver files from the distribution diskettes to that directory.
4. Select or create a directory (D:\CIADB) and copy all eight CIA World Data Base files from the distribution diskettes to that directory.
5. Select or create a directory (D:\PCTOMS) and copy all nine NASA TOMS data files from the distribution diskettes to that directory.
6. Select or create a directory (D:\BATHY) to contain the NAVY bathymetry file. Because of its size, the file was created with the BACKUP command and the RESTORE command must be used to restore it from the distribution diskettes to the root directory of device D. This requires that the file then be copied to the subdirectory and deleted from the root directory. For example,

   ```
   RESTORE A: D:\
   COPY D:\BATHY.DAT D:\BATHY\BATHY.DAT
   DEL D:\BATHY.DAT
   ```

Table 3. Contents of the file SEAPAK.FIG.

```
PC-SEAPAK           VERSION 4.0 (OCTOBER 91)
COLOR
010 000 014 003 015 004 015 001 012 000 015 002 015 000 0
 015 004
LIBRARY = D:\SEAPAK
HELP   0  59  F1         Displays   help   information
highlighted item
KEYS   0  60  F2         Displays a description of the c
keys
CMD    0  61  F3         Invokes the command processor
SAVE   0  65  F7         Saves the parameter values in
set
REST   0  66  F8         Restores the parameter values
save set
BACK   0  67  F9         Moves  back  to  the  previous
screen
NEXT   0  68  F10        Proceeds to the next menu scr
program
PGUP   8  73  PgUp       Moves   to   the   previous   pa
multi-page menu
PGDN   8  81  PgDn       Moves   to   the   next   page
multi-page menu
RIGHT  8   9  Tab        Moves to the array item on the
LEFT   8  15  Shift-Tab  Moves to the array item on the
END    0 113  Alt-F10    Ends current program and retu
top menu
EXIT 16   27   Esc  Exits from PC-SEAPAK
```

7. Set up the environmental variable SEAPAK to point to the SEAPAK directory by typing "SET SEAPAK=D:\SEAPAK\" (the last character "\" is necessary) under the DOS prompt. This statement should be appended to the AUTOEXEC.BAT file in the boot directory so that the environmental variable SEAPAK will
8. Check and modify, if necessary, the file SEAPAK.FIG under the SEAPAK directory. The description of the SEAPAK.FIG file is given later. In this step, you must make sure that the "LIBRARY" in the fourth line of the file is set to the SEAPAK directory created in step 1.
9. Run SPKSETUP by typing "SPKSETUP" in the SEAPAK directory to set up the memory and I/O addresses of the MVP-AT image board and the image display format. The program SPKSETUP is also used to identify the paths for the CIA World Data Base files, the NASA TOMS data files, the Navy bathymetry data file, and HALO88's font and device driver files. A detailed description of the program SPKSETUP is given in the Program Descriptions section of this guide.
10. Run INIT from the SEAPAK directory. This program must be run whenever the system is rebooted (hard or cold) so as to maintain the correct setups for the MVP-AT image board and its display format.

PC-SEAPAK may be started by changing to the SEAPAK directory and typing "SEAPAK". The PC-SEAPAK main menu should be displayed on the screen.

The SEAPAK.FIG file mentioned in step 8 is listed in Table 3 and contains the information needed for setting up the foreground and background colors for the screen, text, and fields, and defines the function keys, for all menu and input screens. In Table 3, the first line is the title information for PC-SEAPAK which will be displayed on the top line of all these screens. The second line specifies whether the display for these screens is in color or monochrome. The default "COLOR" in this line displays all the menu and input screens with colors defined by the color codes in the third line. If "UNKNOWN" is in the second line, the display for the screens will be in monochrome. The third line contains the color codes for the image and overlays of all items used for these screens. The fourth line specifies the location of the PC-SEAPAK directory and it should be changed if the PC-SEAPAK application programs are moved to another directory. The rest of Table 3 specifies the function keys used for all menu and input screens.

Color	Code	Description
Light green	010	System title foreground
Black	000	System title background
Yellow	014	Main window foreground
Cyan	003	Main window background
White	015	Instruction window foreground
Blue	001	Instruction window background
Light red	012	Function key foreground
Black	000	Function key background
White	015	Highlight foreground
Black	000	Highlight background
White	015	Edited item attribute (edit menus)
Black	000	Default values attribute (edit menus)
White	015	Help window foreground
Red	004	Help window background

In step 9, the program SPKSETUP will create two files under the SEAPAK directory specified in the input parameter SPKPATH, so the parameter SPKPATH must have the same directory name as created in step 1. The two files created by SPKSETUP will be named MVPAT.FIG and SPKPATH.PAR. The MVPAT.FIG file has only one line of information which contains two hexadecimal values for the memory and I/O addresses of the MVP-AT image board as well as three integer values--the pixel size, scan method and display mode--to set up the display format for the monitor. The default memory and I/O addresses are D000 and 300, the same as the default setups on the image board. If the memory or the I/O address have been changed on the board, the two values in MVPAT.FIG should also be changed by rerunning SPKSETUP or by editing the file. Depending on the display monitor, the MVP-AT image board can be set up with different display formats that depend on the selection of the pixel size (1, square pixels; 0, pixels with a 4:3 aspect ratio that is only valid for the interlaced scanning method), the scanning method (0, non-interlaced; 1, interlaced), and the displaying mode (0, 512 lines; 1, 480 lines).

The SPKPATH.PAR file contains four lines of text that specify the directories of the CIA World Data Base, the Navy bathymetry data file, the NASA TOMS data files, and the HALO88 font files and device drivers.

2. HOW TO RUN PC-SEAPAK

PC-SEAPAK is a collection of independent programs. A PC-SEAPAK application program may be invoked through the PC-SEAPAK menu mode, the PC-SEAPAK command mode, or the DOS command mode.

2.1 PC-SEAPAK Menu Mode

To invoke the PC-SEAPAK menu mode, enter "SEAPAK" in the SEAPAK directory at the DOS prompt to get the main PC-SEAPAK menu, or enter "MENU" or "M" under the PC-SEAPAK command mode to restore the menu mode. On each menu screen, there are a number of items that may be selected. Each item, displayed in one row, represents a submenu or a program, the title information being on the left side and the submenu or program name on the right side. If the name is enclosed in brackets, it represents a submenu; if it is enclosed in parentheses, the item is a program. To make a selection, type a number or move the cursor with the <UP> or <DOWN> arrow key to the item you want to select and press the <ENTER> key. There are seven function keys defined for each menu screen:

- <F1> - displays the on-line help information for the highlighted item (if it is a program not a submenu);
- <F2> - displays a description of the command keys;
- <F3> - invokes the PC-SEAPAK command mode;
- <F9> or ALT<F10> - displays the previous menu;
- <F10> - selects the highlighted item;
- <ESC> - quits the PC-SEAPAK menu mode.

2.2 PC-SEAPAK Command Mode

To invoke the PC-SEAPAK command, press <F3> while in the PC-SEAPAK menu mode or type "COMMAND" when you are in the SEAPAK directory and at the DOS prompt. The PC-SEAPAK command mode prompt "SEAPAK>" will be issued. This mode allows the user to invoke any program directly by typing the program name followed optionally by the input parameters. This mode provides the more experienced users with a much faster method of invoking PC-SEAPAK programs. There are five formats for invoking a program in this mode:

```
format 1:   PROGNAME PARM1=VALUE1  PARM2=VALUE2 . . .
format 2:   PROGNAME VALUE1 VALUE2 . . .
format 3:   PROGNAME %SAVESET
format 4:   PROGNAME
format 5:   @SCRIPTFILE
```

where PROGNAME is a PC-SEAPAK program name.

In format 1, PARMn (n=1,2,...) are the parameter names defined in the first input screen of the program PROGNAME. For a list of those parameter names, type "HELP PROGNAME" in the PC-SEAPAK command mode and all the parameter names as well as their descriptions and default values will be displayed. This information is defined in the file with the same program name but with extension .PDF. When the parameter name is specified (format 1), PARMn=VALUEn pairs may be listed in any order. All parameters, except those for which default values are assigned, must be explicitly assigned values to bypass the input screen. In format 2, the parameter names are not specified but only the input values are listed following the program name. To skip the input screen, values for all the parameters including those having default values must be specified and must be in the same order as the parameters are listed on the input screen.

In format 3, SAVESET is a saveset name, i.e. a parameter file, which is a collection of all parameter values in the input screen. This file can be created only by the SAVE function key F7 when the input screen is displayed. In this format, all the parameter values will be assigned from the SAVESET file and the input screen will be skipped.

Note that, currently, only the PC-SEAPAK programs that have a parameter definition file (PDF) defined under the SEAPAK directory are able to run using formats 1, 2 and 3. The PDF files are ASCII files and have extension ".PDF".

In format 4, there is no argument after PROGNAME and the input screen will be displayed for the user to input values before the program is executed. This is the same as invoking the program from the PC-SEAPAK menu mode or from the DOS command mode (discussed below).

In format 5, the SCRIPTFILE is an ASCII file that contains a listing of command lines, in any combination of formats 1, 2, 3, or 4, to be executed in sequence. The user may use this format to set up a procedure for a demonstration or an unattended batch run. The "@" symbol is required.

Other commands in addition to the program invocation commands may be used in the PC-SEAPAK command mode. The command "HELP PROGNAME," mentioned above, is used to display the information for input parameters of the program PROGNAME. The command "MENU" or "M" is used to switch to the menu mode. The command "EXIT" returns the user to the DOS command mode.

2.3 DOS Command Mode

The DOS command mode is the mode under DOS control which allows the user to use all the DOS utilities and to run all the commercial application packages. The PC-SEAPAK programs can also be run under this mode since each program exists independently as a DOS executable file. To invoke a PC-SEAPAK program under this mode, change to the SEAPAK directory and then type the program name at the DOS prompt. Although the programs can be run from any directory if the SEAPAK directory path is specified by the environmental variable PATH, the color display for the input screen as well as all on-line help will not be available.

2.4 Parameter Input Screen

For most PC-SEAPAK programs, input parameters must be specified by the user before the programs will start to run. In some cases, the user will be prompted for additional information during the programs' execution. Under PC-SEAPAK, there is always a parameter input screen associated with each input parameter set. Each parameter input screen has the PC-SEAPAK title, the input screen title, the input parameters, each with a brief description and a field to accept the input, and a list of the available function keys.

During a parameter input screen session, the user can only use the <UP> and <DOWN> keys to move the cursor bar (highlight on parameter field) to any parameter field and use <LEFT>, <RIGHT> and <BACKSPACE> to edit the input in the field. Note that the <ENTER> key will terminate the input screen session, so all parameter inputs must be entered before <ENTER> is pressed. The following function keys are defined for each parameter input screen:

- <F1> - displays the on-line help information for the highlighted parameter field;
- <F2> - displays a description of the input screen's function keys;
- <F7> - saves the parameter values on current input screen into a save set;
- <F8> - retrieves and displays parameter values on current input screen from a save set;
- <F9> - goes back to the previous input screen if there is one; otherwise same as ALT<F10>;
- <F10> - goes to next input screen if there is one; otherwise same as using the ENTER key;

ALT<F10> - quits the input screen session and the program and returns to the previous mode;
<ESC> - quits the input screen session and the program and returns to DOS command mode.

2.5 Memory Size

Although DOS allows 640 Kbytes of RAM memory to be used, due to the overhead of DOS itself and the space required for the environment variables, about 600 Kbytes are available for all other applications (under DOS 5.0 without memory resident programs or drivers). This amount of memory is further reduced by the addition of device drivers for such things as a virtual disk, a mouse, the tape drive and memory resident programs such as Sidekick and DECnet-DOS. Also, DESQview requires a fair amount of memory. Since most device drivers are installed in the CONFIG.SYS file, the memory these and other memory resident programs occupy cannot be regained. The only way to clear these is to remove them from the CONFIG.SYS file and execute a cold reboot (turn the machine off, then on).

Running programs without enough memory may cause unpredictable results or hang up the machine. The DOS command CHKDSK may be used to check the amount of currently available memory and the command EXEMOD may be used to check a program's minimum load memory sizes.

Most of the PC-SEAPAK programs have memory load sizes (not the executable file size) of 200 to 400 Kbytes and should not have any problems executing even when some device drivers and memory resident programs are loaded.

3. ADDING ITEMS INTO PC-SEAPAK MENUS

In PC-SEAPAK, each menu can contain up to nine selection items. Each item can be an entry of an application program or a submenu. Each menu has a text file in the SEAPAK directory with the extension ".MNU" which is used by the PC-SEAPAK menu system to display the selection items of the menu on the screen.

Table 5 is the listing of the MAIN menu file presented here as an example. "$START" in the first line and "$END" in the last line are required to bracket the file's information. "$TITLE" in the second line specifies the menu title. "$ID" specifies the entry file of an application program or a submenu. The entry file must be an executable file (".EXE" file) or a batch file (".BAT" file) or a menu file (".MNU") in the SEAPAK directory. Each "$ID" line is followed by a description line that will appear on the menu screen and will be numbered consecutively from 1. The entry file name (without the extension) is written a the end of each corresponding description line. By convention, this name is enclosed within square brackets if it represents a submenu or within parentheses if it represents a program.

Table 5. Listing of the file MAIN.MNU.

```
$START
$TITLE=PC-SEAPAK MAIN MENU
$ID=INGEST.MNU
CZCS and AVHRR ingestion                     [INGEST]
$ID=CZCSL2.MNU
CZCS level-2 processing                      [CZCSL2]
$ID=IMAGING.MNU
MVP-AT frame buffer programs                 [IMAGING]
$ID=IMGFILE.MNU
Image file information                       [IMGFILE]
$ID=GEOGRAPH.MNU
Geographic programs                          [GEOGRAPH]
$ID=MATH.MNU
Mathematical programs                        [MATH]
$ID=UTIL.MNU
Utility programs                             [UTIL]
$END
```

Table 6 is the current PC-SEAPAK menu tree structure. It is easy to add any application programs or submenus into the PC-SEAPAK menu system. First, select a menu file into which you want the new entry (a program or a submenu) to be added. Second, use any editor to add the "$ID" and description lines into the appropriate location in that file. If the new item to be added is a submenu, a menu file with extension ".MNU", having the same format as that of MAIN.MNU (Table 3), should also be created for that submenu. All entry programs specified by the "$ID" statements must exist in the SEAPAK directory. If the executable file is not in that directory, the user can create a batch file in the SEAPAK directory and use it to start any program outside the SEAPAK directory.

4. PC-SEAPAK SPECIFIC TOPICS

Frame Buffer: Under PC-SEAPAK, the 1 Mbyte of video RAM on the MVP-AT board is configured as four 512x512x8 frame buffers numbered 0, 1, 2 and 3. Normally, frame buffers 1, 2 and 3 are used for image display and frame buffer 0 is reserved as an overlay frame buffer (discussed later) to display the cursor, the menu of function keys and other overlay graphics.

Look-up Tables: In the MVP-AT, there are two look-up table sets, the input look-up table (ILUT) and the output look-up table (OLUT). Each of the sets contains 32 palettes numbered from 0 to 31 and each palette has its own red, green and blue look-up table of 256 locations. In this guide, all the palettes mentioned will refer to the output look-up table unless otherwise noted.

```
                    - VAXTOPC
          - CZCSL2      - ATMOS
                                  - L2PROD
          - IMAGING     - INITIAL
                        - FRMBUF
                        - OVERLAYS
                        - LUTCOLOR
                        - MOSAIC
          - IMGFILE     - DATA
                        - HEADER
          - GEOGRAPH    - PROJECTN
          - MATH        - HARDFCT
                        - SOFTFCT
                        - STAT1
                        - STAT2
          - UTIL        - HARDCOPY
                        - MIAMI
```

Palettes: As discussed above, there are 32 palettes numbered 0 to 31 available for the ILUT and OLUT. Each palette has its own red, green and blue look-up table, each of the look-up tables has 256 locations, and each location can have a value of 0 to 255. In most situations for PC-SEAPAK, only the palettes of OLUT are used for pseudocoloring an image and overlaying graphics on an image. Some of the palettes are already reserved for special purposes. Palettes 11 to 14 are used for look-up tables to display images without overlays on frame buffers 0 to 3. Palette 0 is used for the look-up table of the displayed image with an overlay display. Palettes 1 to 7 are used for overlay graphics. Palette 8 is used for the cursor. Palettes 17 and 18 are used for the display of function key menu.

Image Display without Overlay: All four frame buffers may be used to display an image if no overlay is needed. In this case, palettes 11 to 14 in the OLUT are used for the default look-up tables to display images on frame buffers 0 to 3.

Image Display with Overlay: When an image is being displayed, another frame buffer is required to display an overlay. In PC-SEAPAK, frame buffer 0 is reserved for the overlay frame buffer. The eight-bit depth of each pixel in the overlay frame buffer can be separated into two sets, the four least and the four most significant bits. The two four-bit selections are used to select overlay palettes 0 to 15 (the four least significant bits) or 16 to 31 (the four most significant bits). Only one set can be active at one time. In PC-SEAPAK, the least significant four bits (palettes 0 to 15) are used for overlay graphics and the most significant four bits (palettes 16 to 31) are used for the overlay display of the function key menu.

When overlays are used, every pixel in the displayed image frame buffer has its own palette for showing the color on the monitor. The palette for each individual pixel in that frame buffer is determined by the value of the least significant four bits (0 to 15) at the same pixel location as for the overlay frame buffer. Once the palette is determined, the background pixel value (0 to 255) will be used as the index for the intensities of the red, green and blue colors from the palette's corresponding look-up tables.

In PC-SEAPAK, only the seven palettes 1 to 7, of the 16 available, are used for the overlay graphics. The red, green and blue look-up tables for these palettes should always have constant values in each of their 256 locations so that the overlay graphics of a specified palette always have the same color on the displayed image regardless of that image's pixel value. If any of the 256 locations in the look-up tables are not constant, the overlay color on the displayed image may not be same. This is because the pixel value in the frame buffer of the displayed image is used as the index of the color intensities in the look-up tables. Palette 0 is used for the look-up table of the displayed image whenever the overlay is active. In PC-SEAPAK, if there is an overlay, the look-up tables of palette 0 have to be loaded from palettes 12, 13 or 14 which are reserved for image frame buffers 1, 2 and 3 for non-overlay displays.

Cursor: The MVP-AT does not support a hardware cursor device. The cursor used in PC-SEAPAK is designed and controlled entirely by the software and the mouse device. The default cursor is a "+" of size 15x15 pixels and is displayed through the overlay by using the OLUT palette 8 with red as the default color. The default cursor setup can be changed by editing the file SPKDEF.PAR in the SEAPAK directory.

Menu of Function Keys: For most of the PC-SEAPAK programs, function keys are defined for various program functions. For the user to review which function keys are defined and what their assignments are, the function key menu is used. By default, the menu is overlaid on the image frame buffer with default OLUT palette 17 for the foreground and OLUT palette 18 for the background. The default palettes setups may be changed by editing the file SPKDEF.PAR, but must be palettes from 17 to 31. Because the most significant four bits in the overlay frame buffer are used to display the function key menu, the overlay graphics which use the lower four bits will be inactivated. Thus, the menu should always be toggled off after reviewing its text. The mouse's right button and the ALT<F1> key may be used for toggling the display of the function key menu on and off.

File Name Structure under PC-SEAPAK: In the current PC-SEAPAK version, all input and output file names have the same structure as under DOS except that the maximum number of characters cannot exceed 40. The file names should be of the form DRIVE:\PATH\FILNAME.EXT, where DRIVE is the one character drive name, PATH is the directory path, FILNAME is a name of up to 8 characters, and EXT is the extension of the file name and is usually three characters long. The current drive and directory will be used if DRIVE and PATH are omitted. There are no default strings for EXT and FILNAME. Note that some programs (e.g., TP2IMG, TP2DSK, L2MULT) that create output files may use FILNAME as the root and append a one character index to it. In such cases FILNAME should not have more than seven characters.

5. RUNNING PC-SEAPAK UNDER DESQVIEW

Quarterdeck Office System's DESQview is a multitasking and window environment which allows programs to run simultaneously within different windows. PC-SEAPAK may be installed as an item under DESQview's open window menu and invoked by selecting that item. Alternatively, it may be invoked from DESQview's DOS window which must be installed separately on DESQview's open window menu. Also, any PC-SEAPAK program may be installed as an individual item under DESQview's open window menu.

The steps for installing an item on DESQview's open window menu can be found in DESQview's manual and will not be discussed here. There are only two things which need to be considered for the installation of PC-SEAPAK under DESQview: the memory size for running the application program in a window and the program name to start the application. The maximum available memory size under DESQview can be found by using the Memory Status utility supplied by DESQview. This maximum should be used for all the windows running PC-SEAPAK or individual PC-SEAPAK programs. "D:\SEAPAK\SEAPAK" should be used to start the SEAPAK window, and "D:\SEAPAK\PROGNAME.EXE" should be used to start any of the individual PC-SEAPAK programs in a window, where "D:\SEAPAK" is the SEAPAK directory and "PROGNAME" represents one of the specific program name. Also, the SEAPAK directory D:\SEAPAK should be put into the directory field when you install PC-SEAPAK or individual PC-SEAPAK programs into the open window menu. As for the DOS window, any user specified batch file or DOS command can be used to start it. Running programs in the DOS window requires that the DOS window has a sufficient memory allocation.

All PC-SEAPAK programs except the tape ingest programs and the programs that need more memory than DESQview's maximum available size may run under DESQview. The user may use the DOS utility EXEMOD to check the memory load size (not file size) for each program.

6. RUNNING PC-SEAPAK PROGRAMS UNDER DOS PROTECTED MODE

Due to the memory limitation (640 KB) under the DOS real mode, some of the PC-SEAPAK programs such as L2MULT, MAPIMG, BHL2MULT, BHMAPIMG and FILLA that were developed under Microsoft Fortran may have problems being loaded or executed when memory resident programs or device drivers take up excessive amounts of memory. To solve the problem, those programs were converted to run under 386's protected mode with MicroWay's NDP Fortran compiler and Phar Lap's Link and DOS-Extender. The NDP Fortran compiler is a 32-bit compiler that can generate code for the Intel 80387 and Weitek floating-point coprocessors. Phar Lap's Link is a linker that generates executable code to run under 386's protected mode and the DOS-Extender is a program required to load those programs and run under protected mode.

The programs running under 386's protected mode do not have the DOS 640 KB memory limitation. Their limit is the total memory size of the system. Since the DOS-Extender run-time version was purchased, it has been integrated into those programs so that users do not need to buy it separately. Currently, only the following programs are set up to run under protected mode: L2MULT, MAPIMG, BHL2MULT, and BHMAPIMG for the Intel 80387 coprocessor, WTKLM, WTKMP, BHWTKLM and BHWTKMP for the Weitek coprocessor, and FILLA and EOF for both the 80387 and Weitek coprocessors. The Weitek version of programs have the same functions as the Intel 80387 versions but execute about twice as fast. Of course, the system must have a Weitek coprocessor installed for these programs to be used. Most manufacturers provide a Weitek socket on the motherboard.

SUMMARY OF MAJOR PROCESSING STEPS

A typical series of major processing steps that a user may follow in order to process a CZCS or AVHRR scene are presented in Fig. 1. Many of the considerations involved for each of these steps are discussed in detail in following sections of this chapter. Detailed information about individual programs is given in the corresponding sections of PC-SEAPAK programs.

PC-SEAPAK programs are generally independent of each other and the order of their appearance on menus or in Fig. 1 does not imply a forced execution sequence. Although a user's analysis will normally follow a logical progression of steps such as those suggested by Fig. 1, the large number of programs available allow numerous options throughout the analysis approach.

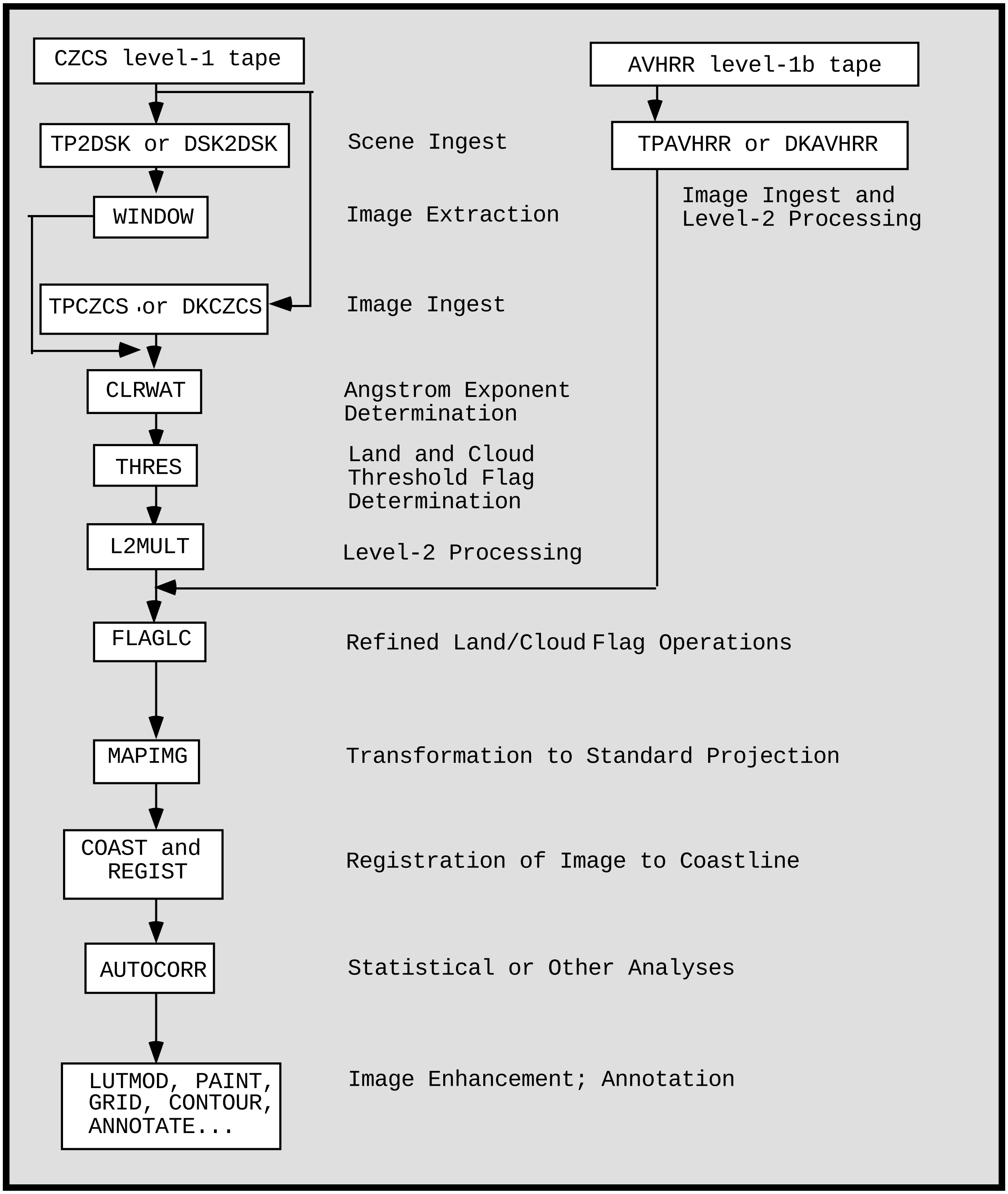

Figure 2. Major processing steps for typical analyses of CZCS and AVHRR images using PC-SEAPAK programs.

INGESTING LEVEL-1 DATA

In this section, the generation of CZCS level-1 images from tape and disk files will be discussed. The creation of level-1 image files from AVHRR tapes is similar to the procedure for CZCS data, but with some important differences. Unlike CZCS files, AVHRR tape files from NOAA can be any number of scan lines. The CZCS level-1 files normally have 970 scan lines per file, but may have fewer. Also, the AVHRR local area coverage (LAC) data has 2048 and global area coverage (GAC) data has 409 samples per scan line whereas a CZCS scan line has 1968 samples. Sea-surface temperature (SST) level-2 products are created when AVHRR data is ingested, while level-2 products from the CZCS must be generated separately (see the section on generating CZCS level-2 products).

The programs TPCZCS, TPAVHRR, DKCZCS and DKAVHRR are used to create 512x512 image files from tape and disk scene files of CZCS and AVHRR LAC and GAC data. However, TP2DSK and DSK2DSK may also be used for CZCS data to ingest up to three complete 970x1968 scenes from a tape (TP2DSK) or from disk (DSK2DSK) as one set of files from which 512x512 image files may be extracted using the program WINDOW. This approach is often more convenient than using TPCZCS or DKCZCS since it permits the user to visually determine the location of the extracted image in the overall scene.

Note that all tape ingest programs in the current version of PC-SEAPAK can work only with the M990 GCR tape drive from Cipher Data Products, Inc., and Flagstaff Engineering's tape utilities. The programs DKCZCS, DKAVHRR and DSK2DSK are disk versions of TPCZCS, TPAVHRR and TP2DSK that ingest data from a disk instead of from tape if the tape data is first copied onto the disk.

Using TPCZCS: The program TPCZCS is used to ingest level-1 CZCS scenes and create 512x512 pixel images. In addition to the creation of full-resolution images, positive reduction factors may be used to subsample the data, since the level-1 scene may have up to 970 scan lines of 1968 samples, and negative reduction factors may be used to create images magnified by pixel duplication. Using TPCZCS requires a little arithmetic unless one assumes the file is a full scene and an overview is desired (reduction factors 4 and 2 for samples and scans, respectively). Usually, a user will want to generate a set of overview images in order to see the full scene. From the overview images, the coordinates of subimages can be determined and they are usually used in the Angstrom exponent determinations required by the level-2 programs discussed in the section on generating CZCS level-2 products.

In PC-SEAPAK, image files of each CZCS band are created independently of the others. Systems like the University of Miami's DSP interleave the data from each channel resulting in one file per scene(s). SEAPAK creates six image files and one control point file which contains the navigation data. In TPCZCS, the user provides a root name and extension for the image files, and the band numbers are appended to the root name automatically. The control point file is simply the root name with a ".CTL" extension (rootname.ctl). Each convention has its advantages and disadvantages. Separation of the image files allows users to easily delete unnecessary files such as IR-band images thus saving disk space, but requires more file management.

In TPCZCS, the WINDOW parameter values determine the start and end pixel and line coordinates. These must match the reduction factors (REDFAC values) used. See the TPCZCS program section for more information.

Using TPAVHRR: This program is used to ingest an AVHRR scene of HRPT, LAC or GAC data from a tape in the format of those generated by NOAA/NESDIS/NCDC/SDSD (Kidwell, 1988) as well as to generate the SST image. The data must be in packed format, with time incrementing, and be a full set copy (as opposed to selective extract subsets where certain channels are selected). Unlike CZCS scenes, the AVHRR scene in this format may contain variable scan line numbers. The program allows the user to scan the tape scene first, if the user has no information of the input scene, in order to get the starting and ending scan line numbers for the windowing (WINDOW) and reduction factor (REDFAC) selections. Also, since the AVHRR scenes may be obtained while the satellite is ascending (flying south to north) or descending (north to south), the enumeration of the samples and scan lines may be reversed. See the TPAVHRR program section for more detailed information.

Using TP2DSK and WINDOW: Rather than ingesting reduced-resolution CZCS scenes one at a time to obtain an overview and then reading in subscenes for merging as described above, the combination of the programs TP2DSK and WINDOW may be used. For TP2DSK, all one needs to specify are the sequence number of the first file and the number of files to be read from the tape. The files must be consecutive satellite scenes as they normally are on tapes obtained from NASA or NOAA. The output is one large file containing the scenes' data at full-resolution. If significantly large gaps exist between the scenes, execution will not be completed. Currently, up to three files can be ingested in this way.

The program WINDOW is very easy to use. The overview of the entire data file will be displayed at reduced resolution in one of the MVP-AT frame buffer along with a default window box. Then, using the function keys, the user can change the box size which will have dimensions that are multiples of 512 in each direction. Single images from one CZCS band or all the bands can be generated that correspond to the current box position. When the appropriate function key is depressed, the user will be prompted for the filenames required. The program automatically uses the boxed area to create a 512x512 sized image.

Using DKCZCS and DKAVHRR: The programs DKCZCS and DKAVHRR are the disk versions of TPCZCS and TPAVHRR and ingest CZCS level-1 data and AVHRR LAC and GAC level-1 data files from disk instead of from tape. TPCZCS and TPAVHRR only supports the Cipher's M990 tape drive with Flagstaff Engineering's tape drive software. Users with different tape drives for their PCs or on different systems must copy these files from tape to disk using the tape utilities supported by the tape drive, or download the files to their PC's from another system, before using the disk version programs.

These programs support two types of disk formats, variable-record length and fixed-record length, for CZCS and AVHRR data. For CZCS level-1 tapes, each scene contains a header file and a data file. Since only the data file is needed, the user must skip the header file when copying the data from tape to disk. In the data file, the first and last records are documentation records and the records in between contain up to two minutes (970 scan lines) of CZCS radiance data. For the variable-record length format, documentation records are 5,328 bytes and the scan-line records are 12,780 bytes, whereas for the fixed-record length format, all records are 12,780 bytes.

For an AVHRR LAC tape, each file has a TBM (Terabit Memory) header as the first record, a data set header as the second record, a dummy third record, and a variable number of data records (fourth to end). Each scan line is contained in two data records. The variable-record length format has lengths of 122 bytes for the TBM header record and 7,400 bytes for the data set header, dummy, and data records; the fixed-record length format uses 7,400 bytes for all records.

For an AVHRR GAC tape, each file has a TBM (Terabit Memory) header as the first record, a data set header as the second record, and a variable number of data records (third to end). Each data record contains two scan lines. The variable-record length format has lengths of 122 bytes for the TBM header record and 6,440 bytes for the data set header and data records; the fixed-record length format uses 6,440 bytes for all records.

Depending on the tape utilities and the system, the user may select the variable-length or the fixed-length format for copying the tape data to disk. At the NASA/GSFC Laboratory for Hydrospheric Processes, we have used CZCS level-1 and AVHRR LAC and GAC files with variable-record lengths created with Cipher's M990 tape drive and Flagstaff Engineering's tape utilities on our PC and fixed-record length files created on a MicroVAX II and downloaded to our PC.

Using DSK2DSK: DSK2DSK is the disk version of TP2DSK which can generate full-resolution CZCS level-1 file from multiple disk scene files. The two disk file formats described in the previous discussion of DKCZCS are also supported by DSK2DSK.

GENERATING CZCS LEVEL-2 PRODUCTS

Presently, PC-SEAPAK has several programs in its CZCS level-2 menu, CZCSL2, and submenus that include a number of tools to assist the user in determining the input parameters required to generate level-2 products. These programs include L2MULT, CLRWAT, BXCLRWAT, L2BOX and THRES. L2MULT creates images of subsurface water radiance (or, optionally, normalized water-leaving radiance) at 443nm, 520nm and 550nm, aerosol radiance at 670nm, pigment concentration, Rayleigh radiance at 443nm (a useful diagnostic quantity when other standard products seem unreasonable) and diffuse attenuation at 490nm. In this discussion, the term "water radiance" will apply to subsurface water radiance, while water-leaving radiance and normalized water-leaving radiance refer to radiances just above the air-water interface. These will be discussed in more detail later. The multiple scattering model of Gordon et al. (1988) is used in all the programs since it is the most sophisticated model available for CZCS analysis and is the model used in the CZCS global processing project (Esaias et al., 1986; Feldman et al., 1989).

L2BOX allows the user to roam a level-1 scene using the cursor and compute the values of the level-2 products and additional quantities within a box. It provides the flexibility of changing input parameters such as the calibration correction factors, the aerosol correction parameters and the ozone optical thicknesses.

The primary parameters required for generating level-2 products are the aerosol correction parameters (the Angstrom exponents or epsilons) and the land/cloud flag threshold. CLRWAT, BXCLRWAT, SCREEN, and ANGST are designed to help determine the aerosol correction parameters while THRES may be used to fine tune the land/cloud flag.

Other parameters, such as the calibration correction factors and the ozone optical thicknesses, can also be varied. However, the use of calibration correction factors other than the default values is not recommended since such factors are not easily determined unless additional field observations of upwelling water radiance are available. Likewise, alternate ozone thicknesses should be used with caution since the default thicknesses are derived from the Total Ozone Mapping Spectrometer (TOMS) data for the time and location of the scene in question.

Early in the CZCS mission, the Nimbus Experiment Team and others realized that the sensor's sensitivity was degrading and that the rate of degradation rate was different for each of the 443nm, 520nm and 550nm bands. However, quantification of the degradation was difficult (Viollier, 1982; Gordon et al., 1983a; Hovis et al., 1985; Mueller, 1985; Gordon, 1987). Because of the relatively large atmospheric contribution to the total observed radiances (Gordon, 1981) and the great sensitivity of the bio-optical algorithms to the estimated water-leaving radiances (Clark, 1981), small errors in the calibration can induce sizable errors in the derived geophysical products rendering them useless for many applications. Thus, a comprehensive investigation of the calibration over the entire period of sensor operation was undertaken during the global reprocessing of the CZCS dataset (Feldman et al., 1989).

By processing large quantities of clear-water imagery, R. H. Evans (unpublished) was able to develop a 'vicarious' calibration that was used in the global processing of the entire CZCS data set. Specifically, the normalized "clear-water" radiances (Gordon and Clark, 1981), $[L_w]_N^{443}$, $[L_w]_N^{520}$ and $[L_w]_N^{550}$, were assumed to be 1.40, 0.48 and 0.30 $mW/cm^2 \cdot \mu m \cdot sr$, respectively, the Ångström exponents were assumed to be 0 and certain geographical regions such as the Sargasso Sea were assumed be "clear-water" sites (pigment concentrations < 0.25 mg/m^3) at all times. Under these assumptions, analyses of the derived $[L_w]_N$'s indicated what calibration adjustments were required to produce the nominal "clear-water" normalized radiance values. The vicarious calibration of the 443nm band is somewhat tenuous because of the great variability in $[L_w]_N^{443}$ even in "clear-water". This calibration is called the "Evans" calibration in the level-2 processing programs.

<u>Step 1 - Determining the Angstrom exponents and the land/cloud flags</u>: In the global CZCS processing mentioned above, Angstrom exponents equal to 0 are used on all scenes and no attempt is made to compute Angstrom exponents for each scene. The terms Angstrom exponent and epsilon are both used interchangeably in discussing the aerosol correction. The reader is referred to Gordon et al. (1983) for a discussion of the terms which are related by the following equation:

$$e(\lambda) = (\lambda/670)^{n(\lambda)}$$

where λ is the wavelength (443, 520 or 550), and $e(\lambda)$ and $n(\lambda)$ are the epsilon and Angstrom exponent, respectively. So, for an epsilon equal to 1, the Angstrom exponent is 0. As epsilon increases, the Angstrom exponent becomes more negative. One of the assumptions in the atmospheric correction algorithm is that the aerosol radiance at 670nm is related to the aerosol radiances at 520nm and 550nm through this equation. Another assumption is that these do not change within a scene. The Angstrom exponent at 443nm is taken to be the average of the values at 520nm and 550nm because the water radiances at 443nm are too variable even in clear water for stable estimates to be derived.

In areas dominated by marine haze such as in the central gyres and along the western continental margins, Angstrom exponents of 0 (or epsilons of 1) are usually adequate. However, in regions influenced by continental haze such as the eastern U.S. coast and the Mediterranean Sea, these values often fail to remove the haze resulting in contamination of the level-2 products by underestimating the aerosol radiance. This produces an overestimation of the water radiance and an underestimation of pigment concentration. On the other hand, high concentrations of dust are often encountered in the eastern tropical Atlantic Ocean, the western Pacific Ocean, and the Arabian Sea. These conditions can cause the 670nm band to saturate making an atmospheric correction impossible. The HAZE parameter (of program L2MULT, for example) has a default value of 254 which flags all saturated pixels, although some conditions may require the flag to be set lower. Dust contaminated data usually require Angstrom exponents greater than zero. One should always compare the water radiance and pigment images with the aerosol radiance or level-1 670nm radiance image to determine if features are correlated. If the haze is correctly removed, there should be no correlation.

When dense or continental haze is present, the user may try CLRWAT or BXCLRWAT in an attempt to find a better set of Angstrom exponents. CLRWAT and BXCLRWAT are described in the PC-SEAPAK programs section. Both CLRWAT (automated mode) and BXCLRWAT (interactive mode) use a set of criteria to eliminate pixels from consideration. Some of these criteria may be adjusted by the user. Solar zenith and spacecraft zenith angles are examples. If the sun is too low in the sky, the radiative transfer models may not work well enough for the estimation of the Angstrom exponents. Aerosol radiance is another example. If the haze is too dense or too small, the estimation of the Angstrom exponents will not be valid for the rest of the scene. Also, pixels which fail the land/cloud flag are eliminated. Defaults are provided for all these. In BXCLRWAT, the user roams the scene with a box cursor looking for the set of Angstrom exponents associated with the lowest value of a quantity called CLOW. CLOW is the ratio e(443)/La(670) where La(670) is the aerosol radiance.

This procedure was developed by the Nimbus Experiment Team and is presented in Williams et al. (1985a and 1985b), but the rationale behind it was never discussed. It has been used by SEAPAK users for several years and has been found to yield consistent and quite acceptable results (see Barale et al., 1986, and McClain et al., 1988). The best locations to search are those with very low pigments because the 670nm radiances will not be affected by the ocean's reflectance. Care must be taken to avoid pixels affected by sensor ringing on the down-scan side of bright areas such as clouds (Mueller, 1988; see the help text for the program RING), an effect that is most noticeable in the 670nm image. In addition, fringe areas around clouds that are not flagged by the land/cloud threshold can cause erroneous estimates of CLOW.

In CLRWAT, the user sets the maximum pigment threshold in order to ensure that clear-water pixels are used. The program then computes the epsilon frequency distributions at 443nm, 520nm and 550nm from all valid pixels. Certain statistics are derived from the frequency distributions and may be output to a text file. These include the minimum, the maximum, the mean, the median, the mean of the lowest 10%, the standard deviation and the interquartile range. From these, the user can select a set of epsilon values to use. CLRWAT also creates a special image whose pixel values indicate the rejection criterion for invalid pixels as well as the clear-water pixels that passed all criteria. This special image may be displayed using the program SCREEN to color the various pixels according to each pixel's category.

When using CLRWAT or BXCLRWAT, care must be taken to set the cloud threshold properly. The default works in most situations, but care must be taken to avoid thin clouds and areas where the 670nm radiances are saturated. Band 5 (750nm) was designed for land/cloud identification. Clouds at low solar elevations tend to be less bright, so if the solar zenith angle is high (the program DMPHDR can be used to find out) or if there are a lot of thin clouds, the default value of 21 counts (gray levels) in the 750nm image may need to be reduced. THRES or READ can be used to determine the "best" threshold. In general, it is advisable to use the level-1 670nm image for BXCLRWAT because it is sensitive to haze, clouds and ringing.

If CLRWAT or BXCLRWAT do not yield useful results, ANGST is often helpful. ANGST is based on a technique developed by Arnone and LaViolette (1984) and is designed to allow the user to interactively remove haze from the level-1 443nm, 520nm and 550nm bands using the 670nm band as the reference aerosol band. In ANGST, one operates on each band separately using the cursor to fine tune the haze removal. This is particularly useful when there is a specific haze feature to be removed. In this way, incremental increases in the Angstrom exponents can be made until there is no evidence of the feature left in the water radiance images. The program allows the user to check the water radiance values in the scene using the cursor and to stretch the image contrast in order to see more clearly the features. In using the level-2 programs which require Angstrom exponents, the same Rayleigh scattering model must be used as was used in determining the Angstrom exponents.

<u>Step 2 - Using L2MULT</u>: (See the detailed descriptions of L2MULT, and other programs of the L2PROD menu, in the program sections for more information on options and parameters.) Once the Angstrom exponents and the land/cloud flag are determined, L2MULT is used to generate the level-2 products. In L2MULT, the multiple scattering model of Gordon et al. (1988) is used. The program is designed to provide as much flexibility as possible in the selection of algorithms and input parameters. An inexperienced person should stick with the defaults provided for parameters such as the ozone optical thicknesses, the calibration algorithm, the pigment algorithm, water radiance range and the method used for the aerosol correction (ITERATE is the selection parameter).

The user is given the choice of generating subsurface upwelling water radiance or normalized water-leaving radiance (Gordon and Clark, 1981) images. The parameter is NORMWAT. The transformation from subsurface water radiance to water-leaving radiance is a function of the Fresnel reflectivity and the index of refraction. However, it is wavelength independent and cancels out when ratios are used in the pigment algorithm. Normalized water-leaving radiances have the solar zenith angle dependence removed and therefore have the advantage of being nearly constant at 520nm and 550nm in clear-water regions. The normalized 443nm water-leaving radiances are variable because of the great sensitivity to pigment concentration at 443nm, even in clear water regions. At this time, algorithms for deriving other quantities from normalized radiances have not been developed. Finally, the user is given the option of applying the Smith and Wilson (1981) iteration method for computing the water and aerosol radiance fields. This option creates an eighth output field for water radiance at 670nm since it does not assume that water radiance at 670nm is zero as does the Gordon et al. (1983) algorithm. For each pixel, if the algorithm does not converge after 10 iterations, it is assumed to be an invalid pixel and a 0 gray level (black) is assigned to all output images at that pixel.

One input which may require some advance consideration is the cloud flag. In L2MULT, the 443nm level-1 radiances are used with the 750nm (band 5) radiances to discriminate land from clouds if the MASKLC parameter is set to "1." In this case, pixels which are brighter than the CLOUD threshold gray level value and which are also flagged by the LANCLD threshold will be set to a 255 gray level in the level-2 images. Pixels which fail the LANCLD threshold, but pass the CLOUD threshold are set to a 0 gray level value. If the CLOUD threshold used results in black areas over the ocean, these pixels may be changed to 255 using the program RESCALE. However, RESCALE operates on the entire image. It is assumed that a blotch of the land areas will be overlaid on the image, so it is not essential that all land be flagged black by the level-2 processing.

There are two pigment algorithms from which to select. The parameter is PIGMENT. One is the standard, two-channel "branching" algorithm of Gordon et al. (1983). This algorithm switches from an equation based on water radiances in the 443nm and 550nm bands to one based on the 520nm and 550nm bands once the concentration reaches 1.5. In this case, PC-SEAPAK also switches to the 520nm-550nm equation once the 443nm subsurface water radiance drops below 0.15. This is done because of imperfections in the switching logic which occasionally allow the 443nm-550nm combination to be used even though it yields values much greater than 1.5. The exact algorithm as implemented in PC-SEAPAK is

1. if Lw(550)=<0, then P=46.34456 (saturated); else,
2. if Lw(443)>0.15,
   then P = A2 * (Lw(443)/Lw(550))**B2, (A)
   where $\log_{10}$(A2)=0.053 and B2=-1.71;
   if P>=1.5 and Lw(520)>0
      then P = A4 * (Lw(520)/Lw(550))**B4, (B)
      where $\log_{10}$(A4)=0.522 and B4=-2.44;
      if P<1.5, then use (A) above;
3. if Lw(443)=<0.15 and Lw(520)>0, then use (B) above;

```
4. if Lw(443)=<0.15 and Lw(520)=<0,
     then P = 46.34456 (saturated);
```

where Lw represents the water-leaving radiance for the band of the specified wavelength (nm) and P is the pigment concentration in mg/m^3.

The other algorithm uses a three-channel equation provided by Dennis Clark (see Muller-Karger et al., 1990):

```
1. if (Lw(550)>0) and (Lw(443)>0 or Lw(520)>0), then
      RATIO = [max(Lw(443),0) + max(Lw(520),0)] / Lw(550)
      P = 5.56 * RATIO**(-2.252); else,
2. P = 46.24456 (saturated).
```

This algorithm does not involve a switching of equations that often results in a minimum for the pigment frequency distribution of the two-channel algorithm.

Finally, L2MULT and CLRWAT allow the user to change the calibration of bands 1 to 4. In the case of multiple scattering, only two options are provided, "Evans" and "User." The parameter is CORR. The CZCS suffered a severe calibration degradation or sensitivity loss which was erratic. Several algorithms were proposed by various investigators to correct for this and all are necessarily coupled to the Rayleigh scattering model they used. The reason for this coupling is that all techniques utilize either direct sea truth measurements or assume clear water radiances over the open ocean and the calibration is adjusted so as to match those values with the assumption that the Angstrom exponents in clear water regions are zero.

The Evans scheme (unpublished; used in the global CZCS processing) is the only one available which corresponds to the multiple scattering model of Gordon et al. (1988). The user should only try defining his own correction factors (FACTOR) when testing the sensitivity of the level-2 products or when he is trying to compare with sea truth observations. These calibration factors only multiply the calibration term as given in Gordon et al. (1983) and do not change the slope and intercept numbers in that term. The Evans calibration modifies the slopes and intercepts for each gain setting and includes a time-dependent correction factor as well. There must be a consistency between the calibration used in deriving the Angstrom exponents and that used in L2MULT.

Table 5. Values of time-independent "Evans" parameters.

parameter	gain	band 1	band 2	band 3	band 4
SLP	1	0.04452	0.03103	0.02467	0.01136
	2	0.03589	0.02493	0.02015	0.00897
	3	0.02968	0.02032	0.01643	0.00741
	4	0.02113	0.01486	0.01181	0.00535
INT	1	0.03963	0.05361	0.06992	0.01136
	2	0.03963	0.06361	0.06992	0.01136
	3	0.03963	0.06461	0.08292	0.01136
	4	0.03963	0.06361	0.07992	0.01136
MULTG	1	1.057	0.969	0.958	1.008
	2	1.060	0.970	0.947	1.020
	3	1.050	0.975	0.931	1.016
	4	1.059	0.960	0.934	1.010
SMULT	--	0.983	1.013	1.017	1.000
IMULT	--	1.0	1.0	1.1461.0	

The conversion of CZCS counts to total radiance (Lt), or calibration, uses the following general equation:

Lt(b) = [Counts(b)*SLOPE(b) + INTCP(b)] * FACTOR(b)

where SLOPE and INTCP are the equations slope and intercept, FACTOR is the correction factor, and b is a CZCS band (channel) number 1 to 4. For the "Evans" option, SLOPE, INTCP, and FACTOR are calculated as follows:

```
SLOPE(b)  = SLP(b,g) * MULTG(b,g) * SMULT(b) *
                [C(b,o) - (A(b,o)*Orbit)]
INTCP(b)  = INT(b,g) * MULTG(b,g) * IMULT(b)
FACTOR(b) = 1.0
```

where SLP and INT are the unmodified calibration slope and intercept, MULTG is a gain-dependent multiplier to SLP and INT, SMULT and IMULT are gain-independent multipliers to SLP and INT, and C and A are the intercept and slope of a time-dependent (orbit number) correction to SLP. The indices b and o represent the sensor gain and orbit. The values of SLP, INT, MULTG, SMULT, and IMULT are listed in Table 1, and those of C and A are listed in Table 2. For the "user" option, SLOPE and INTCP are obtained from Table 3 and FACTOR is as specified by the user.

Once the level-2 products have been created, gray level and geophysical values may be examined using programs such as READ, RLINE and HIST. For linearly scaled quantities, the slope and intercept are stored in the file header and are read by these programs in order to transform gray levels to geophysical values. READ allows the user to roam the image and examine values within a

par.	orbi				
A	<5001	-1.700E-05	-5.000E-06	-2.000E-06	0.0
	5001-6750	-6.000E-05	-5.000E-06	-2.000E-06	0.0
	6751-20000	-1.457E-05	-9.770E-06	-6.620E-06	0.0
	>20000	-1.700E-05	-6.000E-06	-5.000E-06	-5.000E
C	<5001	1.0	1.0	1.0	1.0
	5001-6750	0.785	1.0	1.0	1.0
	6751-20000	1.092	0.967	0.968	1.0
	>20000	1.0426	1.0420.9995	0.9	

user-defined box or at individual points. RLINE allows the user to examine values along lines and HIST can be used to examine the frequency distributions.

All image files are in a one byte per pixel, binary format with pixel values scaled from 0 to 255. In programs such as L2MULT, the user may decide the water radiance scaling by setting the radiance limits using the WATER parameter, but the defaults are 0 to 2.55 mw/(steradian-micron-cm^2). The water, aerosol and 443 Rayleigh radiances are all linear functions of gray level. The water radiance values are adjustable because some scenes may have features with radiances greater than 3.0. Aerosol radiance is scaled for values 0 to 2.55. Rayleigh radiance is scaled according to the minimum and maximum values for the scene and, therefore, its scaling varies from scene to scene.

For pigment concentrations (mg/m^3), PC-SEAPAK calculates the gray level values using the Univ. of Miami DSP system's scaling conversion:

$$GRAY = nint((log10(PIGMENT) + 1.4) / 0.012)$$

with gray scale limits of 2 through 245 (or 1.5 to 245.49 before rounding, corresponding to pigment values of 0.0415 to 35.15). ("Nint" is a function to round to the nearest integer.)

Acknowledgements: The tables used by PC-SEAPAK for the Rayleigh scattering computations were contributed by Howard R. Gordon, James W. Brown, and Robert H. Evans of the University of Miami. Values for Tables 1 and 2 presented here are from Robert H. Evans.

Table 7. Slopes and intercepts for "user" option (from Gord al., 1983).

parameter	gain	band 1	band 2	band 3	band 4
SLOPE	1	0.04452	0.03103	0.02467	0.0113
	2	0.03598	0.02493	0.02015	0.0089
	3	0.02968	0.02032	0.01643	0.0074
	4	0.02113	0.01486	0.01181	0.0053
INTCP	1	0.03963	0.06361	0.07992	0.0113
	2	0.05276	0.08826	0.06247	0.0358
	3	0.02879	0.09752	0.06570	0.0296
	4	0.03359	0.05647	0.04723	0.01646

PROJECTING MULTIPLE IMAGES TO A COMMON MAP

The projection of images to a common map is often required in image analysis when studying a set of associated images. The study of a time series of images over a certain general region (Case 1) or the use of a number of images to form a single composite image covering a wider geographical area (Case 2) are two occasions where such projection is required. In both cases the images are projected to a common imaginary map and the images may or may not actually overlap with each other in geographical area. This section will describe how the projection program MAPIMG may be used to perform projection of multiple images for these two cases.

When the navigation information associated with an image is incorrect, the geocoordinates (as obtained by the program LATLON, for example) of image landmarks will also not be correct. Such images may be corrected using the program REGIST which will simply shift the gray level values relative to their pixel/line (TV) coordinates. (A monitor display of 512 pixels by 512 lines is assumed in this discussion.) This correction may be done independently of the use of MAPIMG which will map the corrected or uncorrected image using the same navigation information. Navigation data for CZCS scenes are usually accurate to within three pixels.

When using MAPIMG it is useful to think of the display (monitor) as a window or view area over an imaginary map of the world. A mapped image output by MAPIMG will normally have a portion or all of the area of the input image visible within this window. For Case 1, output images are often partially outside the window (lost) since each image in the series of images is likely to cover the earth area of interest to a different extent. Therefore the map of the world being considered is often much larger than the window for Case 1. For Case 2 however, output images are likely to be entirely within the window which will cover a large portion of, if not the entire, map. Case 2 output images can also be thought of as various pieces of a map puzzle (or mosaic) which may or may not be completely filled in.

"Output image" as used here refers to the input image as it would appear on the world map. The actual image created by MAPIMG, and contained in the file OUTFILE, is that of the window area of the map which may or may not include all of this "output image." If part of the output image is outside the window, it will be lost (i.e. not included in OUTFILE). Conversely, window pixels that are not within the output image boundary will be black (and stored in OUTFILE as such).

Controlling the Projection Characteristics of the Output

The MAPIMG input parameter PROJECTN determines the projection of the output image as well as of the imaginary map of the world of which it is a part. Although the image is projected onto that map, the input parameters LL_1, LL_2, PIXEL, LINE, and DELTA_P allow the user to control where the window will be positioned over the map as well as the scale of the map. If defaulted, these parameters will be set such that the window will be directly over the output image area of the map and the map's scale will be such that this image will take up as much of the window as possible while remaining entirely within it. These default values are optimal for cases where images are being studied individually instead of as a group. Since these five parameters are used in conjunction with each other, if any one of them is defaulted, they will all be defaulted regardless of any values entered for some.

If no defaults are used, the PIXEL and LINE parameters refer to the TV coordinates of a point on the window whereas LL_1 refers to the geocoordinates (latitude and longitude) of a point on the world map. The points will be associated so that the window point overlays the map point. For a Case 1 study, the user may find it convenient to choose LL_1 to be in the center of the earth region of interest and assign it PIXEL/LINE values of 256/256, the center of the display (window). Alternatively, the user may wish that a certain landmark appear at a certain location on the display. In such a case, the landmark's geocoordinates would be entered for LL_1 and the desired display location specified by PIXEL/LINE. Similarly for Case 2, the geocoordinates of the geographical center of the desired composite image may be entered for LL_1 and 256/256 for PIXEL/LINE.

The use of parameters LL_2 and DELTA_P in conjunction with LL_1, PIXEL, and LINE controls the scale of the map and, hence, also controls how much of the mapped image appears on the display (i.e., within the window). LL_2 represents the geocoordinates of another point on the world map and DELTA_P represents the separation in pixels between that point and the PIXEL/LINE window location. A positive DELTA_P represents a horizontal separation, whereas a negative value represents a vertical separation.

Note that this second point need not be within the window and that the absolute value of DELTA_P may be larger than the display width or height (512 pixels or lines). For given parameters, a larger absolute DELTA_P will decrease the geographical area covered by the window (enlarge the map); a smaller absolute value will increase this area (contract the map). The direction of the second point relative to the first--that is, where they both fall on the world map--is determined solely by the projection.

Although DELTA_P represents the separation in either the horizontal or vertical direction (not the absolute separation), the points for LL_1 and LL_2 must be chosen such that they have both a horizontal AND vertical separation on the imaginary map.

Therefore some a priori knowledge of where these points will fall on that map is required when choosing these parameter values.

A convenient way to determine values for LL_2 and DELTA_P is to use the geocoordinates of another landmark for LL_2 and enter the desired separation between LL_1 and LL_2 for DELTA_P. Another convenient way to determine these values is to determine the scale for the map at LL_1. (In certain cases, depending on the projection, the scale will vary greatly even within the window area.) That is, the user decides how many display pixels (DELTA_P) should separate a longitudinal or latitudinal degree, minute, or second and assign LL_2 and DELTA_P accordingly. For example, if the scale at LL_1 is to be one latitudinal degree per 100 pixels and LL_1 is 10 degrees latitude and 38 degrees longitude, LL_2 would be 9 and 38 degrees and DELTA_P would be -100 (assuming that north is on top for this projection).

MAPIMG will prompt the user for dynamic parameters soon after it has been initiated. The requested parameters will depend on the projection that was specified.

It is important to understand that the default values for these dynamic parameters are calculated on the basis of the input image since the geographical characteristics for the map within the window have not been determined at this point. (These parameters are themselves used in the projection calculations and so, what the map would look like cannot be known at this point.) For example, if PROJECTN is 1 (UTM projection), the value for ZONE will be the number of the UTM zone in which is located the longitudinal midpoint of the input image. This ZONE value may be different from that desired for the common map onto which a series of images are being projection as described in the following paragraphs.

The dynamic parameter default values are meant to serve as a best guess for the map area that appears within the window area assuming that LL_1, LL_2, PIXEL, LINE, and DELTA_P are defaulted. Therefore it is up to the user to set these values so that they correspond to the desired map region within the window. For example, if the midpoint of this region is used for the zone in a UTM projection, this region will be at the center of a UTM-projected (imaginary) world map; if a point to the west of this region is used to determine this zone, the region will be on the right side of such a map.

When the map area within the window is large relative to the output image, as is often true for Case 2 studies, it is important to visualize this map area when deciding these dynamic parameter values. For instance, if an entire Van der Grinten (PROJECTN=19) world map will be within the window, the user may choose the central meridian such that the center of the map features the Americas, Europe/Africa, or the Atlantic or Pacific Oceans.

The input parameter ASPECT enables the user to modify the aspect ratio of the world map by stretching or contracting the horizontal and vertical aspects independently of each other. ASPECT is applied after the projection characteristics are determined by the program and so is independent of all other parameters. Since ASPECT may change the technical characteristics of a projection (a Van der Grinten projection, for example, will no longer be a Van der Grinten projection if ASPECT is not 1), a value other than 1 (the default) should only be used for special purposes such as to allow room on the display area for a caption, for example, or to permit a split screen display of more than one image.

Once the input parameters PROJCTN, LL_1, LL_2, PIXEL, LINE, DELTA_P, and ASPECT and the dynamic parameters have been established for one image, the same values must be used for the other input images in the set. This applies for both, Case 1 and 2, studies. These parameters determine the characteristics of the world map onto which the input images will be projected as well as the view area of the window.

Executing MAPIMG in Batch Mode

Because MAPIMG can only work on one input image file and it may require several minutes for each execution, a batch version has been designed to enable batch execution that allows up to 10 input image files, each with its own input parameter set, to be executed together. Two steps are required to execute this version. First, the program PARMPIMG is used to create or modify an input parameter file that can contain up to 10 independent input parameter sets. The second and main processing step is to use the program BHMAPIMG with the input parameter file generated by PARMPIMG to generate the mapped output images based on the input parameter sets contained in that file.

USING STATDIS TO GENERATE IMAGES FROM IMAGE DATA FILES

Some PC-SEAPAK programs create image "data" files instead of regular PC-SEAPAK image files. Regular files use a byte to store the value of each image pixel so that each pixel may have an integer value of 0 to 255. Data files, on the other hand, use a real number (four bytes) to represent each pixel. The precision for real data is much greater than for byte data: about one part per 8.4 million versus one part per 255. It is therefore very advantageous to perform image calculations using real pixel numbers instead of bytes values. For this reason, programs such as ADDF, MEANF, MULTF and LOGF generate data image files as output which may then be converted to regular image files using the program STATDIS. The image files generated by STATDIS may then be displayed directly on an MVP-AT frame buffer.

The optimal conversion (mapping) of the real data into values of 0 to 255 depends on the distribution of the data. The most straightforward mapping would be to assign the minimum to 0, the maximum to 255, and interpolate linearly for intermediate values. This is the mapping function used by STATDIS to display the initial image from an input linear data image. However, if the data are concentrated over a relatively small portion of their range, this mapping may result in a great loss of resolution for these data. Therefore a primary function of STATDIS is to allow the user to optimize a linear mapping by specifying a smaller data range to be mapped. STATDIS may also be used to assign the same mapping to multiple images of the same geophysical quantity since it is desirable that for such images the gray shades (or pseudocolors) represent the same magnitudes.

Note that since the pigment concentration-to-gray-level mapping is non-linear and is preset, STATDIS does not permit pigment image mappings to be varied.

Because of the larger storage requirements of data image files (four bytes instead of one per pixel), a user may choose to create such files only for a certain region of interest defined by a blotch. If so, that blotch must be used with STATDIS so that STATDIS can reconstruct the image area represented by the corresponding data image file.

The following describes the possible steps needed to create, for a given blotch area, an image resulting from the mathematical manipulation of other images in PC-SEAPAK:

1. Use IMAGE to display the image(s) of interest.
2. Use BLOTCH to define a blotch for the region of interest over the displayed image.
3. Use BPSAV to save the blotch displayed as a disk file.
4. Perform the desired mathematical calculations on the image file(s) for the defined blotch and generate the data image file. Programs such as ADDF, MEANF, MULTF, and LOGF generate such files and allow the user to specify a blotch file for the calculations.

5. Invoke STATDIS while the blotch defined in step 2 is displayed on the MVP-AT.
6. Use STATDIS to determine the image gray level mapping or save the image as a regular image file.

FORMATS OF IMAGE AND CONTROL POINT FILES

Standard PC-SEAPAK image files that can be dropped into MVT-AT frame buffers for display are simple flat files of 512 logical records, each of which is 512-bytes long. Each logical record corresponds to an image line when displayed and each byte corresponds to the pixels on that line. Additional 512-byte records containing header information may precede the image data. These image files normally contain one such header record. Files containing overlay graphics (also referred to as blotch files), are identical in structure except that they do not include any header records.

Users need not normally be concerned with the contents of an image file's header. However, a header's information may be examined using the program DMPHDR. The program MODHDR is provided for the rare occasion when a user may wish to change certain of this information. A complete list of the parameters retained in the header, their data types, and their locations, is presented in Table 1. Note that parameters may be for informational purpose only (i.e., they do not impact any program's calculations), may have more than one meaning depending on the context (i.e. the settings of flags and the program in question), or may be reserved for future use.

Except for images containing gridded data, unmapped images created by such programs as the ingest programs and DSPIMG are each associated with a control point file. Such files contain the navigation information for their corresponding images and are denoted by the extension ".CTL" in their filenames. This information consists essentially of a set of geocoordinates (latitude/longitude pairs) corresponding to a set of display coordinates (pixel/line pairs). These display coordinates are also referred to as control points. From these data, the geocoordinates of all other image pixels can be interpolated for program calculations requiring earth locations. The format of control point files is explained in the following paragraph, although the user is cautioned that modifying such files may cause errors in programs using these data.

345-346	spare	
1-4	area code	I*4
5-6	start year	I*2
7-8	start day	I*2
9-12	start msec	I*4
13-14	orbit number	I*2
15-34	spare	
35-36	gain	I*2
37-38	thresh	I*2
39-40	solar elevation (scene center)	I*2
41-42	solar azimuth (scene center)	I*2
43-44	roll (scene center)	I*2
45-46	pitch (scene center)	I*2
47-48	yaw (scene center)	I*2
49-52	gray-to-data slope	R*4
53-72	spare	
73-76	gray-to-data intercept	R*4
77-96	spare	
97-98	starting pixel of tape ingesting	I*2
99-100	starting line of tape ingesting	I*2
101-102	ending pixel of tape ingesting	I*2
103-104	total lines on tape ingesting	I*2
105-106	pixel reduction factor	I*2
107-108	line reduction factor	I*2
109-110	spare (must be 0)	
111-112	tilt angle	I*2
113-128	spare	
129-132	minimum latitude in the image	R*4
133-136	maximum latitude in the image	R*4
137-140	minimum longitude in the image	R*4
141-144	maximum longitude in the image	R*4
145-146	control points per image line	I*2
147-148	control points per pixel column	I*2
149-164	image corner latitudes	4(R*4)
165-180	image corner longitudes	4(R*4)
181-184	increment in msec	I*4
185-200	four epsilons	4(R*4)
201-236	control point file name	A*36
237-256	five circle parameters	5(R*4)
257-258	display offset	I*2
259-260	stamp for derived images	I*2
261-262	spare	I*2
263-264	normalized water radiance flag	I*2
265-280	spare	
281-282	MAPIMG projection index	I*2
283-284	UTM or SPC zone	I*2
285-344	15 projection parameters	15(R*4)

Byte		
489-512	spare	
347-348		
	C1 - CZCS level-1 image	
	C2 - CZCS level-2 image	
	A6,A7,A8,A9,AA,AB - AVHRR-6,7,8,9,10,11	
	M2 - U. of Miami DSP	
	G - gridded image	
349-350	data type	C*2
	L1 - CZCS or AVHRR level-1	
	TR - total radiance	
	PI - pigment	
	SC - CZCS SST	
	SA - AVHRR SST	
	WR - water radiance	
	RA - Rayleigh radiance	
	AT - AVHRR thermal bands	
	DA - diffuse attenuation	
351-352	band number	I*2
353-354	starting pixel of image	I*2
355-356	ending pixel of image	I*2
357-358	starting line of image	I*2
359-360	ending line of image	I*2
361-364	spare	
365-366	MAPIMG projection index	I*2
367-368	UTM or SPC zone	I*2
369-488	15 projection parameters	15(R*8)

Control point files are ASCII files containing certain variables in the following logical records:

record	parameter	Fortran format
1	NCPP, NCPL, "1"	3I10
2	CPPIX	8I10/
3	CPLIN	8I10/
4	LATMIN, LATMAX, LONMIN, LONMAX, DATLIN	4F12.7,I10
5	CPLAT	8F12.7/
6	CPLON8F12.7/	

Records 5 and 6 are repeated NCPL times, one pair for each CPLIN value. The definitions of these variables are:

NCPP: Number of control points per image line (control point pixels); 1 to 100; usually 26.

NCPL: Number of control points per pixel column (control point lines); 1 to 100; usually 26.

"1": Flag indicating that it is a new format control point file, described herein; the new format was adopted in

April 1988 to allow more flexibility in mapping images to different projections.

CPPIX: Unmapped pixel indices of control points; run from small to large (left to right on the image display); NCPP values ranging from 1 to 512.

CPLIN: Unmapped line indices of control points; run from small to large (top to bottom on the image display); NCPL values ranging from 1 to 512.

LATMIN: Southernmost CPLAT value.

LATMAX: Northernmost CPLAT value.

LONMIN: Westernmost CPLON value.

LONMAX: Easternmost CPLON value.

DATLIN: Equals -1 if 180 deg. longitude crosses the control point field; else, equals 0; may be used as a logical variable.

CPLAT: Latitudes (+-90 decimal degrees) of control points; each CPLAT record contains NCPP values, one for each CPPIX value; there are NCPL CPLAT records, one for each CPLIN value; read in as a two dimensional array where the first index represents the horizontal (pixel) display direction and the second represents the vertical (line) direction; e.g., CPLAT(3,4), the third value of the fourth CPLAT record, is the latitude for the pixel CPPIX(3) on line CPLIN(4); the order of lines run N to S and the order of pixels run W to E.

CPLON: Longitudes (+-180 decimal degrees) of control points; each CPLON record contains NCPP values, one for each CPPIX value; there are NCPL CPLON records, one for each CPLIN value; read in as a two dimensional array where the first index represents the horizontal (pixel) display direction and the second represents the vertical (line) direction; e.g., CPLON(3,4), the third value of the fourth CPLON record, is the longitude for the pixel CPPIX(3) on line CPLIN(4); the order of lines run N to S and the order of pixels run W to E.

In PC-SEAPAK, level-3 images refer to those created by the projection program MAPIMG (and its alternate versions, BHMAPIMG, WTKMP, and BHWTKMP). Level-3 images contain the values of their projection equation parameters in their headers and are not associated with control point files.

PC-SEAPAK MENU TREE

DATE: 10/28/91

MENU/PROGRAM	DESCRIPTION

1. INGEST - CZCS and AVHRR ingestion
   A. CZCSIN - CZCS ingestion
      1. TPCZCS .... Level-1 tape ingest
      2. DKCZCS .... Level-1 disk ingest
      3. TP2DSK .... Full-scene level-1 tape ingest
      4. DSK2DSK .... Full-scene level-1 disk ingest
      5. WINDOW .... Image from full-scene file
   B. AVHRRIN - AVHRR ingestion
      1. TPAVHRR .... NOAA-format level-1b tape ingest
      2. DKAVHRR .... NOAA-format level-1b disk ingest
      3. TPSDRPS .... NORDA-format level-1b tape ingest
      4. DKSDRPS .... NORDA-format level-1b disk ingest
      5. SOLARZ .... Solar zenith correction

2. CZCSL2 - CZCS level-2 processing
   A. L2BOX .... Localized level-2 analysis
   B. FLAGLC .... Land/cloud flag determination
   C. THRES .... Threshold determination
   D. ATMOS - Atmospheric correction and determination
      1. CLRWAT .... Angstrom determination, auto mode
      2. SCREEN .... Valid clear water pixel display
      3. BXCLRWAT .... Angstrom determination, box mode
      4. OZONE .... Ozone/optical thickness values
      5. ANGST .... Interactive Angstrom determination
   E. L2PROD - CZCS level-2 product generation
      1. L2MULT .... Level-2 product generation
      2. BHL2MULT .... Batch mode of L2MULT
      3. PARL2MU .... L2MULT parameter file generation
      4. WTKLM .... L2MULT for WEITEK coprocessor
      5. BHWTKLM .... BHL2MULT for WEITEK coprocessor
      6. L2CON .... Pigment scaling conversion
   F. RING .... Mask out sensor ringing

3. IMAGING - MVP-AT frame buffer programs
   A. INITIAL - MVP-AT initialization
      1. INIT .... MVP-AT initialization
      2. CLR .... Clear frame buffers
      3. SPKSETUP .... Configuration setup
      4. GPCOLOR .... Graphics palette color assignment
      5. BPCOLOR .... LUT palette color assignment
      6. BP1COLOR .... Individual palette color assignment

3. IMAGING - MVP-AT frame buffer programs (continued)

B. FRMBUF - Frame buffer operations

1. IMAGE .... Display image
2. IMAGSAV .... Save image into file
3. IMGXRT .... Display non-SEAPAK image
4. SELECT .... Select frame buffer
5. LOOP .... Loop frame buffer images
6. DSKLOOP .... Loop disk file images
7. IMGLST .... List frame buffer image names
8. ZOOM .... Zoom and roam an image
9. IMGEDIT .... Cut and shift an image

C. OVERLAYS - Overlay graphics manipulation

1. ANNOTATE .... Annotation
2. BLOTCH .... Area-of-interest definition
3. CONTOUR .... Gray-level contouring
4. GPONOFF .... Turn graphics on/off
5. GPCLR .... Clear graphics
6. BPSAV .... Save graphics into file
7. BPLOAD .... Load graphics from file
8. REGION .... Area-of-interest border overlay
9. TRACK .... Aircraft/ship track data analysis

D. LUTCOLOR - Look-up table and color operations

1. TABLOAD .... Load LUT into frame buffer
2. TABSAV .... Save LUT into disk file
3. STRETCH .... Linear contrast stretch
4. PLI .... Piecewise linear stretch
5. LUTMOD .... Gray-level range rescale
6. RESCALE .... Image rescaling
7. PAINT .... False color palette development
8. COLBAR .... Generate color bar

E. MOSAIC - Mosaic programs

1. MOSAIC .... Mosaic image creation
2. RGBDIS .... True color image display

4. IMGFILE - Image file information

A. DATA - Image file data retrieval

1. READ .... Data extraction (box/point)
2. RLINE .... Data extraction (line)
3. ASCIMG .... 2-D array from image

B. HEADER - Image file header information

1. DMPHDR .... Display/print file header
2. MODHDR .... Change header information
3. ADDHDR .... Add header block to image file

C. MERGE .... Merge CZCS/AVHRR images
D. ALIAS .... Assign aliases to file names
E. HILOW .... Min/max image generation

5. GEOGRAPH - Geographic programs
   - A. PROJECTN - Image map projection programs
     - 1. MAPIMG .... Image map projection
     - 2. BHMAPIMG .... Batch mode of MAPIMG
     - 3. PARMPIMG .... MAPIMG parameter file generation
     - 4. WTKMP .... MAPIMG for WEITEK coprocessor
     - 5. BHWTKMP .... BHMAPIMG for WEITEK coprocessor
   - B. REGIST .... Image translation
   - C. GRID .... Latitude/longitude grid overlay
   - D. LATLON .... Latitude/longitude determination
   - E. COAST .... Coastline/geographic features overlay
   - F. BATHYIMG .... Bathymetry image file generation

6. MATH - Mathematical programs
   - A. HARDFCT - Hardware image functions
     - 1. IMGFCT .... Functions for image and constant
     - 2. IMG2FCT .... Functions for two images
     - 3. FILTER .... Filtering and edge detection
     - 4. CONVOLVE .... Image convolution
   - B. SOFTFCT - Software image functions
     - 1. ADDF .... Add./subt./exp. of image file(s)
     - 2. MEANF .... Averaging of image files
     - 3. LOGF .... Logarithm of an image file
     - 4. MULTF .... Mult./div./exp. of two image files
     - 5. STATDIS .... Image from real-valued data file
     - 6. DIFFI .... Difference of two image files
     - 7. DERIV .... Derivatives of an image
     - 8. IMATCH .... Modify image based on another image
   - C. STAT1 - Statistical analyses menu 1
     - 1. HIST .... Frequency distribution
     - 2. BHHIST .... Batch mode of HIST
     - 3. MV .... Mean/variance image generation
     - 4. FILLA .... Image fill/filter, auto mode
     - 5. FILLM .... Image fill, manual mode
     - 6. TSERIES .... Time series statistics plot
     - 7. MEM .... Maximum entropy method
   - D. STAT2 - Statistical analyses menu 2
     - 1. SCATT .... Scattergram plot
     - 2. CORCO .... Correlation coefficient
     - 3. AUTOCORR .... Autocorrelation vs. lags
     - 4. XCORR .... Cross correlation vs. lags
     - 5. VARIOG .... Semivariance vs. lags
     - 6. EOF .... Empirical orthogonal function analysis
     - 7. EOFPLOT .... Plot/MEM of EOF principal components

7. <u>UTIL</u> - Utility programs

A. <u>HARDCOPY</u> - Image hard-copy programs

1. PJTCOL .... PaintJet color selection
2. IMGPRINT .... PaintJet image hard copy
3. PSIMAGE .... Postscript image hard copy

B. <u>MIAMI</u> - Univ. of Miami file format support

1. PSTIMG .... Image from PST file
2. DSPIMG .... Image from DSP file
3. NODSST .... Image from NODS MCSST file
4. PSTXRT .... Image from PSTIMG image

C. <u>VAXTOPC</u> - VAX-to-PC format conversion

1. HDRCVT .... Header block conversion
2. BLOCVT .... Graphics file conversion
3. LUTCVT .... LUT file conversion

PROGRAM NAME: ADDF
DATE: 10/28/91
MENU: SOFTFCT

DESCRIPTION: This program may be used to add or subtract several disk image files, pixel by pixel, according to the following general equation:

OUT = C + sum[W(n)*I(n)**E(n)] for n = 1 to NUM

where OUT is the output data file designated by the parameter OFIL, C corresponds to the constant CONST, W are the weights WEIGHT, I are the image data from the files IN_FIL, E are the exponents EXPONENT, and NUM is the number of IN_FIL files. The image region of interest may be specified by GPAL and BFIL.

The calculation results are stored as real-valued data in OFIL in order to retain maximum accuracy. OFIL may be used subsequently as input to the program STATDIS in order to generate its image, optimize its gray scale, and save it as a disk image file. For a given pixel, if any I(n) value falls outside the RANGE values, or if an arithmetic error occurs during summation, OUT for that pixel will be flagged as "invalid" and subsequently assigned a value that is specified in STATDIS.

PARAMETERS:

(1) **IN_FIL** is the array of the input image file names to be processed. Up to 12 files may be entered at once. All files should contain one header block (512 bytes) followed by 512 blocks of image data.

(2) **WEIGHT** is the array of the weighing factors for IN_FIL. A number must be entered for each IN_FIL to be summed. Each number will be used as a multiplicative factor for the pixel values of its corresponding image (raised to the EXPONENT power) during summation. To illustrate the use, consider the following examples:
   1) for simple summation, set CONST=0, WEIGHT(n)=1, and EXPONENT(n)=1;
   2) to raise a single image to the 3rd power, set CONST=0, WEIGHT(1)=1, and EXPONENT(1)=3;
   3) to subtract image 2 from image 1, set CONST=0, WEIGHT(1)=EXPONENT(1)=EXPONENT(2)=1, and WEIGHT(2)=-1.

(3) **EXPONENT** is the array of the exponents for IN_FIL. A number must be entered for each IN_FIL to be summed. Each number will be used as the power by which to raise the pixel values of its corresponding image during summation. Note that EXPONENT not equal to one will affect the units of their respective terms. It is the user's responsibility to ensure that the final units of terms are consistent. Arithmetic errors may occur during summation if inappropriate EXPONENT values are used. For example, errors will occur if EXPONENT is too large or too small, or if negative EXPONENT is used

with zero or negative input image pixel values. Output data values of pixels for which arithmetic errors have occurred will be flagged as "invalid" and may be assigned any desired value when using the program STATDIS. (See the documentation for the program STATDIS dealing with the parameter INVAL for further information). Such pixels cannot be distinguished from those flagged as "invalid" because of range restrictions which are described later. ADDF will display the number of pixels with such errors, if any have occurred, at the end of its processing. With the use of an appropriate blotch or values for RANGE, these pixels may be excluded from the calculations. However, these arithmetic errors may indicate that your values for EXPONENT and other input parameters are incorrect and should be changed.

(4) **OFIL** is the name for the "data" file output to the disk. This file is composed of floating point numbers for higher accuracy. OFIL may be used as input to the program STATDIS in order to generate its image, optimize its gray scale, and save it as a PC-SEAPAK image file. Note, however, that the same blotch specification used in ADDF will be needed by STATDIS (i.e., the same blotch must be used unless GPAL=0). "Data" files such as OFIL cannot be dropped directly into the image display unit as images or used as input to this program. STATDIS must be used to generate and save image files from "data" files. In this way, you can interactively obtain, using STATDIS, an optimum gray scale for the image file corresponding to the range or subrange of data values in the "data" file. By convention, "data" file names end with the extension ".DAT" whereas image file names end with ".IMG". Note that the disk space required by a "data" file is proportional to the blotch area and may be much more than that required by an image file which is always 513 blocks. For a full image (GPAL=0, the equivalent of a full-image blotch), a "data" file will require 2049 blocks or about four times the space of an image file; for a blotch covering less than a quarter of the image, however, the "data" file will be smaller than an image file.

(5) **MODE** is a flag which indicates whether the pixel values of the IN_FIL image(s) represent data (such as temperature or radiance) that are linearly related to gray levels, or pigment concentrations which are non-linear. A "1" should be entered for linear data and a "2" for pigment data.

(6) **RANGE** defines the range of IN_FIL pixel values to use for the summation. The user should enter two values in the input data units. For a given pixel location, if a value for any IN_FIL falls outside the RANGE values, the corresponding pixel in OFIL will be flagged as "invalid." These "invalid" pixels may be assigned any value when using STATDIS to generate the image from OFIL. Again, the RANGE values must conform to the units of the IN_FIL image(s) as specified by MODE and FACTOR (i.e. pigment concentration or units linearly proportional to gray levels). For example, to exclude only

land and cloud pixels, the RANGE values should be 1.0 and 254.0 (the default values) for gray levels (MODE=1 and FACTOR=1) or 0.0409 and 44.46 for pigment concentrations (MODE=2).

(7) **CONST** is a constant (in output data units) which is to be added to the summation. The user should enter a real number whose units match those of the other terms.

(8) **FACTOR** is a linear scale factor used only if MODE=1, i.e. when a linear data-to-gray scale mapping function for the IN_FIL image(s) is used. If greater than zero, it will represent the factor by which to divide the gray values of IN_FIL pixels in order to convert them into actual data values; if zero or less, the slope and intercept for this mapping function will be obtained from each file header of the IN_FIL disk image files. In order to retain the gray values, enter 1 (the default value); for sea surface temperature (SST), enter 8; for water radiance data, enter 85; for aerosol radiance data, enter 100.

(9) **GPAL** is the graphics palette which defines the blotch area(s) of interest and is in the range -7 to 7. If the number entered is positive, pixels within the blotch will be considered. If the number is negative, pixels outside the blotch will be considered. Only blotches defined by this graphics palette (the absolute value of GPAL) of the blotch file BFIL will be used. If "0" is entered, the entire image area (512 x 512) will be used and BFIL will be ignored.

(10) **BFIL** is the name of the blotch file which defines the image area(s) of interest unless GPAL= 0. Only blotches defined by the graphics palette corresponding to GPAL will be used. Blotches may be drawn and saved as files using the programs BLOTCH and BPSAV.

FUNCTION KEY DEFINITIONS:
No function keys are used.

PROGRAM NAME: ADDHDR
DATE: 10/28/91
MENU: HEADER

DESCRIPTION: This program allows the user to add a header block (512 bytes) at the beginning of an image file or a group of image files. The header block to be added may be a blank or a header from another image file.

PARAMETERS:
(1) **IFIL** is the file name that specifies an image file or a group of image files to be inserted with a header block (512 bytes) at the beginning of each image file. The header block to be added is specified by the parameter HFIL. The wild card characters "*" and "?" may be used to specify a group of files: "?" to replace a single character and "*" to replace multiple characters in the IFIL name.
(2) **HFIL** is the file name whose header block (the first 512 bytes) is to be added into the file(s) specified in IFIL. If this parameter is blank, a blank header block will be used.

FUNCTION KEY DEFINITIONS:
No function keys are used.

PROGRAM NAME: ALIAS
DATE: 10/28/91
MENU: IMGFILE

DESCRIPTION: This program allows the user to assign file name(s) to alias name(s) so that alias names may be used for file specifications in the program IMAGE. Note that to use an alias name, the user must enter an apostrophe, " ' ", before the alias name. A list of all alias names is kept in the ASCII file ALIAS.PAR in the SEAPAK directory. This file may be printed or edited using regular DOS commands. If the parameter FILNAM is blank, this program can also be used to list the file name(s) assigned to the alias name(s) which match the specification of the parameter ALIAS.

PARAMETERS:

(1) **ALIAS** is the alias name. If FILNAM is blank, the program will list all alias names that match the specification of ALIAS and the file names assigned to them. The wild card character "*" may be used anywhere in the ALIAS character string when FILNAM is blank. If FILNAM is not blank and does not contain "*", ALIAS will be recorded as the alias name of FILNAM. If there is "*" in FILNAM, the characters that replace the "*" in each file name found to match the FILNAM specification will be appended to ALIAS to form the corresponding alias names.

(2) **FILNAM** is the file name to be assigned to the alias name specified in ALIAS. If FILNAM does not contain the wild card character "*", the program will just assign the file name FILNAM to the alias name ALIAS. If there is "*" in FILNAM, the characters that replace the "*" in each file name found to match the FILNAM specification will be appended to ALIAS to form the corresponding alias names. (The "*" must be the last character prior to the period of the file name extension.) For example, if there are four files TEST1.IMG, TEST2.IMG, TEST3.IMG, TEST4.CTL in the current directory and ALIAS is "XX" and FILNAM is "TEST*", these files will be assigned to the alias names XX1, XX2, XX3, and XX4. However, if FILNAM is "TEST*.IMG", then only the first three files (with extensions ".IMG") will be assigned to the alias names XX1, XX2, and XX3. If FILNAM is blank, the program will list all alias names that match the specification of ALIAS and the file names assigned to them.

FUNCTION KEY DEFINITIONS:
No function keys are used.

PROGRAM NAME: ANGST
DATE: 10/28/91
MENU: ATMOS

DESCRIPTION: ANGST provides an alternative method to CLRWAT for estimating the Angstrom exponents required for removing aerosol radiance from a CZCS level 1 scene. The technique is based on Arnone and LaViolette (1984) and allows the user to interactively select the Angstrom exponent for the aerosol correction, correct the image and read the resulting subsurface water radiance values. The atmospheric correction algorithm is based on Gordon et al. (1988).

The user can visually correct a scene which may not have clear water or has distinct haze bands. When the aerosols have sharp structure, the Angstrom exponent can be increased until the structure disappears. The haze will appear as bright areas in the undercorrected scene, but if the scene is overcorrected, the structure will become darker than adjacent clear areas.

The correction is performed on each of channels 1 through 3 independently rather than simultaneously as in CLRWAT. Thus, the program requires that the level 1 radiance image files from any one of channels 1, 2 or 3 and channel 4. Channel 4 image file is required since the aerosol correction is based on the residual radiance in channel 4 after it has had the Rayleigh component removed. The channel 5 image file may be used, but not required, for the reference of land/clouds.

Once the program is initiated, it removes the Rayleigh radiance from the level 1 data. After this is accomplished, the user may change the Angstrom exponent by a horizontal translation of the cursor using the mouse or cursor keys. Function key F2 is used when a correction is to be made.

One approach of using ANGST is to follow some of the procedures in the 'clear-water' radiance algorithm which is applied in CLRWAT. First, correct channels 2 and 3 remembering that the absolute magnitude of the Angstrom exponent for channel 2 is usually greater than or equal to that for channel 3, and then average the Angstrom exponents in channels 2 and 3 and apply that value to channel 1. Continental haze has Angstrom exponents greater than or equal to zero; marine haze has Angstrom exponents of about zero; and dust has Angstrom exponents less than or equal to zero.

PARAMETERS:

(1) **IFIL1** is the file name of a level 1 radiance scene to be corrected. CZCS level 1 band 1, 2, or 3 image file should be used. The IFIL1 and IFIL2 have to be from the same scene.

(2) **IFIL2** is the CZCS level 1 band 4 image file. The IFIL1 and IFIL2 have to be from the same scene.

(3) **IFIL3** is the land/clouds reference file. The CZCS level 1 band 5 image file should be used.

(4) **LANCLD** is the channel 5 threshold in gray level value used to identify land and clouds. All pixels with values exceeding this value are assigned a value of 255.

(5) **CORR** is the index of the correction method to use for calculating total radiances:
   1: Use factors and method (time and gain dependent) of R. Evans (Univ. of Miami).
   2: Use correction factors specified by FACTOR.

(6) **ILTOPT** specifies the ILT option: If "1", ephemeris data from the ILT record of the level-1 scene will be used. If "0", much of these data will be obtained from the documentation record or calculated by SEAPAK based on the location and time at the start of the scene.

(7) **GPAL** is the graphics palette used to mark the location of cursor.

(8) **ANGS_RNG** are minimum and maximum Angstrom exponent values. The values set the range of values that can be applied for the aerosol correction and correspond to the extreme right side of the screen and extreme left side of the screen, respectively, when moving the cursor horizontally to select an Angstrom exponent.

(9) **OZONE** are optical thicknesses (in meters) for bands 1 to 4. If the value "-999" is entered, the values used will be from the PC-TOMS database for the day of the input CZCS scene and for the point nearest to the image center. If the PC-TOMS data point is missing or an error occurs accessing the data, a message to that effect will be displayed on the terminal along with the default values. If defaults are used, the values will be 0.00106, 0.0144, 0.0279, and 0.0125. These thicknesses are the products of the absorption coefficients (3.4E-6, 46E-6, 89E-6, and 40E-6) used at the Univ. of Miami and an average amount of 313 Dobson units of ozone.

(10) **FACTOR** are the correction factors to use for calculating total radiances of bands 1 to 4, respectively. These will be used only when CORR=2.

DYNAMIC PARAMETERS:

I. Parameter for outputting subsurface water radiance image into a file.

(1) **OFIL** is the output file name to be used to save the subsurface water radiance image.

FUNCTION KEY DEFINITIONS:

ESC: Exits the program.

F1: Displays current Angstrom exponent value. Any single horizontal movement will increase or decrease current value by (max(ANGS_RNG) - min(ANGS_RNG)) / 512.

F2: Displays the subsurface water radiance image by removing the aerosol radiance, which is calculated with current Angstrom exponent value, from the Rayleigh corrected level 1 band 1, 2, or 3 image.

F3: Displays the subsurface water radiance values and the mean and standard deviation inside current cursor box.

F4: Outputs the solar and the spacecraft zenith and azimuth angles used in the Rayleigh scattering computations. Additional information output are the subsurface "clear water" radiances that correspond to the solar zenith angle at the cursor location.
F5: Changes the size of the box cursor in a loop of sizes 1x1, 3x3, 5x5, 7x7, 9x9, 11x11, 13x13, and 15x15.
F6: Marks the cursor at current location.
F7: Allows the user to enhance the contrast of the corrected scene in order to determine more clearly the structure in the scene.
F8: Displays the cursor location (center of the cursor box) in pixel/line as well as in latitude/longitude coordinates.
F9: Displays the next image frame buffer.
F10: Allows the user to save current subsurface water radiance image into a file. Dynamic parameter OFIL will be requested.
ALT F1: Toggles the function key menu display on/off.
ALT F9: Allows the user to process another band. The parameter IFIL1 will be requested.
ALT F10: Allows the user to change the calibration parameters CORR and FACTOR. Once these are entered the sequence repeats by recomputing the total radiance and subtracting the Rayleigh radiance.
MOUSE LEFT BUTTON - Same as function key F1.
MOUSE RIGHT BUTTON - Toggles the function key menu display on/off.

PROGRAM NAME: ANNOTATE
DATE: 10/28/91
MENU: OVERLAYS

DESCRIPTION: The program ANNOTATE writes character/symbol overlays on the current displayed frame buffer. There are two text modes available, dot text and stroke text, each of which has different font selections available (see Appendix). The user can select the text mode and the font, change the size of the characters, the colors of the characters, the color of character's background (dot text) or fill (stroke text), the orientation of the text (dot text supports only 0, 90, 180, and 270 degree orientations). The user can write characters directly through keyboard or save the character strings into a buffer and write out that buffer at any time to any cursor position.

PARAMETERS:
None.

DYNAMIC PARAMETERS:
For changing parameters of dot text (press F1)
(1) **DOT_H** specifies the height in pixels of the dot text, it should always be a multiple of 8.
(2) **DOT_W** specifies the width in pixels of the dot text, it should always be a multiple of 8.
(3) **DOT_ANG** specifies the direction in degrees of the dot text to be displayed. Only 0, 90, 180 and 270 are valid inputs.
(4) **G_PAL** specifies the overlay color palette to be used for the dot text, only 0 to 7 are valid inputs. To change the color of the palette(s), use program BPCOLOR or BP1COLOR.
(5) **GB_PAL** specifies the overlay color palette to be used for the background of the dot text, only 0 to 7 are valid inputs. To change the color of the palettes(s), use program BPCOLOR or BP1COLOR.
(6) **POS_MODE** specifies how the annotation stored in the text buffer will be displayed relative to the cursor position.
    1. the cursor location is the start of the annotation.
    2. the cursor location is the end of the annotation.
    3. the cursor location is the center of the annotation.
(7) **DOT_FONT** specifies the font file selection for dot text. There are seven fonts available.
    1. HALO 88 default   2. HALO001.FNT   3. HALO002.FNT
    4. HALO010.FNT   5. HALO011.FNT   6. HALO012.FNT
    7. HALO013.FNT
    For font definitions, check the appendix in this guide.
(8) **TXT_BUF** specifies the text strings up to 80 characters to be saved in the buffer which can be displayed as the annotation whenever the function key F4 is pressed.

For changing parameters of stroke text (press F2)

(1) **STRK_FONT** specifies the font file selection for stroke text. There are 19 available fonts.

1. HALO102.FNT	2. HALO103.FNT	3. HALO104.FNT
4. HALO105.FNT	5. HALO106.FNT	6. HALO107.FNT
7. HALO108.FNT	8. HALO109.FNT	9. HALO111.FNT
10. HALO115.FNT	11. HALO201.FNT	12. HALO202.FNT
13. HALO203.FNT	14. HALO204.FNT	15. HALO205.FNT
16. HALO206.FNT	17. HALO207.FNT	18. HALO208.FNT
19. HALO209.FNT		

For font definitions, check the appendix in this guide.

(2) **STRK_H** specifies the height in pixels of the stroke text.

(3) **STRK_ANG** specifies the direction in degrees of the stroke text to be displayed.

(4) **STRK_ASP** specifies the aspect ratio of the stroke text.

(5) **G_PAL** specifies the overlay color palette to be used for the stroke text. Only 0 to 7 are valid inputs. To change the color of the palette(s), use program BPCOLOR or BP1COLOR.

(6) **FILL_PAL** specifies the overlay color palette to be used for filling the stroke text, only 0 to 7 are valid inputs. To change the color of the palette(s), use program BPCOLOR or BP1COLOR.

(7) **POS_MODE** specifies how the annotation stored in the text buffer will be displayed relative to the cursor position.
1. the cursor location is the start of the annotation.
2. the cursor location is the end of the annotation.
3. the cursor location is the center of the annotation.

(8) **TXT_BUF** specifies the text string (up to 80 characters) to be saved in the buffer which can be displayed as the annotation whenever the function key F4 is pressed.

FUNCTION KEY DEFINITIONS:

ESC: Exits the program.
F1: Allows one to change the current setups for the dot text.
F2: Allows one to change the current setups for the stroke text.
F3: Toggles text mode from dot text to stroke text.
F4: Causes the annotation stored in the stoke text buffer or the dot text buffer to be displayed depending on the current text mode and its status.
F5: Displays the next image frame buffer.
F6: Displays the pixel/line coordinates of the cursor position.
ALT F1: Toggles the function key menu display on/off.
MOUSE RIGHT BUTTON - Same as ALT F1

PROGRAM NAME: <u>ASCIMG</u>
DATE: <u>10/28/91</u>
MENU: <u>DATA</u>

DESCRIPTION: ASCIMG is a program which can be used to generate an ASCII file of an image. Up to five PC-SEAPAK images or any rectangular subscene from them can be converted at one time to ASCII flat-file equivalents. This program not only allows one to select a portion of the scene for conversion to ASCII files but also allows one to subsample the scene or flip it around from left to right or top to bottom. Also, the format of the ASCII output file records may be specified by the user.

PARAMETERS:
(1) **IN_FILE1-IN_FILE5** contain the list of input image files one wants to convert to ASCII files. These files when converted will correspond to the output image files (OU_FILE1-OU_FILE5) and will all have been processed in the same manner.
(2) **OU_FILE1-OU_FILE5** contain the ASCII equivalents of the respective PC-SEAPAK image files listed in (IN_FILE1-IN_FILE5). Note that all these files will be generated using the same values for all the other input parameters. These files will not contain any header records. The format is specified by the user. See the parameter FORMAT for a detailed description of their record formats.
(3) **ST_PIX** defines the location of the start pixel for the rectagular area of the image(s) for which ASCII file(s) will be generated. ST_PIX/ST_LIN and END_PX/END_LN define the full rectangle. The value one inputs for ST_PIX depends on the location of the origin which in turn is determined by the parameter P_DIR and TOT_PX. In other words, if P_DIR=1, pixel positions are enumerated from left to right and ST_PIX is the pixel position of a left corner. If P_DIR=2, pixel positions are enumerated from right to left, and ST_PIX is the pixel position of the right corner of the rectangle. This means that the number entered for ST_PIX is determined by counting pixels from the right starting at the origin (which is defined by TOT_PX), e.g. the rightmost pixel (the origin) is 1, the next is 2, etc. Note that all this also means that ST_PIX can never be greater than END_PIX.
(4) **ST_LIN** is the location of the start line for the rectagular area of the image(s) for which ASCII file(s) will be generated. As mentioned earlier, ST_PIX/ST_LIN and END_PX/END_LN define the full rectangle. As for ST_PIX, the value one inputs for ST_LIN depends on the location of the origin which in turn is determined by the parameter L_DIR and TOT_LN. In other words, if L_DIR=1, line positions are enumerated from top to bottom; ST_LIN is the line position of a top corner. If L_DIR=2, line positions are enumerated from bottom to top and ST_LIN is the line position of a bottom corner of the rectangular box. In a similar fashion to ST_PIX, the number

entered for ST_LIN is determined by counting lines from the bottom starting at the origin (which is defined by TOT_LN), e.g. the bottommost line (the origin) is 1, the next is 2, etc. It is evident that this means that ST_LIN cannot be greater than TOT_LN. From all of this it is also clear that ST_LIN cannot be greater than END_LIN.

(5) **END_PX** is the location of the end pixel and helps to define one corner of the rectangular area of the image(s) for which ASCII file(s) will be generated. END_PX cannot be less than ST_PIX since the origin for counting the pixels starts from the ST_PIX direction. In other words, if P_DIR=1, pixel positions are enumerated from left to right and END_PX is the pixel position of a right corner. If P_DIR=2, pixel positions are enumerated from right to left and END_PX is the pixel position of a left corner. END_PX cannot be greater than TOT_PX.

(6) **END_LN** is the location of the end line and helps to define one corner of the rectangular area of the image(s) for which ASCII file(s) will be generated. Again due to the location of the origin, END_LN cannot be less than ST_LIN. Also, if L_DIR=1, line positions are enumerated from top to bottom and END_LN is the line position of a bottom corner. If L_DIR=2, line positions are enumerated from bottom to top and END_LN is the line position of a top corner. END_LN cannot be greater than TOT_LN.

(7) **P_SUBS** is the parameter which specifies the pixel subsampling rate. For example, if P_SUBS=2, only every other pixel from ST_PIX to END_PX will be processed and the resulting ASCII image (OU_FILEs) will be reduced by a factor of two in the pixel (horizontal) direction. Note that the last pixel processed for each line will be

ST_PIX + (N-1)*P_SUBS

where N is the number of pixels processed per line or

Integer((END_PX-ST_PIX + P_SUBS)/P_SUBS).

(8) **L_SUBS** defines the line subsampling rate. For example, if L_SUBS=2, only every other line from ST_LIN to END_LN will be processed and the resulting OU_FILEs will represent images reduced by a factor of two in the line (vertical) direction. Note that the last line processed for each file will be

ST_LIN + (N-1)*L_SUBS

where N is the number of lines processed per image or

Integer ((END_LN-ST_LIN + L_SUBS)/L_SUBS).

(9) **MODE** specifies whether the image data (IN_FILEs) are linearly related to gray scales or are pigment concentrations. Enter 1 (the default value) if the pixel values of the displayed image represent data such as temperature or radiances that are linearly related to gray levels (see FACTOR below); enter 2 if they represent pigment concentrations (mg/m3).

(10) **FACTOR** is a parameter which is used only when the displayed image is linearly related to the gray scale, i.e. when MODE=1. If FACTOR is positive, it will represent the factor by which to divide the gray values of the image pixels in

order to convert them into actual data values. If a zero or negative number is entered, the slope and intercept for this mapping function will be obtained from the file header of each IN_FILEs. To retain the gray scale values, enter 1 (the default value); for sea surface temperature (SST), enter 8; for water radiance data, enter 85; for aerosol radiance data, enter 100.

(11) **FORMAT** specifies a FORTRAN format for the records of OU_FILEs. Generally, the default format ("0(I5)" or "1P,0(G13.5)" depending on the MODE=1 or 2) should be used. The format should have the general form of a repeat count (N) followed by a field descriptor for the numeric output types I, F, E, D, or G. A field descriptor is composed of the letter type identifier (T), a width specification (W), and, for non-integer types, a decimal specification (D). If N is not specified, it defaults to 1; if it is explicitly 0, it is set to the number of pixels processed per image line (X); if it is less than X, each image line will wrap around using as many output records as needed (see below). In addition, the scale factor (P), the plus sign control (S), and the exponent specifier (E) may also be used; if omitted, the FORTRAN defaults of 0, SS, and 2, respectively, will be used. AGAIN IT SHOULD BE EMPHASIZED THAT THE DEFAULT VALUE "0(I5)" or "1P,0(G13.5)" SHOULD BE ADEQUATE FOR MOST PURPOSES. The following table presents examples of valid FORMAT values.

FORMAT	N	T	W	D	P	S	E
1P,0(G13.5)	X	G	13	5	1	SS	2
SP,I4	1	I	4			SP	
18(F6.2)	18	F	5	2		SS	
-2P,SP,10(E16.2E4)	10	D	16	2	-2	SP	4

Parentheses and commas may be omitted, but if they are used, they must be used according to FORTRAN format syntax rules. For example, the default FORMAT, "1P,0(G13.5)", may also be written as "1P0G13.5" or "(1P0(G13.5))" but NOT as "1P0G(13.5)" or "1P0,G13.5". Slash record terminators ("/") may also be included according to FORTRAN rules. Blanks are ignored and lower or upper case letters may be used. For integer output (T="I"), the real-valued image pixels are rounded off to the nearest integer. (Please refer to the Microsoft FORTRAN manual for additional definitions and syntax rules.)

The number of output records needed for one image line will be

NR = integer((X + N - 1) / N)

where N and X are as defined above. (Note that additional records due to the use of slash record terminators in FORMAT are not included in any record calculations.) The last record of each NR set of records will contain remainder (P/N)*N pixel values. The character width of every output record will be N * W plus, if a delimiter is added, N, (e.g.

for DELIM="/"), the character width of each output record will be W*N + N). Records which do not contain N values will be filled with trailing blanks.

(12) **DELIM** may be used to insert a character (single character or a character closed by single or double quotes) for delimiter after each pixel data value field in the ASCII output files. Certain spreadsheet or statistical programs, which one may wish to use on the output files, require such delimiters. The character blank must be enclosed within quotes when entering it as value to DELIM and the character tab must be entered as ">" or ">", since the tab cannot be accepted in the input screen. If this field is blank (default), it indicates that no delimiters are to be used. Note that, in any case, blanks may be present between pixel values when the field width specified by FORMAT is large enough.

(13) **HDR_NO** is the number of header records in each of the input images (IN_FILEs). It is assumed that each input image has the same number of header records. PC-SEAPAK image files normally have one header record (the default value). These records must not be counted in any image line specification (ST_LIN, END_LN, and TOT_LN). The ASCII output files, OU_FILEs, may or may not contain any header records depending on the value of TYPE.

(14) **FLIP** defines the ASCII output file orientation. Enter one of the following values to designate the orientation of the images represented in OU_FILEs relative to those in IN_FILEs:
  0: same (the default value);
  1: reversed in the horizontal direction (mirror image);
  2: reversed in the vertical direction (upside down);
  3: reversed in the horizontal and vertical directions (mirror and upside down)

(15) **TYPE** indicates whether the ASCII output file(s), OU_FILEs, should be modified for an IBM-PC based program called SURFER. If the regular ASCII output with no header blocks is desired, one should enter a zero. On the other hand if one intends to use these files with SURFER, one should enter a value of 1. This causes the program to generate a special 5 line header required by SURFER which precedes the pixel data.

(16) **P_DIR** indicates whether one is counting pixel positions from left to right (enter 1 if so) or from right to left (in which case, enter a 2). Recall that if P_DIR = 1, the leftmost pixel is 1; if P_DIR = 2, the rightmost pixel (as defined by TOT_PX) is 1. See ST_PIX, END_PX, and TOT_PX for more information.

(17) **L_DIR** indicates whether one is counting line positions from top to bottom (enter 1 if so) or from bottom to top (in which case, enter a 2). Recall that if L_DIR = 1, the topmost line is 1; if L_DIR = 2, the bottommost line (as defined by TOT_LN) is 1. See ST_LIN, END_LN, and TOT_LN for more information.

(18) **TOT_PX** is used only if P_DIR=2. The value for this parameter will generally correspond to the width in pixels of

the display system or to the rightmost pixel of the ASCII image one is interested in producing. TOT_PX essentially enables PC-SEAPAK to determine the rightmost pixel of an image. For example, if TOT_PX=512, then the 512th pixel of each image line will be considered position 1 for the purpose of specifying ST_PIX and END_PX.

(19) **TOT_LN** is used only when L_DIR=2. The value for this parameter will generally correspond to the length in lines of the display system or to the bottommost line of the ASCII image one is interested in producing. TOT_LN essentially enables PC-SEAPAK to determine the bottommost line of an image. For example, if TOT_LN=512, then the 512th line of each image will be considered as position 1 for the purpose of specifying ST_LIN and END_LN.

FUNCTION KEY DEFINITIONS:

No function keys are used.

PROGRAM NAME: AUTOCORR
DATE: 10/28/91
MENU: STAT2

DESCRIPTION: This program plots autocorrelation or autocovariance vs. lags, of the currently displayed image over a user defined line, rectangular box, or parallelogram. The calculations can be based on gray levels, pigment concentrations, or any linearly scaled data units. A user specified range can be used to exclude land, clouds, or other invalid pixel values during the calculations. The number of lags is determined by the number of pixels along the line, along the horizontal or vertical side of the box, or along the first or second side of the parallelogram. For a box or parallelogram, the autocorrelation and the autocovariance for each lag are calculated line by line first and then averaged across all lines (i.e., all the lines are weighted equally).

PARAMETERS:

(1) **MODE** specifies the data type of the displayed image. A value of "1" (the default value) should be entered if the pixel values of the displayed image represent data (such as temperature) that are linearly related to gray levels. A value of "2" should be entered if they represent pigment concentrations (mg/m3).

(2) **FACTOR** is a non-negative scaling factor which is used only if MODE=1, i.e. the data-to-gray scale mapping function is linear for the displayed image. It is ignored when MODE=2. If FACTOR is positive, it will represent the factor by which to divide the gray values in order to convert them into actual data values. If zero is entered, the slope and intercept for this mapping function will be obtained from the header of the disk file for the displayed image. In order to retain the gray values, a "1" (the default value) should be entered ; for sea surface temperature (SST), enter 8; for water radiance data, enter 85; for aerosol radiance data, enter 100.

(3) **RANGE** defines the range of the pixel values to use for the calculations of autocorrelation or autocovariance. Two values should be entered that conform to the units of the displayed image (i.e. pigment concentration or units linearly proportional to gray levels) as specified by MODE and FACTOR. Pixel values less than the smaller RANGE value and those greater than the larger RANGE value will be excluded from the calculations. For example, to exclude land and cloud pixels for a level-2 CZCS image, the RANGE values should be 1.0 and 254.0 (the default values) for gray levels (MODE=1 and FACTOR=1) or 0.04093 and 45.0 for pigment concentrations (MODE=2).

DYNAMIC PARAMETERS:

I. Parameters for generating the plot.

(1) **OPTION** specifies whether to calculate and plot the autocorrelation ("1") or autocovariance ("2").

(2) **DIR** indicates the direction for which to calculate the autocorrelation or autocovariance and is used for a box or parallelogram only. A "1" is entered to indicate that the calculations will be along the horizontal direction of a box or in the direction of the first defined side (i.e., between the first and second corners) of a parallelogram. A "2" is entered to indicate that the calculation will be along the vertical direction of a box or the second side of a parallelogram (between the second and third corners). This parameter refers to the most recently defined area. The initial default value is 1.

(3) **G_PAL** is the graphics palette to be used for the autocorrelation or autocovariance plot.

(4) **XLABEL** is the label for the X axis of the autocorrelation or autocovariance plot and may contain up to 40 characters. Upper and lower case letters and other characters may be used. The initial default label is "LAGS"; subsequently, the previously entered label is used as the default.

(5) **YLABEL** is the label for the Y axis of the autocorrelation or autocovariance plot and may contain up to 40 characters. Upper and lower case letters and other characters may be used. The initial default label is "AUTOCORRELATION"; subsequently, the previously entered label is used as the default.

(6) **TITLE** is the title for the autocorrelation or autocovariance plot. It may contain up to 40 characters and will appear below the graph. Upper and lower case letters and other characters may be used.

II. Parameters for outputting the plot data to a file.

(1) **OPTION** specifies whether to calculate and output the autocorrelation ("1") or autocovariance ("2") plot.

(2) **O_FIL** is the output file name which will contain the lag numbers in the first column, the corresponding autocorrelation or autocovariance values in the second column, and the number of observations in the third column. A discrete character plot may also be generated, depending on the parameter PFLAG, after the third column. A name of "CON" for this parameter will send the output to the screen and "LPT1" or "LPT2" will send the output to the printer.

(3) **PFLAG** may have a value of "Y" or "N" to specify whether or not to generate a discrete character plot in the output file.

(4) **DIR** is analogous to DIR of DYNAMIC PARAMETERS I.

III. Parameters for clearing the graphics palette

(1) **CLR_PAL** is the number of the palette from which to clear overlay graphics. A "-1" is to used to clear all overlay graphics.

FUNCTION KEY DEFINITIONS:

ESC: Exits this program.

F1: Defines a line over which the autocorrelation or autocovariance values of different lags are to be obtained. More than one line segment may be used in order to approximate a curved line.

F2: Defines a box (a rectangle with horizontal and vertical sides, i.e. sides along the pixel or line direction) over which the autocorrelation or autocovariance values of different lags are to be obtained.

F3: Defines a parallelogram over which the autocorrelation or autocovariance values of different lags are to be obtained. Three corners will need to be specified in a clockwise or counter-clockwise direction using the left and/or right mouse buttons.

F4: Asks the user to enter parameters (see DYNAMIC PARAMETERS I) for autocorrelation or autocovariance calculations on different lags and plots the variogram.

F5: Outputs the plot data to the screen, the printer, or an ASCII file. The parameters of DYNAMIC PARAMETERS II will be requested.

F6: Displays the next image frame buffer.

F7: Turns all graphics palettes on/off.

F8: Turns the displayed image on/off.

F9: Increases the current graphics palette by 1 or resets it to 1 if the value is greater than 7. The current graphics palette is used for defining the line (F1), box (F2), or parallelogram (F3).

F10: Clears all the overlay graphics or a specified graphics palette. The parameter CLR_PAL will be requested.

ALT F9: Displays the current cursor position.

ALT F10: Requests new values for parameters MODE, FACTOR and RANGE (see PARAMETERS)

ALT F1: Toggles function key menu display on/off.

MOUSE RIGHT BUTTON - Toggles function key menu display on/off.

PROGRAM NAME: BATHYIMG
DATE: 10/28/91
MENU: GEOGRAPH

DESCRIPTION: This program creates a bathymetry image file from the world bathymetry data file, BATHY.DAT. This file must be stored in the directory defined by the program SPKSETUP. The file contains data at 10 minute latitude and longitude intervals. The program uses a bilinear interpolation algorithm to determine the depth of each point first, then use MIN_GRAY, MAX_GRAY, MIN_DATA and MAX_DATA to convert the depth to a gray level for the output image.

BATHY.DAT contains 1,081 ((90+90)*6+1) records, one for each 10-minute interval from -90S to 90N. Each record consists of 2,161 (360*6+1) two-byte values for 10 minute longitude intervals from 0 to 360 degrees for a total file size of 4,672,082 (2161*1081*2) bytes. A file with 5-minute resolution data is available for this program but is only distributed by request due to its large size (18,675,362 bytes).

PARAMETERS:
(1) **OUTFIL** is the name of the file to create for the bathymetry image.
(2) **NORTH** is the latitude (SOUTH to 90) to be mapped to the starting line SLIN of the output image.
(3) **SOUTH** is the latitude (-90 to NORTH) to be mapped to the ending line SLIN of the output image.
(4) **WEST** is the longitude (-180 to EAST) to be mapped to the starting pixel SPIX of the output image. Note that 0 to 360 or -180 to 180 may be used to specify longitude degrees.
(5) **EAST** is the longitude (WEST to 360) to be mapped to the ending pixel EPIX of the output image. Note that 0 to 360 or -180 to 180 may be used to specify longitude degrees.
(6) **SLIN** is the starting line (row 1 to ELIN) of the output image which corresponds to the latitude NORTH.
(7) **ELIN** is the ending line (row SLIN to 512) of the output image which corresponds to the latitude SOUTH.
(8) **SPIX** is the starting pixel (column 1 to EPIX) of the output image which corresponds to the longitude WEST.
(9) **EPIX** is the ending pixel (column SPIX to 512) of the output image which corresponds to the longitude EAST.
(10) **MIN_GRAY** is the minimum gray level value (0 to MAX_GRAY) to be assigned to the depth specified by MIN_DATA.
(11) **MAX_GRAY** is the maximum gray level value (MIN_GRAY to 255) to be assigned to the depth specified by MAX_DATA.
(12) **LAND** is the gray level value (0 to 255) to use for land areas.
(13) **MIN_DATA** is the minimum depth (in meters) to be assigned to the gray level MIN_GRAY for the output. If this value or MAX_DATA is -9999, the program will obtain the minimum value from the input file and will require a longer time to run.

All data with depths between MIN_DATA and MAX_DATA will be converted to gray levels as follows:

```
SLOPE = (MAX_GRAY - MIN_GRAY) / (MAX_DATA - MIN_DATA)
GRAY  = MIN_GRAY + (DEPTH - MIN_DATA) * SLOPE
GRAY  = min(max(GRAY, MIN_GRAY), MAX_GRAY)
```

Note that all data with depths less than MIN_DATA and greater than 0 (land) will be assigned to MIN_GRAY.

(14) **MAX_DATA** is the maximum depth (in meters) to be assigned to the gray level MAX_GRAY for the output. If this value or MIN_DATA is -9999, the program will find the maximum value from the input file and will require a longer time to run. All data with depths between MIN_DATA and MAX_DATA will be converted to gray levels as follows

```
SLOPE = (MAX_GRAY - MIN_GRAY) / (MAX_DATA - MIN_DATA)
GRAY  = MIN_GRAY + (DEPTH - MIN_DATA) * SLOPE
GRAY  = min(max(GRAY, MIN_GRAY), MAX_GRAY)
```

Note that all data with depths greater than MAX_DATA will be assigned to MAX_GRAY.

FUNCTION KEY DEFINITIONS:

No function keys are used.

PROGRAM NAME: BHHIST
DATE: 10/28/91
MENU: STAT1

DESCRIPTION: This program generates the histogram data files from a set of input image files. The histogram can be collected on the full image or on blotched areas as well as on full data ranges or on specified data ranges. Each output file contains five columns of data, the histogram index, the data value, the frequency counts, the percentage of frequency, and the cumulative frequency counts. An optional histogram bar chart in text mode can also be generated in each output files.

PARAMETERS:

(1) **IMGFILS** are the input image file names to be processed. Up to 36 file names may be entered. However, since the wild card (* or ?) file format is supported, up to 300 image files can be processed. Note that if there is only one file entered for IMGFILS, the program will assume it is a text file and read the input image files from this file. Note that all the image files should have a header block.

(2) **O_EXT** is the extension name to be used for all the output file names. The output file names will be decided by replacing the path and extension in each of IMGFILS with O_PATH and O_EXT. Note that if the O_PATH is "*", then only the extension in IMGFILS will be replaced by O_EXT.

(3) **B_FIL** is the name of the blotch file that defines the image areas of interest when B_PAL is not 0. Only image data within (B_PAL greater than 0) or outside (B_PAL less than 0) of the blotch areas defined by graphics palette B_PAL will be used for histogram.

(4) **B_PAL** is the graphics palette that defines the blotches in B_FIL. The value should be in the range of -7 to 7. If the number entered is positive, pixels within the blotches will be considered. If the number is negative, pixels outside the blotches will be considered. If "0" is entered, the entire image area (512 x 512) will be used and B_FIL will be ignored.

(5) **RANGE** defines the range of IMGFILS pixel values to use for the histogram. The user should enter two values in the input data units. The RANGE values must conform to the units of the IMGFILS as specified by MODE and FACTOR (i.e. pigment concentration or units linearly proportional to gray levels). For example, to exclude land and clouds pixels, the RANGE values should be 1.0 and 254.0 for gray levels (MODE=1 and FACTOR=1) or 0.0409 and 44.46 for pigment concentrations (MODE=2).

(6) **MODE** is a flag that indicates whether the pixel values of the IMGFILS image(s) represent data (such as temperature or radiance) that are linearly related to gray levels, or

pigment concentrations which are non-linear. A "1" should be entered for linear data and a "2" for pigment data.

(7) **FACTOR** is a linear scale factor used only if MODE=1, i.e. when a linear data-to-gray scale mapping function for the IMGFILS image(s) is used. If greater than zero, it will represent the factor by which to divide the gray values of IMGFILS pixels in order to convert them into actual data values; if zero is entered, the slope and intercept for this mapping function will be obtained from each file header of the IMGFILS disk image files. In order to retain the gray values, enter 1 (the default value); for sea surface temperature (SST), enter 8; for water radiance data, enter 85; for aerosol radiance data, enter 100.

(8) **CHART** is a flag to specify whether to generate the histogram bar chart in text mode on the output files. Enter 0 for No, or 1 for Yes.

(9) **O_PATH** is the path name to be used for the output files. To keep the output files as the same path of IMGFILS, the O_PATH has to be "*". Otherwise, the O_PATH specified here will replace the path specified in IMGFILS for the output files.

FUNCTION KEY DEFINITIONS:

No function keys are used.

PROGRAM NAME: BHHIST
DATE: 10/28/91
MENU: STAT1

DESCRIPTION: This program generates the histogram data files from a set of input image files. The histogram can be collected on the full image or on blotched areas as well as on full data ranges or on specified data ranges. Each output file contains five columns of data, the histogram index, the data value, the frequency counts, the percentage of frequency, and the cumulative frequency counts. An optional histogram bar chart in text mode can also be generated in each output files.

PARAMETERS:

(1) **IMGFILS** are the input image file names to be processed. Up to 36 file names may be entered. However, since the wild card (* or ?) file format is supported, up to 300 image files can be processed. Note that if there is only one file entered for IMGFILS, the program will assume it is a text file and read the input image files from this file. Note that all the image files should have a header block.

(2) **O_EXT** is the extension name to be used for all the output file names. The output file names will be decided by replacing the path and extension in each of IMGFILS with O_PATH and O_EXT. Note that if the O_PATH is "*", then only the extension in IMGFILS will be replaced by O_EXT.

(3) **B_FIL** is the name of the blotch file that defines the image areas of interest when B_PAL is not 0. Only image data within (B_PAL greater than 0) or outside (B_PAL less than 0) of the blotch areas defined by graphics palette B_PAL will be used for histogram.

(4) **B_PAL** is the graphics palette that defines the blotches in B_FIL. The value should be in the range of -7 to 7. If the number entered is positive, pixels within the blotches will be considered. If the number is negative, pixels outside the blotches will be considered. If "0" is entered, the entire image area (512 x 512) will be used and B_FIL will be ignored.

(5) **RANGE** defines the range of IMGFILS pixel values to use for the histogram. The user should enter two values in the input data units. The RANGE values must conform to the units of the IMGFILS as specified by MODE and FACTOR (i.e. pigment concentration or units linearly proportional to gray levels). For example, to exclude land and clouds pixels, the RANGE values should be 1.0 and 254.0 for gray levels (MODE=1 and FACTOR=1) or 0.0409 and 44.46 for pigment concentrations (MODE=2).

(6) **MODE** is a flag that indicates whether the pixel values of the IMGFILS image(s) represent data (such as temperature or radiance) that are linearly related to gray levels, or

pigment concentrations which are non-linear. A "1" should be entered for linear data and a "2" for pigment data.

(7) **FACTOR** is a linear scale factor used only if MODE=1, i.e. when a linear data-to-gray scale mapping function for the IMGFILS image(s) is used. If greater than zero, it will represent the factor by which to divide the gray values of IMGFILS pixels in order to convert them into actual data values; if zero is entered, the slope and intercept for this mapping function will be obtained from each file header of the IMGFILS disk image files. In order to retain the gray values, enter 1 (the default value); for sea surface temperature (SST), enter 8; for water radiance data, enter 85; for aerosol radiance data, enter 100.

(8) **CHART** is a flag to specify whether to generate the histogram bar chart in text mode on the output files. Enter 0 for No, or 1 for Yes.

(9) **O_PATH** is the path name to be used for the output files. To keep the output files as the same path of IMGFILS, the O_PATH has to be "*". Otherwise, the O_PATH specified here will replace the path specified in IMGFILS for the output files.

FUNCTION KEY DEFINITIONS:

No function keys are used.

PROGRAM NAME: BHL2MULT
DATE: 10/28/91
MENU: L2PROD

DESCRIPTION: This program is the batch run mode of the program L2MULT. It reads the input parameter sets from the parameter file one by one and generates the level-2 images for each of the input parameter sets. The parameter file must be created by the program PARL2MU. A log file which contains all the messages of the batch run can be created if desired.

PARAMETERS:

(1) **PAR_FIL** is the input parameter file name for this batch run. This file must be created by the program PARL2MU.

(2) **LOG_FIL** is the log file name. If a file name for LOG_FIL is given, then all the messages displayed on the terminal for this batch run will also be written to this file. If the LOG_FIL is blank, then no log file will be created.

FUNCTION KEY DEFINITIONS:
No function keys are used.

PROGRAM NAME: BHMAPIMG
DATE: 10/28/91
MENU: PROJECTN

DESCRIPTION: This program is the batch run mode of the program MAPIMG. It reads the input parameter sets from the parameter file one by one and generates the mapped images for each of the input parameter sets. The parameter file must be created by the program PARMPIMG. A log file which contains all the message of the batch run can be created if desired.

PARAMETERS:

(1) **PAR_FIL** is the input parameter file name for this batch run. This file must be created by the program PARMPIMG.

(2) **LOG_FIL** is the log file name. If a file name for LOG_FIL is given, then all the messages displayed on the terminal for this batch run will also be written to this file. If the LOG_FIL is blank, then no log file will be created.

FUNCTION KEY DEFINITIONS:
No function keys are used.

PROGRAM NAME: BHWTKLM
DATE: 10/28/91
MENU: L2PROD

DESCRIPTION: The program BHWTKLM is another version of the program BHL2MULT. It uses the Weitek numerical coprocessor and runs under the protected mode with the Phar Lap DOS-Extender. The program accepts the input parameter file and the log file entered by the user and then, it invokes the protected mode program WTKL2MLT.EXE (bound with DOS-Extender) using the parameter and the log file names. The program WTKL2MLT.EXE reads the input parameter sets one by one from the input parameter file and then generates the level-2 products for each of the input parameter sets. Actually, the BHWTKLM is just a driver program (run under real mode) and the main process program is the WTKL2MLT.EXE (run under protected mode).

PARAMETERS:
(1) **PAR_FIL** is the input parameter file name for this batch run. This file must be created by the program PARL2MU.
(2) **LOG_FIL** is the log file name. If a file name for LOG_FIL is given, then all the messages displayed on the terminal for this batch run will also be written to this file. If the LOG_FIL is blank, then no log file will be created.

FUNCTION KEY DEFINITIONS:
No function keys are used.

PROGRAM NAME: BHWTKMP
DATE: 10/28/91
MENU: PROJECTN

DESCRIPTION: The program BHWTKMP is another version of the program BHMAPIMG. It uses the Weitek numerical coprocessor and runs under the protected mode with the Phar Lap DOS-Extender. The program accepts the input parameter file and the log file entered by the user and then, it invokes the protected mode program WTKMPIMG.EXE (bound with DOS-Extender) using the parameter and the log file names. The program WTKMPIMG.EXE reads the input parameter sets one by one from the input parameter file and generates the mapped images for each of the input parameter sets. Actually, the BHWTKMP is just a driver program (run under real mode) and the main process program is the WTKMPIMG.EXE (run under protected mode).

PARAMETERS:
(1) **PAR_FIL** is the input parameter file name for this batch run. This file must be created by the program PARMPIMG.
(2) **LOG_FIL** is the log file name. If a file name for LOG_FIL is given, then all the messages displayed on the terminal for this batch run will also be written to this file. If the LOG_FIL is blank, then no log file will be created.

FUNCTION KEY DEFINITIONS:
No function keys are used.

PROGRAM NAME: BLOCVT
DATE: 10/28/91
MENU: VAXTOPC

DESCRIPTION: The program BLOCVT is used to convert the blotch image file from the VAX SEAPAK format into the PC-SEAPAK format. It allows the SEAPAK blotch image files created on the VAX to be used in the PC. Note that only byte values of 1, 2, 4, 8, 16, 32, 64 in the input file will be converted to byte values of 1, 2, 3, 4, 5, 6 and 7 in the output file. All other possible values between 1 and 127 created on the VAX IIS by the result of the overlapping of IIS graphics planes will be set to 0 and therefore will not be displayed on the MVP-AT. This is because the IIS on the VAX supports seven independent graphics planes which can overlap, but the MVP-AT on the PC supports seven nonindependent graphics palettes with no overlapping capability. The user should also notice that the default colors of the seven IIS graphics planes and the seven MVP-AT graphics palettes may be different. To change the default colors of the graphics palettes for the MVP-AT, the programs BPCOLOR and BP1COLOR may be used. The user can also use the program LUTMOD to do this conversion step by step. This program enables the user to convert any value (1 to 127) in the blotch created on the VAX into a value of 1 to 7 to be used in PC-SEAPAK.

PARAMETER:
(1) **VAX_BLO** is the name of the input blotch image file to be converted. This file should be created on the VAX with the SEAPAK program BPSAV and transferred to the PC.
(2) **PC_BLO** is the name of the output file containing the converted blotch to be used in PC-SEAPAK.

FUNCTION KEY DEFINITIONS:
No function keys are used.

PROGRAM NAME: BLOTCH
DATE: 10/28/91
MENU: OVERLAYS

DESCRIPTION: BLOTCH allows the user to define up to 10 polygon regions and fill them in with color. The polygons can be concave or convex, and the lines are allowed to cross. One locates the cursor at the desired starting point for the polygon and then depresses the "pick new vertex" key. After the next vertex is chosen, the "pick new vertex" key is again depressed. This defines the new vertex as well as causes a line to be drawn from the previous one. This process can be continued until the desired polygon is defined or the maximum number of vertices (500) has been reached. If necessary, the previous line may be erased by using the "delete last vertex" key. The polygon is defined after the "close region" key is depressed and it connects the first and last vertices. At this time, the user may fill the interior or exterior of the polygon region by moving the cursor inside or outside the polygon and using the "fill in blotch" key. The user may erase a filled blotch area by moving the cursor inside it and depressing the "erase blotch" key. The user also may change the graphics palette to define another blotch by using the "change graphics palette" key. There are seven graphics palettes, numbered 1 to 7, that can be used in this program with the standard default colors: red, green, yellow, blue, pink, cyan, and black. The programs GPCOLOR and BPCOLOR can be used to change these default colors. Additional function keys are provided for dropping a new image, turning the image on/off, displaying the cursor position, moving the cursor to a specified latitude/longitude position, saving the overlay blotch graphics into a file, and loading blotch graphics from a file.

PARAMETERS:
There are no parameters.

DYNAMIC PARAMETERS:
I. Used for dropping a new image (function key F7).
(1) **IMGFILE** is the name of the disk file containing the image to drop. This must be a standard 512x512x8 bit image with a known number of header blocks.
(2) **FRMBUF** is the index number (1-3) of the frame buffer to receive the image.
(3) **HEADNO** specifies the number of 512-byte header blocks in the new image. This number of blocks will be skipped before reading the image data.
(4) **YNIMG** is a flag indicating whether to display the dropped image (1) or leave on the current frame buffer being displayed (0).
II. Used for moving the cursor to a new latitude and longitude.

(1) **LAT** is the latitude where the cursor is to be moved. The value may be in decimal degrees, DMS format or radians (see parameter UNITS).

(2) **LON** is the longitude where the cursor is to be moved. The value may be in decimal degrees, DMS format or radians (see parameter UNITS)

(3) **UNITS** is the units of LAT and LON :

1. Decimal degrees (initial default value).
2. DMS format, sDDDMMMSSS.SS, where s is for the sign, DDD is for degrees, MMM is for minutes and SSS.SS is for seconds of an arc (for example, -75030000.00 DMS is equal to -75.5 degrees, 163006000 is equal to 163.1 degrees).
3. Radians.

Note that modulo arithmetic is used for all three types of units. For example, -100.0, 260.0, 620.0, etc., are all equivalent degrees and may be entered for 100 west longitude.

III. Used for saving blotch graphics into a file.

(1) **BLOFILE** is the file name in which to save all the overlay graphics created in this program. The output file will contain 512x512 bytes of data from the overlay frame buffer without any header blocks.

IV. Used for restoring blotch graphics from a file.

(1) **BLOFIL1** is the file name of the overlay graphics which are to be loaded into overlay frame buffer.

FUNCTION KEY DEFINITIONS:

ESC: Exits the program.

F1: Allows the user to select a new vertex. After the first vertex has been selected, it also causes a line to be drawn connecting the previous vertex to the present vertex.

F2: Deletes the last vertex as well as the line connecting that vertex and the previous one.

F3: Closes the polygon region by connecting the first and last vertices.

F4: Fills the interior or the exterior of a polygon depending on whether the cursor is inside or outside the polygon. The filling color is defined by current graphics palette.

F5: Erases a blotch area in which the cursor is located.

F6: Changes the overlay graphics palette by increasing the current palette number by one. If the value is greater than seven, it will be reset to one.

F7: Allows the user to drop a new image into a frame buffer.

F8: Displays the next image frame buffer.

F9: Displays the cursor's pixel and line position (TV coordinates) as well the corresponding latitude and longitude.

F10: Allows the user to move the cursor to a new position specified by a latitude and longitude.

ALT F1: Toggles the function key menu display on/off.

ALT F9: Saves the blotch graphics in the overlay frame buffer into a user specified file.

ALT F10: Loads blotch graphics from a user specified file into the overlay frame buffer.

MOUSE LEFT BUTTON - Same as function key F1.

MOUSE RIGHT BUTTON - Same as function key ALT F1.

PROGRAM NAME: BP1COLOR
DATE: 10/28/91
MENU: INITIAL

DESCRIPTION: BP1COLOR allows the user to assign a specified color to a specified output look-up table (OLUT) palette. Usually, the OLUT palette 0 is used for the LUT of the displayed image when there is an overlay. OLUT palettes 1 to 7 are used for the overlay graphics (although there are 16 palettes available for the overlay graphics, most of the time only 7 are used in PC-SEAPAK), OLUT palette 8 is used for the cursor, OLUT palettes 11 to 14 are used for the LUTs of frame buffers 0 to 3 without overlay, and OLUT palettes 17 and 18 are used for the LUTs of the overlay and displayed image when displaying the function key menu.

PARAMETERS:
(1) **PALETTE** specifies the OLUT palette (0 to 31) to be set up.
(2) **RED** specifies that all the 256 entries of the red LUT in the palette specified in parameter PALETTE will be set to this value. However, a -1 value which will set the LUT to be a linear ramp.
(3) **GREEN** specifies that all the 256 entries of the green LUT in the palette specified in parameter PALETTE will be set to this value. However, a -1 value which will set the LUT to be a linear ramp.
(4) **BLUE** specifies that all the 256 entries of the blue LUT in the palette specified in parameter PALETTE will be set to this value. However, a -1 value which will set the LUT to be a linear ramp.

FUNCTION KEY DEFINITIONS:
No function keys are used.

PROGRAM NAME: BPCOLOR
DATE: 10/28/91
MENU: INITIAL

DESCRIPTION: BPCOLOR allows the user to set up the output look-up table (OLUT) palettes 0 to 19 to specified colors. Usually, the OLUT palette 0 is used for the LUT of the displayed image when there is an overlay. OLUT palettes 1 to 7 are used for the overlay graphics (although there are 16 palettes available for the overlay graphics, most of the time only 7 are used in PC-SEAPAK), OLUT palette 8 is used for the cursor, OLUT palettes 11 to 14 are used for the LUTs of frame buffers 0 to 3 without overlay, and OLUT palettes 17 and 18 are used for the LUTs of the overlay and displayed image when displaying the function key menu. Each palette (0 to 19) has red, green and blue input entries and only 0, 1, 2 and 3 are valid inputs for those entries. The value 0 means all the 256 entries in the red, green or blue LUT will be assigned to 0 for that palette, the value 1 assigns all 256 entries to a value of 255, the value 2 assigns all 256 entries to a value of 127, the value 3 assigns the 256 entries to a linear ramp (from 0 to 255). To assign any other values (except 0, 127, 255) to all the 256 entries of red, green and blue LUTs in a palette, one can use program BP1COLOR. The default input values for the palettes in this program have been set up in the program, but the user can edit the text file PALETTE.PAR under SEAPAK directory to change the default input values.

PARAMETERS:
(1) **RED** specifies how the 256 entries of the red LUT will be set up for the palettes. A value of 0 will assign all 256 entries to 0, a value of 1 will assign the 256 entries to 255, a value of 2 will assign the 256 entries to 127, and a value of 3 will assign the 256 entries to a linear ramp.
(2) **GREEN** specifies how the 256 entries of the green LUT will be set up for the palettes. A value of 0 will assign all 256 entries to 0, a value of 1 will assign the 256 entries to 255, a value of 2 will assign the 256 entries to 127, and a value of 3 will assign the 256 entries to a linear ramp.
(3) **BLUE** specifies how the 256 entries of the blue LUT will be set up for the palettes. A value of 0 will assign all 256 entries to 0, a value of 1 will assign the 256 entries to 255, a value of 2 will assign the 256 entries to 127, and a value of 3 will assign the 256 entries to a linear ramp.

FUNCTION KEY DEFINITIONS:
No function keys are used.

PROGRAM NAME: BPLOAD
DATE: 10/28/91
MENU: OVERLAYS

DESCRIPTION: BPLOAD restores a graphics overlay onto the displayed image from a file previously created by the program BPSAV. The graphics are read into the overlay frame buffer.

PARAMETERS:
(1) **OVGRFIL** is the name of the disk file from which to input the overlay graphics.
(2) **CLEAR** is a flag indicating whether to clear any currently displayed graphics before restoring the input file's graphics ("Y") or combine the two ("N"). If "N", RFLAG will also be used.
(3) **RFLAG** is used when CLEAR="Y" to specify whether the current or restored graphics will have precedence when their pixels overlap. If "Y", graphics pixels from the file OVGRFIL will replace current graphics pixels when they occur at the same position; if "N", the current graphics pixels will remain unchanged.

FUNCTION KEY DEFINITIONS:
No function keys are used in this program.

PROGRAM NAME: BPSAV
DATE: 10/28/91
MENU: OVERLAYS

DESCRIPTION: BPSAV saves 512x512 bytes of data from the overlay frame buffer 0 into a file. For all programs which create overlay graphics on the displayed image, this program can be used to save the overlay graphics. The saved overlay graphics can then be loaded over any displayed image with the program BPLOAD.

PARAMETERS:
(1) **OVGRFILE** is the name of the disk file to create for saving the overlay graphics.

FUNCTION KEY DEFINITIONS:
No function keys are used.

PROGRAM NAME: BXCLRWAT
DATE: 10/28/91
MENU: ATMOS

DESCRIPTION: This program applies the clear water radiance algorithm to a CZCS level-1 scene in order to generate the atmospheric correction factors (in terms of "epsilons" and Angstrom exponents) used for the water radiance bands (1 to 3) in processing to level 2. The technique is to assume an initial guess for the Angstrom exponents, compute the level-2 normalized water-leaving radiance and pigment fields, eliminate pixels from consideration that do not meet specific criteria, assign the normalized water-leaving radiance at 520 nm and 550 nm of the qualifying pixels to the nominal values defined by Gordon and Clark (1981) and compute the epsilons and Angstrom exponents for those pixels.

This program uses the manual search mode (box mode) which is a modification of epsilon search techniques described in Williams et al. (1985b). There is another mode (automated mode) used by the program CLRWAT which is described elsewhere. BXCLRWAT determines "clear water" pixels inside a box by using a set of criteria (same as in CLRWAT), each of which is applied to pixels not excluded by previous criteria. The criteria and the sequence in which they are applied are as follows (ranges are inclusive):

1. Exclude land, cloud, or haze pixels: pixels whose band 5 values are greater than LANCLD (land and cloud threshold) or whose band 4 values are 255 (avoids pixels with saturated 670 nm radiances). (LANCLD is an input parameter.)
2. Exclude pixels of high sun or scanner zenith angles: pixels at which the sun zenith is greater than SUN or scanner zenith angle is greater than SCAN. (SUN and SCAN are input parameters.) This criterion is used to avoid pixels with large atmospheric path radiances which may not be accurately corrected.
3. Exclude aerosol pixels: pixels for which aerosol radiance (La(670)) values are not within the input parameter AEROL4 range. Pixels with large aerosol radiances may not be accurately corrected and pixels with low values may not contain sufficient aerosol radiance to distinguish the estimate from sensor noise.
4. Exclude pixels whose normalized band 2 or 3 water radiance (calculated using the ANGEXP input values) falls outside the NLW520 and NLW550 ranges (input parameters), respectively.
5. Exclude pixels whose pigment concentrations are greater than the input parameter PTHRES.
6. Exclude pixels for which the band 2 or 3 epsilons fall outside the EPS520 and EPS550 ranges (input parameters), respectively.
7. Exclude pixels whose epsilon values are not either monotonically increasing or decreasing. The wavelength de-

pendence on aerosol scattering should be uniformly increasing or decreasing with wavelength.

The algorithm (Gordon et al., 1983) for calculating the pigment concentrations for criterion 5 uses two-channel equations:

```
1. if Lw(550)=<0, then P=46.34456 (saturated); else,
2. if Lw(443)>0.15,
     then  P = A2 * (Lw(443)/Lw(550))**B2,        (A)
     where log10(A2)=0.053 and B2=-1.71;
     if P>=1.5 and Lw(520)>0
        then  P = A4 * (Lw(520)/Lw(550))**B4,     (B)
        where log10(A4)=0.522 and B4=-2.44;
        if P<1.5, then use (A) above;
3. if Lw(443)=<0.15 and Lw(520)>0, then use (B) above;
4. if Lw(443)=<0.15 and Lw(520)=<0,
     then P=46.34456 (saturated);
```

where Lw represents the water-leaving radiance for the band of the specified wavelength (nm) and P is the pigment concentration in mg/m^3.

The state of polarization of the light is taken into account in the calculations of the multiple Rayleigh scattering (exact radiative transfer theory; Gordon et al., 1988).

The lowest value of CLOW (epsilon(443)/La(670)) and various statistical parameters are also computed from the distribution of the Angstrom exponents of the qualifying pixels inside the box and displayed on the terminal. The statistics computed are the mean, the median, and the mean of lowest 10% of values, as well as the minimum, the maximum, the standard deviation and the quartile range (the difference between the 75th and 25th percentiles).

The user can roam the scene using a defined box area (15x15, 31x31, or 63x63 pixels) until the lowest value of CLOW has been found in a location away from the problem areas mentioned above. Since the program outputs values to the terminal, the Angstrom exponents should be noted whenever a lower CLOW is encountered.

PARAMETERS:

(1) **INFILE** is the name of an unmapped, level-1 CZCS, PC-SEAPAK image file (including the band digit). The program will need to access all five band images associated with the specified file. (Any of the five may be specified.) These files should therefore reside in the same directory.

(2) **ILTOPT** specifies the ILT option: If "1", ephemeris data from the ILT record of the level-1 scene will be used. If "0", much of these data will be obtained from the documentation record or calculated by SEAPAK based on the location and time at the start of the scene.

(3) **CORR** is the index of the correction method to use for calculating total radiances:

1: Use factors and method (time and gain dependent) of R. Evans (Univ. of Miami).

2: Use correction factors specified by FACTOR.

(4) **LANCLD** is the land/cloud threshold to identify land and cloud pixels in exclusion criterion 1. The use of this criterion in the program's algorithm is described in the main help text above.

(5) **SUN** is the solar zenith angle threshold used to avoid pixels with large atmospheric path radiances in exclusion criterion 2. The use of this criterion in the program's algorithm is described in the main help text above.

(6) **SCAN** is the scanner zenith angle threshold used to avoid pixels with large atmospheric path radiances in exclusion criterion 2. The use of this criterion in the program's algorithm is described in the main help text above.

(7) **AEROL4** is the range for valid values of aerosol radiances (La(670)) used for exclusion criterion 3. The use of this criterion in the program's algorithm is described in the main help text above.

(8) **NLW520** is the range for valid values of normalized band 2 (520nm) water radiances used for exclusion criterion 4. The use of this criterion in the program's algorithm is described in the main help text above.

(9) **NLW550** is the range for valid values of normalized band 3 (550nm) water radiances used for exclusion criterion 4. The use of this criterion in the program's algorithm is described in the main help text above.

(10) **PTHRES** is the maximum clear-water valid pigment concentration (mg/m3) used for exclusion criterion 5. The use of this criterion in the program's algorithm is described in the main help text above.

(11) **EPS520** is the range for valid values of band 2 (520nm) epsilon values used for exclusion criterion 6. The use of this criterion in the program's algorithm is described in the main help text above.

(12) **EPS550** is the range for valid values of band 3 (530nm) epsilon values used for exclusion criterion 6. The use of this criterion in the program's algorithm is described in the main help text above.

(13) **FACTOR** are the correction factors to use for calculating total radiances of bands 1 to 4, respectively. These will be used only when CORR=2.

(14) **OZONE** are the optical thicknesses (in meters) for bands 1 to 4, respectively. If the value "-999" is entered, the values used will be from the PC-TOMS database for the day of the input CZCS scene and for the point nearest to the image center. If the PC-TOMS data point is missing or an error occurs accessing the data, a message to that effect will be displayed on the terminal along with the default values. These default thicknesses are 0.00106, 0.0144, 0.0279, and 0.0125, and are the products of the absorption coefficients (3.4E-6, 46E-6, 89E-6, and 40E-6) used at the Univ. of Miami and an average amount of 313 Dobson units of ozone.

(15) **ANGEXP** are the angstrom exponents for bands 1 to 4, respectively, for use in calculating the normalized water radiances

and the pigment. These radiances and pigment are used in applying exclusion criteria 4 and 5. (See main help text above.)

FUNCTION KEY DEFINITIONS:

ESC: Exits the program.
F1: Calculates the Angstrom exponents on the current box.
F2: Changes the box size in a loop with sizes 15x15, 31x31 and 63x63.
F3: Changes the overlay graphics palette by increasing current palette number by one and if the value is greater than seven it will be reset to one.
F4: Marks the box at the current position in the color defined by current graphics palette.
F5: Displays the center position of the box in pixel/line coordinates and in latitude/longitude coordinates.
ALT F1: Toggles the function key menu display on/off.
MOUSE LEFT BUTTON: Same as function key F1.
MOUSE RIGHT BUTTON: Same as function key ALT F1.

PROGRAM NAME: CLR
DATE: 10/28/91
MENU: INITIAL

DESCRIPTION: The program CLR clears (erases) selected frame buffers of the MVP-AT. None of the palettes in the look-up tables are modified.

PARAMETERS:
(1) **FRMBUF** is the index (0-3) of the frame buffer to be cleared. A value of -1 may be entered to clear all four frame buffers.

FUNCTION KEY DEFINITIONS:
No function keys are used.

PROGRAM NAME: CLRWAT
DATE: 10/28/91
MENU: ATMOS

DESCRIPTION: This program applies the clear water radiance algorithm to a CZCS level-1 scene in order to generate the atmospheric correction factors (in terms of "epsilons" and Angstrom exponents) used for the water radiance bands (1 to 3) in processing to level 2. The technique is to assume an initial guess for the Angstrom exponents, compute the level-2 normalized water-leaving radiance and pigment fields, eliminate pixels from consideration that do not meet specific criteria, assign the normalized water-leaving radiance values at 520 nm and 550 nm of the qualifying pixels to the nominal values defined by Gordon and Clark (1981) and compute the epsilons and Angstrom exponents for those pixels.

This program uses the automated search mode which is a modification of epsilon search techniques described in Williams et al. (1985b). There is another mode (manual mode or box mode) used by the program BXCLRWAT which is described elsewhere. CLRWAT determines "clear water" pixels by using a set of criteria, each of which is applied to pixels not excluded by previous criteria. The criteria and the sequence in which they are applied are as follows (ranges are inclusive):

1. Exclude land, cloud, or haze pixels: pixels whose band 5 values are greater than LANCLD (land and cloud threshold) or whose band 4 values are 255 (avoids pixels with saturated 670 nm radiances). (LANCLD is an input parameter.)
2. Exclude pixels of high sun or scanner zenith angles: pixels at which the sun zenith is greater than SUN or scanner zenith angle is greater than SCAN. (SUN and SCAN are input parameters.) This criterion is used to avoid pixels with large atmospheric path radiances which may not be accurately corrected.
3. Exclude aerosol pixels: pixels for which aerosol radiance (La(670)) values are not within the input parameter AEROL4 range. Pixels with large aerosol radiances may not be accurately corrected and pixels with low values may not contain sufficient aerosol radiance to distinguish the estimate from sensor noise.
4. Exclude pixels whose normalized band 2 or 3 water radiance (calculated using the ANGEXP input values) falls outside the NLW520 and NLW550 ranges (input parameters), respectively.
5. Exclude pixels whose pigment concentrations are greater than the input parameter PTHRES.
6. Exclude pixels for which the band 2 or 3 epsilons fall outside the EPS520 and EPS550 ranges (input parameters), respectively.

7. Exclude pixels whose epsilon values are not either monotonically increasing or decreasing. The wavelength dependence on aerosol scattering should be uniformly increasing or decreasing with wavelength.

The algorithm (Gordon et al., 1983) for calculating the pigment concentrations for criterion 5 uses two-channel equations:

```
1. if Lw(550)=<0, then P=46.34456 (saturated); else,
2. if Lw(443)>0.15,
     then  P = A2 * (Lw(443)/Lw(550))**B2,        (A)
     where log10(A2)=0.053 and B2=-1.71;
     if P>=1.5 and Lw(520)>0
        then  P = A4 * (Lw(520)/Lw(550))**B4,     (B)
        where log10(A4)=0.522 and B4=-2.44;
        if P<1.5, then use (A) above;
3. if Lw(443)=<0.15 and Lw(520)>0, then use (B) above;
4. if Lw(443)=<0.15 and Lw(520)=<0,
     then P=46.34456 (saturated);
```

where Lw represents the water-leaving radiance for the band of the specified wavelength (nm) and P is the pigment concentration in mg/m^3.

The state of polarization of the light is taken into account in the calculations of the multiple Rayleigh scattering (exact radiative transfer theory; Gordon et al., 1988).

Various statistical parameters are also computed from the distribution of the Angstrom exponents of the qualifying pixels. The statistics computed are the mean, the median, and the mean of lowest 10% of values, as well as the minimum, the maximum, the standard deviation and the quartile range (the difference between the 75th and 25th percentiles). The particular set of Angstrom exponents selected for use with the program L2MULT is up to the user. CLRWAT also creates a text file having the extension "CLR" (the root name is the filename corresponding to the input file INFILE, but without the channel number), which has all the statistical information displayed in a table. As with the other level-2 programs, a text file having the extension "L2P" and containing additional information is generated. The program also creates an image file having the extension "SCR" that contains a color code corresponding to the categories of pixels determined according to the algorithm described above. The SCR file can be displayed using the program SCREEN.

PARAMETERS:

(1) **INFILE** is the name of an unmapped, level-1 CZCS, PC-SEAPAK image file (including the band digit). The program will need to access all five band images associated with the specified file. (Any of the five may be specified.) These files should therefore reside in the same directory. Also, the INFILE name is used to formulate the names of three output files having the extensions "L2P", "CLR", and "SCR". One character prior to the INFILE extension (if any) is removed when creating these names. For example, if INFILE is "SCENE3", then SCENE.L2P, SCENE.CLR and SCENE.SCR will be created.

(2) **ILTOPT** specifies the ILT option: If "1", ephemeris data from the ILT record of the level-1 scene will be used. If "0", much of these data will be obtained from the documentation record or calculated by SEAPAK based on the location and time at the start of the scene.

(3) **CORR** is the index of the correction method to use for calculating total radiances:

1: Use factors and method (time and gain dependent) of R. Evans (Univ. of Miami).

2: Use correction factors specified by FACTOR.

(4) **LANCLD** is the land/cloud threshold to identify land and cloud pixels in exclusion criterion 1. The use of this criterion in the program's algorithm is described in the main help text above.

(5) **SUN** is the solar zenith angle threshold used to avoid pixels with large atmospheric path radiances in exclusion criterion 2. The use of this criterion in the program's algorithm is described in the main help text above.

(6) **SCAN** is the scanner zenith angle threshold used to avoid pixels with large atmospheric path radiances in exclusion criterion 2. The use of this criterion in the program's algorithm is described in the main help text above.

(7) **AEROL4** is the range for valid values of aerosol radiances (La(670)) used for exclusion criterion 3. The use of this criterion in the program's algorithm is described in the main help text above.

(8) **NLW520** is the range for valid values of normalized band 2 (520nm) water radiances used for exclusion criterion 4. The use of this criterion in the program's algorithm is described in the main help text above.

(9) **NLW550** is the range for valid values of normalized band 3 (550nm) water radiances used for exclusion criterion 4. The use of this criterion in the program's algorithm is described in the main help text above.

(10) **PTHRES** is the maximum clear-water valid pigment concentration (mg/m3) used for exclusion criterion 5. The use of this criterion in the program's algorithm is described in the main help text above.

(11) **EPS520** is the range for valid values of band 2 (520nm) epsilon values used for exclusion criterion 6. The use of this criterion in the program's algorithm is described in the main help text above.

(12) **EPS550** is the range for valid values of band 3 (530nm) epsilon values used for exclusion criterion 6. The use of this criterion in the program's algorithm is described in the main help text above.

(13) **FACTOR** are the correction factors to use for calculating total radiances of bands 1 to 4, respectively. These will be used only when CORR=2.

(14) **OZONE** are the optical thicknesses (in meters) for bands 1 to 4. If the value "-999" is entered, the values used will be

from the PC-TOMS database for the day of the input CZCS scene and for the point nearest to the image center. If the PC-TOMS data point is missing or an error occurs accessing the data, a message to that effect will be displayed on the terminal along with the default values. The actual values used will be listed in the L2P log file. If defaults are used, the values will be 0.00106, 0.0144, 0.0279, and 0.0125. These thicknesses are the products of the absorption coefficients (3.4E-6, 46E-6, 89E-6, and 40E-6) used at the Univ. of Miami and an average amount of 313 Dobson units of ozone.

(15) **ANGEXP** are the angstrom exponents for bands 1 to 4, respectively, for use in calculating the normalized water radiances and the pigment. These radiances and pigment are used in applying exclusion criteria 4 and 5. (See main help text above.)

FUNCTION KEY DEFINITIONS:

No function keys are used.

PROGRAM NAME: COAST
DATE: 10/28/91
MENU: GEOGRAPH

DESCRIPTION: This program allows the user to generate a coastline overlay for SEAPAK images using the CIA World Data Base II (WDB-II). Function key F9 is available for using an ASCII file to enter alternate or additional data to those of the CIA WDB-II. Additional function keys are available to drop new images; change the frame buffer; change, turn on/off, or erase the current graphics palette; and save the coastline graphics to a file or restore it from a file. It should be noted that the coastline is generated over the entire screen even though the image may only take up a portion of the screen.

PARAMETERS:
None.

DYNAMIC PARAMETERS:
I. Used in dropping the coastline:

(1) **INDEX** is the array of indices representing the features to be drawn over the image. The indices may be entered in any order followed by 0 to indicate that no subsequent indices are entered. Duplicate or invalid indices will be removed after input. The following indices may be specified:
 1 major coasts/islands/lakes
 2 additional major islands/lakes
 3 intermediate islands/lakes
 4 minor islands/lakes
 6 intermittent major lakes
 7 intermittent minor lakes
 8 reefs
 9 major salt pans
 10 minor salt pans
 13 major ice shelves
 14 minor ice shelves
 15 glaciers

(2) **SSRATE** is the array of the CIA WDB-II data base subsampling rate for the corresponding coastline INDEX. An SSRATE value of n indicates that only every nth data base value will be used. For most applications, the maximum value (6) should be adequate while requiring the least amount of time for the program to run.

(3) **LATRNG1** is the northern limit of the image in degrees. The default value -99999 indicates that the limit specified in the header will be used. Note that this parameter is only for the user to change the image limit specified in the header and does not set up a window for the coast line.

(4) **LATRNG2** is the southern limit of the image in degrees. The default value -99999 indicates that the limit specified in

the header will be used. Note that this parameter is only for the user to change the image limit specified in the header and does not set up a window for the coast line.

(5) **LONRNG1** is the western limit of the image in degrees. The default value -99999 indicates that the limit specified in the header will be used. Note that this parameter is only for the user to change the image limit specified in the header and does not set up a window for the coast line.

(6) **LONRNG2** is the eastern limit of the image in degrees. The default value -99999 indicates that the limit specified in the header will be used. Note that this parameter is only for the user to change the image limit specified in the header and does not set up a window for the coast line.

II. Used in dropping a new image:

(1) **IMGFILE** is the name of the disk file containing the image to drop. This must be a standard 512x512x8 bit image with a known number of header blocks.

(2) **FRMBUF** is the index number (1-3) of the frame buffer to receive the image.

(3) **HEADNO** specifies the number of 512-byte header blocks in the new image. This number of blocks will be skipped before reading the image data.

(4) **YNIMG** is a flag indicating whether to display the dropped image (1) or leave on the current frame buffer being displayed (0).

III. Used in saving the coastline graphics into a file:

(1) **BLOFILE** is the file name to save all the overlay graphics created by this program. The output file actually contains 512x512 bytes of data from the overlay frame buffer 0 and their values should always be between 0 and 7.

IV. Used in restoring the coastline graphics from a file.

(1) **BLOFIL1** is the input file name of the overlay graphics which contains 512x512 bytes of data with values between 0 and 7 and is to be loaded into the overlay frame buffer 0.

FUNCTION KEY DEFINITIONS:

ESC: Exits the program.

F1: Initiates the actual drawing of the coastline. Before the coastline is drawn, however, the user will be prompted for the coastline indices (see parameter INDEX) of the CIA WDB-II mapbase.

F2: Allows the user to drop a new image into the frame buffer.

F3: Displays the next image frame buffer.

F4: Changes the overlay graphics palette by increasing the current palette by one and is reset to one if the value is greater than seven.

F5: Toggles the current graphics palette on/off.

F6: Clears the current graphics palette.

F7: Allows the user to save the current overlay graphics data (in overlay frame buffer 0) into a file.

F8: Allows the user to restore the overlay graphics from a file into the overlay frame buffer 0.

F9: Allows the user to enter location data from an ASCII file. The data should be in the format of the following example.

```
111  33.598  130.113
111  33.581  130.098
999  9999    9999
222  33.242  134.184
...  ....    .....
```

The first, three-digit field is significant only when it contains "999," indicating the end of a series of points comprising a continuous segment to be plotted. The second and third fields are the decimal degree latitude and longitude coordinates and may be in any real format. At least one blank character must seperate the fields. The program will automatically read all data to the end of the file.

ALT F1: Toggles the function key menu display on/off.

MOUSE RIGHT BUTTON - Toggles the function key menu display on/off.

PROGRAM NAME: COLBAR
DATE: 10/28/91
MENU: LUTCOLOR

DESCRIPTION: COLBAR is a program that displays a color bar on currently displayed frame buffer. The direction (horizontal or vertical), screen location, color, size and number of blocks of the color bar can be changed by the user. A look-up table file saved using the program PAINT can be loaded into the color bar. There is a default color setup for up to 32 color blocks which is defined in the file LKTBL.PAR under the SEAPAK directory. The image with the color bar can be saved by exiting COLBAR with the color bar toggled "ON" and then saving the image using the program IMAGSAV.

PARAMETERS:
(1) **BLOCKS** is the total number of color blocks associated with the color bar to be displayed. Only values between 1 and 32 are valid input. The gray level values in the range of LGREYLEV and HGREYLEV (0 and 255 initially and can be changed using function key F8) will be evenly divided into the specified color blocks
(2) **IROW** specifies the starting line (row) on the displayed screen for the color bar.
(3) **ICOL** specifies the starting pixel (column) on the displayed screen for the color bar.
(4) **TROW** is the total number of lines (rows) for the color bar.
(5) **TCOL** is the total number of pixels (columns) for the color bar.
(6) **IDIR** defines whether the color bar will be horizontal or vertical. IDIR = 0 for horizontal and 1 for vertical.

DYNAMIC PARAMETERS:
I. Used for changing color bar location.
(1) **IROW** see PARAMETERS section.
(2) **ICOL** see PARAMETERS section.
(3) **TROW** see PARAMETERS section.
(4) **TCOL** see PARAMETERS section.
(5) **IDIR** see PARAMETERS section.
II. Used for changing gray level ranges and number of color blocks.
(1) **LGREYLEV** is the minimum gray level to be pseudocolored. The range between LGREYLEV and HGREYLEV should always be greater than or equal to the number of color blocks BLOCKS and the valid input for them are between 0 and 255 inclusive.
(2) **HGREYLEV** is the maximum gray level to be pseudocolored. The range between LGREYLEV and HGREYLEV should always be greater than or equal to the number of color blocks BLOCKS and the valid input for them are between 0 and 255 inclusive.
(3) **BLOCKS** see PARAMETERS section.

III. Used for changing the breakpoints of color blocks.

(1) **GREY_LEVEL** is an array of breakpoints to be assigned in the color blocks. The values should be entered in order. The parameters LGREYLEV and HGREYLEV will be used to check the low range of the first color block and the high range of the last color block. For example, the LGREYLEV=20, HGREYLEV=200 and the array of GREY_LEVEL entered is (10, 40, 100, 150, 220) then only four color blocks (1 to 4) will be created with gray level ranges defined as (20-40), (41-100), (101-150), (151-200).

IV. Used for saving color blocks and look-up tables.

(1) **LUTFIL2** is the output file name which the color block information and the look-up tables of red, green and blue defined by the color blocks will be saved to.

V. Used for restoring color blocks and look-up tables.

(1) **LUTFIL3** is the input look-up table file name to be loaded. Only files created using the programs PAINT or COLBAR which contain both the color block information and the look-up tables can be used.

FUNCTION KEY DEFINITIONS:

ESC: Exits the program.

F1: Allows the user to modify the colors of the color bar.

F2: Allows the user to change the color bar locations.

F3: Toggles the color bar display on/off.

F4: Toggles the image display in gray shades or in colors defined in the color bar.

F6: Allows the user to save present look-up tables which defines the currently displayed color bar into a file. The saved file can be used in programs PAINT, COLBAR and TABLOAD.

F7: Allows the user to display the color bar by retrieving the look-up tables from a file previously saved using the programs PAINT or COLBAR.

F8: Enables the user to modify the minimum and maximum gray level ranges and the number of color blocks. The valid values for the minimum and maximum gray level ranges should be between 0 and 255 and the valid value for number of color blocks should be between 1 and 32. The new specified minimum and maximum ranges will then be evenly divided into the new specified total number of color blocks.

F9: One can change the breakpoints for the color blocks using this key. After depressing this key, the user is prompted with the parameter GREY_LEVEL. The user should enter the values desired for the gray level breaks. The endpoints are assumed to be LGREYLEV and HGREYLEV and are not to be entered (key F8 can redefine this range if need be) unless blocks having single value ranges of 0 or 255 are desired. Up to 32 points may be entered. The breakpoints defined here will overwrite the setup, both the color block numbers and the breakpoints, defined in key F8.

ALT F1: Toggles the function key menu display on/off.

MOUSE RIGHT BUTTON - Same as ALT F1

PROGRAM NAME: CONTOUR
DATE: 10/28/91
MENU: OVERLAYS

DESCRIPTION: This program allows the user to contour an image at specified gray levels. The algorithm compares, horizontally and vertically, all the adjacent pixels on the image with the gray level value for contouring. If the gray level value for the contouring lies between (inclusive only on one side) the gray level values of any two adjacent pixels, the pixel with the greater gray level value will be set on the overlay frame buffer as a contour pixel. Note that this algorithm may generate isolated points as well as open contours.

The gray levels can be specified by an input value or as the value corresponding to the current cursor location. Gray level mask values, values to exclude from the contouring, can also be defined. The contours may be drawn on the full image or inside or outside blotches. Other options allow the user to fill between two contours, to change the frame buffer and the default graphics palette, to turn the overlay graphics and the displayed image on and off, and to save overlay graphics into a file or load them from a file.

PARAMETERS:
None.

DYNAMIC PARAMETERS:

I. Parameters for adding or deleting contours.

(1) **CONTOUR_VALUES** are the gray level values (0-255) for the contours to be added or deleted. Up to 10 values may be entered. Due to the algorithm (see the main help text), gray level 0 will have the same result as gray level 1.

(2) **GRAPHICS_PALETTE** are the graphics palettes (0-7) used for each corresponding contour specified in CONTOUR_VALUES. This parameter is needed only for adding contours. Note that graphics palette 0 will generate "transparent" contours, clearing any previous graphics along those lines.

II. Parameter for masking values when drawing contours.

(1) **MASK** specifies the gray level values for masking, i.e. values to ignore when drawing contours. If it is undesirable to contour in the vicinity of certain values, MASK allows the user to avoid these values. This is often helpful in obtaining clean contours when the image is noisy at the contour value. Acceptable values are 0 to 255, or -1 for none. Up to five values can be specified.

III. Parameter for clearing the graphics palette.

(1) **CLR_PAL** is the number of the palette from which to clear overlay graphics. A "-1" is to used to clear all overlay graphics.

IV. Parameter for saving overlay graphics into a file:

(1) **BLOFILE** is the file name to create for saving all overlay graphics created by this program. The output file will contain 512x512 bytes of data (values 0 to 7) from frame buffer 0.

V. Parameter for restoring overlay graphics from a file.

(1) **BLOFIL1** is the file name of the overlay graphics which contains 512x512 bytes of data (values 0 to 7) to be loaded into overlay frame buffer 0.

VI. Parameters for filling two contours

(1) **FIL_PAL** is the graphics palette (0-7) to be used for the filling.

(2) **FIL_VAL** are the two gray level values to be used in the filling process. Only the gray level values used in generating the contours (function key F1 or F2) are valid inputs. Note that the program fills all image pixels which have gray level values between (inclusive) these two values. Since the pixels on a contour may have values greater than the gray level values for that contour (see main help text), the pixels on the contours may not be filled.

VII. Parameter for full image or blotch selection

(1) **B_PAL** is the graphics palette containing the blotch areas for contouring. An integer value -7 to 7 should be entered. If the number is positive, only the pixels within the blotch will be considered; if negative, only the pixels outside the blotch will be considered. If "0" is entered, the entire image area (512 x 512) will be used.

FUNCTION KEY DEFINITIONS:

ESC: Exits the program.

F1: Allows the user to draw contours for different gray level values and on a different graphics palette. The parameters of DYNAMIC PARAMETERS I will be requested.

F2: Draws the contour with the gray level value of current cursor position and with color defined by the current graphics palette.

F3: Allows the user to delete contours created by F1 or F2. The parameter CONTOUR_VALUES of DYNAMIC PARAMETERS I will be requested.

F4: Displays current cursor position on the image and the gray level value of that pixel.

F5: Lists the gray level values and graphics palettes for the contours generated by F1 and F2.

F6: Displays the next image frame buffer.

F7: Turns all graphics palettes on/off.

F8: Turns the displayed image on/off.

F9: Increases the current graphics palette by 1 or resets it to 1 if the value is greater than 7. The current graphics palette is used for generating blotches (ALT F5) and contours with the gray level value of the current cursor position (F2).

F10: Clears all overlay graphics from a specified graphics palette. The parameter CLR_PAL will be requested.

ALT F1: Toggles the function key menu display on/off.

ALT F4: Allows the user to change the mask values when drawing contours. The parameter MASK of DYNAMIC PARAMETER II will be requested.

ALT F5: Allows the user to use the current graphics palette to define blotch areas for contouring. Once the key is pressed, a new function key set will be defined and the blotch areas created previously, if any, and the cursor will be displayed. At this time, the user can move the cursor around and press F1 or the mouse's left button to define a new vertex or F2 to erase the last vertex. As many as 500 vertices can be defined for each blotch area and up to 10 blotch areas can be defined. Key F3 is used to close the blotch area being defined and to fill the region with the color of the current graphics palette. Key F4 is used to erase a blotch area; this can only be done when the cursor is inside the blotch area. After the blotch areas are created, the ESC key must be used to return to the main function key set.

ALT F6: Redisplays the blotch areas created with ALT F5.

ALT F7: Allows the user to save the current overlay graphics data (in frame buffer 0) into a file.

ALT F8: Allows the user to restore overlay graphics from a file into frame buffer 0.

ALT F9: Allows the user to fill with color between two contours. The parameters FIL_PAL and FIL_VAL of DYNAMIC PARAMETER VI will be requested.

ALT F10: Allows the user to select the full image, or inside or outside of blotch areas for contouring. The parameter B_PAL will be requested.

MOUSE RIGHT BUTTON - Same as ALT F1.

PROGRAM NAME: CONVOLVE
DATE: 10/28/91
MENU: HARDFCT

DESCRIPTION: This program performs a transformation that gives each pixel in an image a new value that is a function of the pixels in its immediate neighborhood. The image to be transformed is in the source frame buffer SBUF and the resulting transformed image is stored in the destination frame buffer DBUF. The transformation array is user defined and stored in the parameter KERNEL. Note that if the row number KROW or column number KCOL of the kernel is even, the pixel to the top and left of center is the default central pixel. The convolution function is:

P'(x,y) = Sum of (K(i,j) * P(x+i, y+j))

where P is the SBUF pixel value at pixel (column) position x and line (row) y, K is the kernel, i ranges from -KROW/2 to KROW/2, and j ranges from -KCOL/2 to KCOL/2. The results are not normalized. The program IMGFCT may be used to perform additional arithmetic functions on the results.

PARAMETERS:

(1) **SBUF** is the frame buffer (0-3) on whose pixels the convolution will be performed.

(2) **DBUF** is the frame buffer (0-5) in which the image resulting from the convolution will be stored. (DBUF values of 4 and 5 are used to refer to frame buffers of the image memory configured as two 16-bit buffers where 4 is equivalent to the regular 8-bit buffers 0/1 and 5 is equivalent to buffers 2/3.) The results are not normalized. DBUF 4 or 5 should be used unless the user is certain that the results do not exceed 8 bits (signed). The results will be displayed on the monitor. If DBUF is 4 or 5, only the low-byte frame buffer (i.e., the regular buffers 0 or 2) of each will be displayed.

(3) **KROW** is the number of rows (2-11) to use for the kernel.

(4) **KCOL** is the number of columns (2-11) to use for the kernel.

(5) **KERNEL** is the two dimensional array of the kernel to be used for the convolution. All values must be between -127 and 127.

FUNCTION KEY DEFINITIONS:
No function keys are used.

PROGRAM NAME: CORCO
DATE: 10/28/91
MENU: STAT2

DESCRIPTION: This program calculates the correlation coefficient and other statistics for two images currently residing in two of the MVP-AT frame buffers (FBUF1 and FBUF2). The pixels used in this analysis can be the full image or the inside or outside of blotch areas and whose values are within specified ranges (RANGE1 and RANGE2). The statistical calculations include the mean values and the standard deviations for each image and the coefficients of skewness and of excess (kurtosis) for each image.

Function keys are also provided to display the scatterplot, to create or modify the blotch areas, to load a blotch from a file, to turn the displayed image or the graphics on/off, to change the current graphics palette and to change the ranges for the analyses and plots.

PARAMETERS:

(1) **FBUF1** is the frame buffer for the first input image. An integer between 1 and 3 should be entered. If a scatterplot will be requested (function key F2), the X axis of the scatterplot will be used for the image in FBUF1 and the Y axis for the FBUF2 image. Note that FBUF1 and FBUF2 cannot have the same value.

(2) **FBUF2** is the frame buffer for the second input image. An integer between 1 and 3 should be entered. If a scatterplot will be requested (function key F2), the X axis of the scatterplot will be used for the image in FBUF1 and the Y axis for the FBUF2 image. Note that FBUF1 and FBUF2 cannot have the same value.

(3) **MODE1** defines whether the image in FBUF1 is scaled linearly or is in pigment concentration. A value of "1" (the default value) should be entered if the pixel values of the FBUF1 image represent data (such as temperature) that are linearly related to gray levels. A value of "2" should be entered if they represent pigment concentrations (mg/m3).

(4) **MODE2** defines whether the image in FBUF2 is scaled linearly or is in pigment concentration. A value of "1" (the default value) should be entered if the pixel values of the FBUF2 image represent data (such as temperature) that are linearly related to gray levels. A value of "2" should be entered if they represent pigment concentrations (mg/m3).

(5) **FACTOR1** is a non-negative scaling factor which is used only if MODE1=1, i.e. the data-to-gray scale mapping function is linear for the FBUF1 image. It is ignored when MODE1=2. If FACTOR1 is positive, it will represent the factor by which to divide the gray values of FBUF1 pixels in order to convert them into actual data values. If zero is entered, the slope and intercept for this mapping function will be obtained from the header of the disk file for the FBUF1 image. In order to

retain the gray values, a "1" (the default value) should be entered; for sea surface temperature (SST), enter 8; for water radiance data, enter 85; for aerosol radiance data, enter 100. Note that the use of different linear mapping functions does not alter the appearance of the scatterplot or histograms in any way other than ensuring that the values labelling the axes reflect those of the image data.

(6) **FACTOR2** is the linear, data-to-gray scale mapping function for FBUF2. See the description of FACTOR1 whose function is analogous.

(7) **RANGE1** defines the range of FBUF1 pixel values to use for the calculation of the statistics and scatterplot. Two values should be entered for this parameter. These values should conform to the units of the FBUF1 image (i.e. pigment concentration or units linearly proportional to gray levels) as specified by MODE1 and FACTOR1. Pixel values less than the smaller RANGE1 value and those greater than the larger RANGE1 value will be excluded from the analysis and plots. (Thus pixels rejected by this criterion will also eliminate the corresponding FBUF2 pixel from consideration). For example, to exclude land and cloud pixels for a level 2 CZCS image, the RANGE1 values should be 1.0 and 254.0 (the default values) for gray levels (MODE1=1 and FACTOR1=1) or 0.04093 and 45.0 for pigment concentrations (MODE1=2).

(8) **RANGE2** defines the range for FBUF2 values in data units. See the description for RANGE1 whose function is analogous.

DYNAMIC PARAMETERS:

I. Used in statistical calculations and scatterplots.

(1) **BPAL** is the graphics palette containing the blotch area of interest. An integer in the range -7 to 7 should be entered. If the number is positive, only the pixels within the blotch will be considered; if the number is negative, only the pixels outside the blotch will be considered. If "0" is entered, the entire image area (512 x 512) will be used.

(2) **GPAL** is the graphics palette to be used to display the scatterplot. Any value from 1 to 7 may be used.

FUNCTION KEY DEFINITIONS:

ESC: Exits the program.

F1: Calculates and displays the statistical products which include the correlation coefficient between the images and the number of pixel pairs used, the mean values and standard deviations for each image, and the coefficients of skewness and of excess (kurtosis) for each image.

F2: Displays the scatterplot. The parameters BPAL and GPAL will be requested. BPAL specifies whether the full image or the inside or the outside of blotch areas will be used for the scatterplot. GPAL is the graphics palette to use for the scatterplot.

F3: Allows the user to define the blotch areas to be used for statistical calculations (F1) or scatterplot (F2). Once the key is pressed, a new function key set will be defined and the blotch areas created previously, if any, and the cursor will be displayed. At this time, the user can move the cursor around and press F1 (or the mouse left button) to define a new vertex or F2 to erase the last vertex. As many as 500 vertices can be defined for each blotch area and up to 10 blotch areas can be defined. Key F3 is used to close the blotch area (connect the last and first vertices and fill the area with the color defined for the current graphics palette). Key F4 is used to erase a blotch area; this can only be done when the cursor is inside the blotch area. After the blotch areas are created or modified, the ESC key has to be used to return to the main function key set.

F4: Allows the user to change the input parameters MODE1, MODE2, FACTOR1, FACTOR2, RANGE1, and RANGE2.

F5: Redisplays the blotch areas defined by F3.

F6: Switches the display between the two images defined by FBUF1 and FBUF2.

F7: Turns all overlay graphics on/off.

F8: Turns the displayed image on/off.

F9: Changes the current graphics palette by increasing the palette number by one. If the value is greater than seven, it will be reset to 1.

F10: Clears the overlay graphics defined by the current graphics palette.

ALT F5: Allows the user to load the blotch areas from a file created previously using the program BLOTCH.

ALT F1: Toggles the function key menu display on/off.

MOUSE RIGHT BUTTON: Same as ALT F1.

PROGRAM NAME: DERIV
DATE: 10/28/91
MENU: SOFTFCT

DESCRIPTION: This program calculates the spatial derivatives of an input image file. One output data file (in a non-image format) is created for each derivative requested. For those output files, the program STATDIS must be used to display them.

The following derivatives may be requested:

```
DX(x,y) = (P(x,y) - P(x-1,y)) / XDIST    (1st derivative in X direction)
DY(x,y) = (P(x,y) - P(x,y-1)) / YDIST    (1st derivative in Y direction)
DXDY(x,y) = DX(x,y) + DY(x,y)            (sum of derivatives)
GRAD(x,y) = (DX(x,y)**2 + DY(x,y)**2) ** 0.5       (gradient magnitude)
D2X(x,y) = [P(x+1,y)+P(x-1,y)-2*P(x,y)]/XDIST**2   (2nd derivative in X direction)
D2Y(x,y) = [P(x,y+1)+P(x,y-1)-2*P(x,y)]/YDIST**2   (2nd derivative in Y direction)
D2XY(x,y) = D2X(x,y) + D2Y(x,y)          (Laplacian)
```

where P(x,y) is the gray or pigment value at pixel x, line y.

PARAMETERS:
(1) **IFIL** is the name of the input image file to be processed.
(2) **OFIL** is the root part of the names of the output data files produced. One output file will be created for each derivative requested. The name of an output file will consist of the name specified by OFIL and a suffix corresponding to the derivative. Note that if the name of OFIL has more than four letters, only the first four letters will be used. For example, if all seven derivatives are requested and OFIL is "TEST.DAT", the following files would be created:
TESTDX.DAT,
TESTDY.DAT,
TESTDXDY.DAT,
TESTGRAD.DAT,
TESTD2X.DAT,
TESTD2Y.DAT,
and TESTD2XY.DAT.
The image files may require substantially less disk space than the corresponding data files specified by OFIL. This is illustrated by the fact that if a full image blotch is used, each of these files will require 2049 blocks (512 bytes of each block) of disk space as opposed to the normal image file of 513 blocks.

(3) **DX** is a flag indicating whether or not to calculate the first derivative in the X direction. A "1" should be entered to perform this calculation. The formula for this derivative is

DX(x,y) = (P(x,y) - P(x-1,y)) / XDIST

where P(x,y) is the gray or pigment value at pixel x, line y.

(4) **DY** is a flag indicating whether or not to calculate the first derivative in the Y direction. A "1" should be entered to perform this calculation. The formula for this derivative is

DY(x,y) = (P(x,y) - P(x,y-1)) / YDIST

where P(x,y) is the gray or pigment value at pixel x, line y.

(5) **DXDY** is a flag indicating whether or not to calculate the sum of the first partial derivatives. A "1" should be entered to perform this calculation. The formula for this derivative is

DXDY(x,y) = DX(x,y) + DY(x,y)

where P(x,y) is the gray or pigment value at pixel x, line y.

(6) **GRAD** is a flag indicating whether or not to calculate the magnitude of the gradient. A "1" should be entered to perform this calculation. The formula for this derivative is

GRAD(x,y) = (DX(x,y)**2 + DY(x,y)**2) ** 0.5

where P(x,y) is the gray or pigment value at pixel x, line y.

(7) **D2X** is a flag indicating whether or not to calculate the second derivative in the X direction. A "1" should be entered to perform this calculation. The formula for this derivative is

D2X(x,y) = [P(x+1,y)+P(x-1,y)-2*P(x,y)]/XDIST**2

where P(x,y) is the gray or pigment value at pixel x, line y.

(8) **D2Y** is a flag indicating whether or not to calculate the second derivative in the Y direction. A "1" should be entered to perform this calculation. The formula for this derivative is

D2Y(x,y) = [P(x,y+1)+P(x,y-1)-2*P(x,y)]/YDIST**2

where P(x,y) is the gray or pigment value at pixel x, line y.

(9) **D2XY** is a flag indicating whether or not to calculate the sum of the second partial derivatives (the Laplacian). A "1" should be entered to perform this calculation. The formula for this derivative.

D2XY(x,y) = D2X(x,y) + D2Y(x,y)

where P(x,y) is the gray or pigment value at pixel x, line y.

(10) **XDIST** is the distance between pixels in the X direction. The units for XDIST and YDIST must be the same.

(11) **YDIST** is the distance between pixels in the Y direction.

(12) **MODE** is a flag which indicates whether the pixel values of the IFIL image represent data (such as temperature or radiance) that are linearly related to gray levels, or pigment concentrations which are non-linear. A "1" should be entered for linear data and a "2" for pigment data.

(13) **FACTOR** is a linear scale factor used only if MODE=1, i.e. when a linear data-to-gray scale mapping function for the IFIL image is used. If greater than zero, it will represent the factor by which to divide the gray values of IFIL pixels in order to convert them into actual data values; if zero or less, the slope and intercept for this mapping function will be obtained from each file header of the IFIL disk image files. In order to retain the gray values, enter 1 (the default value); for sea surface temperature (SST), enter 8; for water radiance data, enter 85; for aerosol radiance data, enter 100.

(14) **RANGE** defines the range of IFIL pixel values to use for the calculations of derivatives. The user should enter two values in the input data units. For a given pixel location, if a value for any IFIL falls outside the RANGE values, the corresponding pixel in the output data files will be flagged as "invalid." These "invalid" pixels may be assigned any value when using STATDIS to generate the image from those output files. Again, the RANGE values must conform to the units of the IFIL image as specified by MODE and FACTOR (i.e. pigment concentration or units linearly proportional to gray levels). For example, to exclude only land and cloud pixels, the RANGE values should be 1.0 and 254.0 (the default values) for gray levels (MODE=1 and FACTOR=1) or 0.0409 and 44.46 for pigment concentrations (MODE=2).

(15) **ORIGIN** is a flag indicating the location of the origin for the image. One should enter a "0" if the origin of the image is at its top left corner or a "1" if the origin of the image is at its bottom left corner.

(16) **GPAL** is the graphics palette which defines the blotch area(s) of interest and is in the range -7 to 7. If the number entered is positive, pixels within the blotch will be considered. If the number is negative, pixels outside the blotch will be considered. Only blotches defined by this graphics palette (the absolute value of GPAL) of the blotch file BFIL will be used. If "0" is entered, the entire image area (512 x 512) will be used and BFIL will be ignored.

(17) **BFIL** is the name of the blotch file which defines the image area(s) of interest unless GPAL= 0. Only blotches defined by the graphics palette corresponding to GPAL will be used. Blotches may be drawn and saved as files using the programs BLOTCH and BPSAV.

FUNCTION KEY DEFINITIONS:

No function keys are used.

PROGRAM NAME: DIFFI
DATE: 10/28/91
MENU: SOFTFCT

DESCRIPTION: DIFFI lets you obtain a difference image file from two input image files. The differencing may be performed linearly using actual gray level units or, for images of pigment concentrations (a non-linear gray-to-data mapping), using the chlorophyll values. The differencing takes place such that input image file 2 is subtracted from input image 1. A gray level is designated by the user to represent the pixels for which the difference is zero and thus serves as an offset to the positive and negative differences. For example, for linear differencing, if a value of 128 is designated to represent this zero difference level, pixels with a difference of 5 will be displayed as gray level 133 and pixels with a difference of -5 will be displayed as gray level 123.

PARAMETERS:
(1) **INFIL1** is the file name of an image from which the image file INFIL2 is subtracted.
(2) **INFIL2** is the file name of an image to be subtracted from the file INFIL1.
(3) **OUTFIL** is the output image file name to contain the difference of INFIL1 and INFIL2.
(4) **IMODE** specifies the data mode for differencing. The user should enter a "1" to specify a linear mode or a "2" to specify a pigment mode. In linear mode, the difference is taken directly using the gray levels of each pixel of the input image files and then multiplied by WEIGHT. In pigment mode, the corresponding pigment values of each pixel of the input files are first determined. The difference is then taken in pigment values and multiplied by WEIGHT. Finally, this difference is converted back to gray levels.
(5) **ZERO** is the gray level value to be assigned to pixels with no difference between the two input images. This ZERO value serves as an offset for the positive and negative difference values. This is a very important parameter since negative difference values cannot be displayed. For example, in linear mode, if the user specifies a ZERO value of 128, all the pixels with a difference value of 50 will be displayed with the gray level 178 (128+50), while all the pixels with a difference value of -50 will be displayed with the gray level 78 (128-50). This parameter can have any integer value in the range [0,255].
(6) **WEIGHT** is the multiplicative factor for the difference, i.e. OUT=WEIGHT*(INFIL1-INFIL2)+ZERO. Note that a careful choice of the parameters WEIGHT and ZERO are required to obtain a meaningful image, i.e. one whose values stay within the screen range of [0, 255]. Values less than 0 will be set to 0 and values greater than 255 will be set to 255.

FUNCTION KEY DEFINITIONS: No function keys are used.

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GLOSSARY

ASCII Acronym for American Standard Code for Information Interchange, a code for representing an alphanumeric and symbol character set in binary.

AVHRR Advanced Very High Resolution Radiometer. This is one of the sensors aboard the NOAA series of satellites. There are four channels for even numbered satellites such as NOAA-10 and five channels for odd numbered satellites such as NOAA-9. The radiance bands measured are 0.58-0.68, 0.725-1.1, 3.55-3.93, 10.5-11.5, and, for odd-numbered satellites, 11.5-12.5 um. (See **GAC** and **LAC**.)

Band A wavelength range of spectrum within which a sensor makes measurements. (See **AVHRR**, **CZCS**, **Channel**.)

Block A quantity of storage or data in bytes. Equals 512 bytes unless otherwise specified.

Blotch A colored-in area on a overlay graphics which normally corresponds to a region of interest for associated image(s). A blotch enables the system to differentiate between the areas inside and outside this region when performing analyses on images. (See **Region of Interest**.)

Case 1 Water Areas where phytoplankton and derivatives are the primary determinant of the water's optical characteristics. Such areas are normally in the open ocean.

Case 2 Water Areas where water sediments are the primary determinant of the water's optical characteristics. Such areas are normally coastal regions.

Channel Spectral band at which measurements are made by a radiometer. The CZCS has six such channels; the AVHRR, four or five. (See **Band**.)

Counts Refers to the digitized value of the radiance measured by a radiometer for an individual point (pixel). Usually applies to data prior to various corrections which convert them to physical units. CZCS uses 8 bits per pixel so count values range from 0 to 255. Count values are used to generate level-1 images.

CRT CZCS calibrated radiance (level-1) tape.

CZCS Coastal Zone Color Scanner, a scanning radiometer aboard the Nimbus-7 satellite with channels at 0.433-0.453, 0.510-0.530, 0.540-0.560, 0.660-0.680, 0.700-0.800, and 10.5-12.5 um, and a resolution at nadir of 825 m^2. It was functional from November 1978 to June 1986.

Display Coordinates Refers to the vertical and horizontal coordinates of a picture element on an image display. Also called **TV coordinates**.

DOS The acronym for Disk Operating System, the operating system for which PC-SEAPAK was developed.

DOS extender Provides for a 80386 chip a protected mode run-time environment for application programs running undr DOS. Allows memory greater than 640 Kbytes to be accessed by application programs. (See **DOS**, **real mode**, **protected mode**.)

Dropping an Image Refers to the loading of a digital image contained in a disk file into a frame buffer of the MVP-AT.

DSP An image analysis system developed for CZCS and AVHRR data at the University of Miami.

Frame Buffer Random access memory area in the MVP-AT used to store digitized images. For PC-SEAPAK, the MVP-AT's on-board one megabyte of memory is configured into four 512x512x8-bit frame buffers. These four buffers are numbered 0 to 3. Some PC-SEAPAK programs permit the memory to be accessed as two 512x512x16-bit frame buffers, numbered 4 and 5. In that case, the 16-bit buffer 4 is equivalent to the two 8-bit buffers 0 and 1 and buffer 5 is equivalent to buffers 2 and 3. (See **MVP-AT**.)

Full-Scan Image A CZCS image whose width is 1,968 pixels--a full scan line. The number of lines may vary. The image is a full-resolution image produced by the program TP2DSK. The program WINDOW may be used to display such images and to create regular, 512x512 PC-SEAPAK images. Also referred to as full-width or full-size images.

GAC Global Area Coverage, the lower resolution coverage provided by the AVHRR data. The resolution is approximately 4 km.

Gray Level Digitized value used to represent a pixel quantity. When displayed on an image system, such a value is assigned a gray shade or level. Normally, 8 bits per pixel are used for this digitization so that gray levels range from 0 (black) to 255 (white). The quantity represented may be count, level-1, level-2, or level-3 data.

GSFC NASA's Goddard Space Flight Center in Greenbelt, Maryland.

HRPT High resolution picture transmission, direct readout AVHRR data. (See **LAC**.)

Image File A 512x512-byte, flat file containing gray level values for an image which can be displayed on the MVP-AT. Each byte represents one image pixel. Additional 512-byte records containing the header information may precede the image data. PC-SEAPAK images typically contain one such header record.

I/O The acronym for input/output.

ILUT Input look-up table set. It modifies the input gray-scale values before they enter the frame buffer. For the MVP-AT, each of the red, green and blue look-up tables in the ILUT is divided into 32 256-byte palettes numbered 0 to 31.

LAC Local Area Coverage, the higher resolution coverage provided by the AVHRR. The resolution is approximately 1 km.

Lag A space or time interval separating points in correlation and spectral analyses.

Land Mask A graphics depicting the location of land; often used as an overlay to satellite imagery. May be used as a blotch to exclude processing of land or water areas in an image.

Level 1 Refers to a satellite image whose data have been corrected for sensor calibration. For CZCS, these data represent observed radiance values derived from the 8-bit count transmitted by the satellite.

Level 2 Refers to a satellite image whose data represents a geophysical parameter derived from level-1 images. To derive level-2 CZCS images, level-1 images from various bands of the same scene are used. Level-2 images include images such as those of water radiances, pigment concentrations, aerosol radiances, and diffuse attenuation for the CZCS or SST images for the AVHRR.

Level 3 Refers to a satellite image which has been mapped to a non-satellite perspective projection. Such mapping is normally (but not necessarily) performed on level-2 images.

Line Refers to the vertical location or coordinate of a picture element when used in conjunction with "pixel." (See **Display Coordinates**.)

LUT Look-up table. In MVP-AT, there is an input look-up table set (**ILUT**) and an output look-up table set (**OLUT**).

MS-DOS Acronym for Microsoft Disk Operating System. (See **DOS**.)

MVP-AT Image processing board, used by PC-SEAPAK, for the IBM PC AT from Matrox Electronic Systems Limited. (See **Frame Buffer**.)

NASA National Aeronautics and Space Administration.

NOAA National Oceanic and Atmospheric Administration, Dept. of Commerce.

OLUT Output look-up table set. It modifies the gray-scale intensity fed from the frame buffer to the output display device. For the MVP-AT, each of the red, green and blue look-up table in the OLUT is divided into 32 256-byte palettes numbered 0 to 31.

Overlay Refers to graphics that are displayed non-destructively in conjunction with an image (i.e., without altering the image). In PC-SEAPAK, frame buffer 0 is normally used to display overlays. An overlay may be saved in, or restored to the frame buffer from, a graphics (or "blotch") file identical in structure to image files but without header blocks.

Palette The palette is a look-up table which contains red, green, and blue 256-byte look-up tables. For the MVP-AT, there are 32 palettes each for the input look-up table (**ILUT**) and for the output look-up table (**OLUT**).

Pixel 1. The smallest element of a digital image for which a value is assigned. This may refer to the individual points at which a radiometer takes measurements or the picture elements of an image display. (See **Sample**.)
2. Refers to the horizontal location or coordinate of a picture element when used in conjunction with "line." (See **Display Coordinates**.)

Protected mode Aspecial operating mode for 80286 and 80386 chips that supports memory protection, addressing using segment selectors, and 16bit or 32-bit (for 80386) instruction sets. (See **DOS**, **DOS extender**, **real mode**.)

Real mode The DOS operation mode for 8086/8088, 80286, and 80386 chips that allows up to one megabyte of memory addressed and does not provide any memory protection features. (See **DOS**, **DOS extender**, **protected mode**.)

Region of Interest (ROI) A portion of an image, corresponding to one or more blotch areas, to be processed by a program. Certain PC-SEAPAK programs allow either the blotch (inside) or non-blotch (outside) areas to be specified as the ROI. (See **Blotch**.)

Registration Refers to the process of manipulating an image so that its earth-surface points may be superimposed on those of another image or graphics display.

Remap To project an image using the PC-SEAPAK program MAPIMG to a standard map projection.

Sample Usually refers to a data point along a scan line but also used interchangeably with **pixel**.

Scan Line A line of measurements (**samples**) taken during one rotation of a satellite sensor across its flight path.

SCSI Small computer system interface, an industry standard interface that provides high-speed access to peripheral devices.

SST Sea surface temperature. In PC-SEAPAK, refers to level-2 data derived from the AVHRR.

TOMS The Total Ozone Mapping Spectrometer aboard the Nimbus-7 satellite. Uses backscattered ultraviolet to make total ozone measurements at a resolution of 50 to 150 km.

TV Coordinates Same as **display coordinates**.

APPENDIX I
PC-SEAPAK HARDWARE AND SOFTWARE REQUIREMENTS AND OPTIONS

Lists of the hardware and software used for the PC-SEAPAK system are listed. Each item is preceded by a symbol to indicate whether it is required (*), recommended (!), or optional (o). Since the prices listed here are only meant as guidelines based on our most recent purchases or price lists we obtained from various vendors, they may not represent the lowest or most recent quotes available.

Basic System

Although PC-SEAPAK was developed on a COMPAQ Deskpro 386/20, it can be run on most 386-compatible computers with an AT bus, an EGA controller, and an Intel 80387 coprocessor. The COMPAQ Deskpro 386/20 has been discontinued and replaced by the Deskpro 386/25 and 386/33. PC-SEAPAK has been installed and run on the Deskpro 386/25 and 386/33 here at NASA/GSFC Oceans Computing Facility as well as by several user groups. The Deskpro 386/33 is recommended because of its better CPU speed and hardware configuration. **Note that conflict problems have been reported for the ZENITH computer using the MVP-AT image board and it is therefore not recommended.**

! Compaq Deskpro 386/33. Price: 5,165
- 4 MB memory
- 120 MB fixed disk drive with integrated controller
- Integrated VGA controller
- Eight expansion slots
- 1.44 MB 3.5" floppy drive
- Enhanced keyboard

Vendor:Any Compaq computer dealer.

Comments:
1. Higher price for larger hard disk. 320 MB or 650 MB internal drives are available. If no other external hard disk or rewritable/erasable optical drive is added to the system, the 320 or 650 MB hard disk is recommended. One of the expansion slots in this system is occupied by the floppy diskette control card and is not free to use.
2. All compatible 386 computers with AT bus are also recommended.

! 80387 (33 MHz) floating-point coprocessor. Price: 300
Vendor:Any Compaq computer dealer.
Comments: 1. 33 MHz is necessary for COMPAQ 386/33.
2. Most of the PC-SEAPAK application programs are built with Microsoft's Fortran and C compilers and the Intel 80387 coprocessor to be used for numerical calculations. MicroWay's NDP Fortran-386 compiler is also used to build some large application programs to run under protected mode with the 80387 coprocessor or the Weitek 3167 chips.

o 2 MB 32-bit memory module. Price: 300
Vendor:Any Compaq computer dealer.
Comments: 1. At least 4 MB of memory is recommended.
2. More memory can be used for virtual disk or running multitasks under DESQview.
3. With Phar Lap's DOS-Extender and MicroWay's NDP Fortran-386 compiler, application programs as large as the memory limit can be built.

! Additional 3.5" 1.44 MB or 5.25" 1.2 MB floppy drive. Price: 182
Vendor:Any Compaq computer dealer.

! 3167 (Weitek) 33 MHz numerical coprocessor board. Price: 1,100
Vendors: 1. Any Compaq computer dealer.
2. MicroWay Inc.
Comments: 1. 33 MHz is necessary for the COMPAQ 386/33.
2. The Microsoft compilers (Fortran, C) cannot generate code for the Weitek chips. MicroWay's NDP Fortran-386 compiler is used to generate code for the Weitek chips.

o AST-VGA adapter. Price: 350
Vendor:AST Research, Inc.
Comments: 1. This is recommended only for the Deskpro 386/25. The Deskpro 386/33 already contains an integrated VGA adapter in the system board.
2. It also supports EGA and CGA which are necessary for PC-SEAPAK.

* Matrox MVP-AT image board. Price: 5,495
Vendors: 1. Any Matrox dealer.
2. Matrox Electronic Systems.
Comments: 1. The cable to connect the board and the monitor must be bought separately.
2. Two cable lengths are available and are listed below.

* 4' PC-OCABLE-4 video output cable. Price: 65

Vendors: 1. Any Matrox dealer.
2. Matrox Electronic Systems.

Comments: 1. This cable is used to connect the MVP-AT board and the image display monitor.
2. The 10' PC-OCABLE-10 is another option.

o 10' PC-ICABLE-10 video input cable. Price: 100

Vendors: 1. Any Matrox dealer.
2. Matrox Electronic Systems.

Comments: 1. This cable is used to connect the video input device and the MVP-AT board.
2. This is not necessary for PC-SEAPAK applications.

Monitors

o Compaq VGA monitor. Price: 496

Vendor:Any Compaq computer dealer.

Comments: 1. For regular text and graphic display.
2. Size, 14"; resolution, 640x480.

! NEC Multisync 3D or 4D. Price: 665

Vendor:Any microcomputer dealer.

Comments: 1. For regular text and graphic display.
2. Size, 14"; resolution. 1024x768.

! Mitsubishi HA3905L9 ADK. Price: 2,000

Vendor:Mitsubishi Electronics America, Inc.

Comments: 1. Size, 20"; resolution, 1024x800.
2. For interlace and non-interlace mode image display.

External Storage

! Cipher M990 tape drive, controller card, utility package and software library. Price: 7,090

Vendor:1. Overland Data, Inc. (ODI)
2. Flagstaff Engineering, Inc.

Comments: 1. This is a 1/2" 9-track tape drive.
2. Cipher has a new model M995 tape drive to replace the old model M990.
3. Flagstaff Engineering, Inc. had sold the 9-track tape drive business to Overland Data, Inc.
4. Overland Data, Inc. sells its own controller card and software utility and library. ODI may carry over the Flagstaff Engineering, Inc.'s controller card and software for some time.

5. Only the Cipher M990 or M995 tape drive with the controller card and the software driver from Flagstaff Engineering, Inc. is supported in the PC-SEAPAK tape ingest programs. The ODI's controller card is not supported by the PC-SEAPAK tape ingest programs.
6. PC-SEAPAK supports disk ingest programs that allow the user to ingest data from disk if the data on the tape can be copied to the disk.
7. ODI has tape utility programs for its own controller that allow the user to copy the data from the tape to the disk.

! Storage and backup system:
Various DAT, 8mm, erasable optical disk systems are available.

Hard Copy

o HP LaserJet II. Price: 1,610
o Parallel interface cable. Price: 15
Vendor:Any Hewlett Packard dealer.
Comment: For high quality text output.

! HP PaintJet color printer. Price: 930
! Parallel interface cable. Price: 15
o Black pen cartridge. Price: 21
o Color pen cartridge. Price: 26
Vendor:Any Hewlett Packard dealer.
Comment: This printer will be supported as a hard copy device for images from PC-SEAPAK.

o Tektronix 4693RGB color screen printer. Price: 6,500
Vendor:Tektronix, Inc.
Comment: This can only handle non-interlaced inline RGB video signal.

o QMS ColorScript 100 Model 10 Price: 8,995
Vendor:QMS, Inc.
Comment: This can only handle postscript formatted file.

VAX-to-PC Communication

o 3Com thin-wire Ethernet controller
with T-connector (model Etherlink II, 3C503). Price: 289
Vendor: 3Com Corporation.

Software

! DESQview 386. Price: 180
! DESQview 2.3. Price: 130
! QEMM-386 5.1. Price: 60

Vendors: 1. Any computer dealer.
2. Quarterdeck Office System.

Comment: 1. DESQview 386 is the combination of DESQview and QEMM-386.
2. DESQview is a multitasking DOS operating environment.
3. QEMM is a memory management program that allows the user to load memory resident programs to the high memory and to emulate the expanded memory by using the extended memory.

! Compaq MS-DOS 3.31 to 5.0. Price: 90

Vendor: Any Compaq computer dealer.

Comment: 1. The PC-SEAPAK is developed under Compaq MS-DOS 3.31.
2. PC-SEAPAK had been tested running under DOS 4.1 and 5.0.

o Microsoft Fortran compiler. Price: 280
o Microsoft C compiler. Price: 280
* Microsoft mouse (serial version) Price: 120

Vendor: Any microcomputer dealer.

o NDP Fortran 386 compiler for DOS. Price: 495

Vendor: MicroWay, Inc.

Comments: 1. This compiler generates native 80386 32-bit object code that runs in protected mode under MS-DOS.
2. It can also generate code to use Weitek chip.
3. To use with Phar Lap's 386 development system, it can generate application programs which use the whole memory available on the system.

o Phar Lap's 386 development system. Price: 525

Vendor: Phar Lap Software, Inc.

Comments: 1. This development system includes the DOS-Extender and the 386|ASM/LINK.
2. This package is necessary to link and run all application programs developed under NDP Fortran-386 compiler.

o Imager-AT interpreter command and software library. Price: 1,000

Vendors: 1. Any Matrox dealer.
2. Matrox Electronic Systems.

o WordPerfect Version 5.1. Price: 180
Vendor:Any computer dealer.
Comment: All PC-SEAPAK documentation was prepared using WordPerfect 5.1.

Vendor Information

3COM Corporation.
Address: 3165 Kifer Road, Santa Clara, CA 95052
Tel.: (408) 562-6400 or (800) 638-3266

AST Research, Inc.
Address: 2121 Alton Avenue, Irvine, CA 92714
Tel.: (714) 863-1333

Cipher Data Products
Address: 9715 Business Park Ave., San Diego, CA 92131
Tel.: (619) 578-9100

Flagstaff Engineering, Inc.
Address: 1120 Kaibab Lane, Flagstaff, AZ 86001
Tel.: (602) 779-3341

Hewlett Packard
Address: P.O. Box 3640, Sunnyvale, CA 94088-3640
Tel.: (800) 538-8787

Matrox Electronic Systems Limited
Address: 1055 St. Regis Boulevard, Dorval, Quebec, Canada
Tel.: (514) 685-2630

Media Cybernetics
Address: 8484 Georgia Avenue, Silver Spring, MD 20910
Tel.: (301) 495-3305

MicroWay, Inc.
Address: Building #20, Cordage Park, Plymouth, MA 02360
Tel.: (508) 748-7341

Mitsubishi Electronics America, Inc.
Address: 110 New England Avenue, Piscataway, NJ 08854
Tel.: (201) 981-1414

Overland Data, Inc.
Address: 5600 Kearney Mesa, San Diego, CA 92111
Tel.: (619) 571-5555 or (800) 729-8725

Phar Lap Software, Inc.
Address: 60 Aberdeen Avenue, Cambridge, MA 02138
Tel.: (617) 661-1510

QMS, Inc.
Address: One Magnum Pass, Mobile, AL 36618
Tel.: (800) 523-2696

Quarterdeck Office Systems
Address: 150 Pico Boulevard, Santa Monica, CA 90405
Tel.: (213) 392-9851

Tektronix, Inc.
Address: Wilsonville Industrial Park, P.O. Box 1000
Wilsonville, OR 97070
Tel.: (503) 682-3411

APPENDIX II

HALO88 FONT STYLES

HALO88 fonts are provided along with PC-SEAPAK on a separate diskette through a licensing agreement with Media Cybernetics. The following table describing these font styles is from Media Cybernetics' manual for HALO88.

ABCDEFGHIJKLMNOPQRSTUVWXYZ1234567890
abcdefghijklmnopqrstuvwxyz!@#$%^&*()

HALO102

ABCDEFGHIJKLMNOPQRSTUVWXYZ1234567890
abcdefghijklmnopqrstuvwxyz!@#$%^&()*

HALO103

ABCDEFGHIJKLMNOPQRSTUVWXYZ1234567890
abcdefghijklmnopqrstuvwxyz!@#$%^&*()

HALO104

ABCDEFGHIJKLMNOPQRSTUVWXYZ1234567890
abcdefghijklmnopqrstuvwxyz!@#$%^&()*

HALO105

ABCDEFGHIJKLMNOPQRSTUVWXYZ1234567890
abcdefghijklmnopqrstuvwxyz!@#$%^&*()

HALO106

ABCDEFGHIJKLMNOPQRSTUVWXYZ1234567890
abcdefghijklmnopqrstuvwxyz!@#$%^&*()

HALO107

ΑΒΗΔΕΦΓΙΑΚΜΝΟΠΘΧΣΤΤ«ΩΞΨΖ1234567890
αβηδεφγχικλμνοπ∇ρστυωξψ(√√→←↑↓(∂()

HALO108

ABCDEFGHIJKLMNOPQRSTUVWXYZ1234567890
abcdefghijklmnopqrstuvwxyz!$%&*()

HALO205

ABCDEFGHIJKLMNOPQRSTUVWXYZ1234567890
abcdefghijklmnopqrstuvwxyz!$%&*()

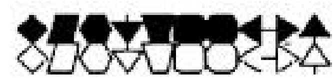
HALO206

ABCDEFGHIJKLMNOPQRSTUVWXYZ1234567890
abcdefghijklmnopqrstuvwxyz!$%&*()

HALO207

ABCDEFGHIJKLMNOPQRSTUVWXYZ1234567890
!$&()

HALO208



HALO250

HALO Font Styles

HALO001

HALO002

ABCDEFGHIJKLMNOPQRSTUVWXYZ1234567890
abcdefghijklmnopqrstuvwxyz!@#$%^&*()

HALO010

HALO011

HALO012

ABCDEFGHIJKLMNOPQRSTUVWXYZ1234567890
abcdefghijklmnopqrstuvwxyz!@#$%^&*()

HALO013

HALO109

HALO111

HALO115

ABCDEFGHIJKLMNOPQRSTUVWXYZ1234567890
abcdefghijklmnopqrstuvwxyz!$%&*()

HALO201

ABCDEFGHIJKLMNOPQRSTUVWXYZ1234567890
abcdefghijklmnopqrstuvwxyz!$%&*()

HALO202

ABCDEFGHIJKLMNOPQRSTUVWXYZ1234567890
abcdefghijklmnopqrstuvwxyz!$%&*()

HALO203

ABCDEFGHIJKLMNOPQRSTUVWXYZ1234567890
abcdefghijklmnopqrstuvwxyz!$%&*()

HALO204

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13. ABSTRACT *(Maximum 200 words)*

PC-SEAPAK is designed to provide a complete and affordable capability for processing and analysis of NOAA Advanced Very High Resolution Radiometer (AVHRR) and Nimbus-7 Coastal Zone Color Scanner (CZCS) data. Since the release of version 3.0 over a year ago, significant revisions have been made to the AVHRR and CZCS programs and to the statistical data analysis module, and a number of new programs have been added. This new version has 114 procedures listed in its menus. The package continues to emphasize user-friendliness and interactive data analysis. Additionally, because the scientific goals of the ocean color research being conducted have shifted to larger space and time scales, batch processing capabilities have been enhanced, thus allowing large quantities of data to be easily ingested and analyzed. The development of PC-SEAPAK has been paralled by two other activities that have been influential and assistive: the global CZCS processing effort at GSFC and the continued development of VAX-SEAPAK. SEAPAK incorporates the instrument calibration and supports all levels of data available from the CZCS archive.

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