EARTH SYSTEM MONITOR

CD-ROM brings environmental data archives to the desktop

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In the 1990s CD-ROM has become the preferred data distribution medium in use at the NOAA national data centers. Data managers and data users alike benefit from the combination of large data volume, small size, long expected lifetime, and low cost provided by CD-ROM.

Some individuals and organizations view CD-ROM as a special system or consider it equivalent to a printed publication. Basically, however, CD-ROM is just a data storage and data distribution medium. As personal computing evolved in the office and home, CD-ROM was developed to deliver large amounts of data easily and inexpensively to the desktop. To meet user demand for ever larger data volumes and for instant access to data, the search continues for better data delivery systems.

Wide area networks—such as today's Internet and the developing National Research and Education Network (NREN)—continue to increase the speed and ease with which large volumes of data can be accessed online. Cable TV companies are rapidly stringing fiber optic lines and may also get into the data distribution business. As online access becomes the dominant data distribution method of the future, the demand for data on disc delivered via the mail is likely to wane.

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But for now CD-ROM is the medium of choice for convenient desktop data storage and efficient data distribution. Using CD-ROM technology, the NOAA national data centers are making their vast environmental data holdings more easily accessible than ever before.

CD-ROM Basics

The current generation of CD-ROMs can hold up to 680 megabytes of data. CD-ROM drives have access speeds ranging from 180 to 600 milliseconds and data transfer rates ranging from 150 to 600 kilobytes per second. A typical price for a CD-ROM drive is $400 but may range from $200 to $1500 depending on performance and special features. The performance of the drives has been improving, but the access speeds and transfer rates do not approach the speeds of magnetic disk drives. Blue laser technology (which is available today) makes it possible to quadruple the capacity of a CD-ROM, but the disc will not be in a standard format.

The ISO (International Standards Organization) 9660 standard adopted for CD-ROMs enables them to be read on different computer systems and drives from many different vendors. This standard format is one of the main advantages of CD-ROMs and largely accounts for their rapid proliferation and widespread use. Data written to disk according to the specifications of the ISO 9660 format can be read by all of the widely used computer systems (IBM compatible PCs, Macintoshes, and UNIX workstations).

Extensions to the ISO 9660 format support either the Macintosh HFS file structure or UNIX file systems with long file names and access privileges. A straight Macintosh HFS CD-ROM can be read only on a Mac. A hybrid HFS/ISO 9660 disc will appear as an HFS disc to a Mac but will look like a normal ISO disc on other platforms with straight ISO 9660 drivers. Similarly, a disc in the Rock Ridge format is a UNIX/ISO 9660 hybrid that provides full UNIX functionality when read with Rock Ridge drivers but that looks like a standard ISO disc when accessed with ISO 9660 drivers. Although file names and
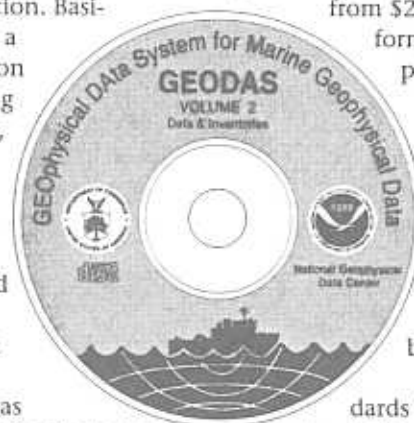
NOAA Earth System Data Directory installed on workstation for improved services

To provide improved access and enhanced service to users, the NOAA Earth System Data Directory (NOAADIR) has been installed on a Sun SPARC-10 workstation at NOAA's Earth System Data and Information Management (ESDIM) office. WAIS, the Wide Area Information Server, is installed on the workstation to provide Internet users with access to a full text version of the NOAA Directory, as well as the National Environmental Data Referral Service (NEDRES), and the NOAA Product Information Catalog.

The NOAA Earth System Data Directory provides a key to both managing and accessing global change data in NOAA. The Directory is being used to document NOAA data sets and data systems that support global change and other earth science studies. Users can access the Directory at no cost through national telecommunication systems such as Internet or through dial-in tele-phone lines including an 800 number.

The NOAA Directory is one of the directories in the Global Change Master Directory System. This national and international system of directories uses the Directory Interchange Format (DIF) for the exchange of data descriptions between directories. The international Committee on Earth Observation Satellites sponsors the International Directory Network (IDN) that has three Coordinating Nodes: (1) the NASA Master Directory; (2) the European Space Agency Directory in Frascati, Italy; and (3) the Japanese Directory at the National Space Development Agency.

All NOAA data descriptions entered into the NOAA Directory are transferred to the Global Change Master Directory maintained at the NASA Goddard Space Flight Center, Greenbelt, Maryland. Through interconnections to the three IDN Coordinating Nodes, NOAA Directory users can access worldwide data directory information.

The NOAA Directory continues to grow and now contains descriptions of over 1,400 NOAA data sets. Recent additions include about 350 descriptions of foreign meteorological data reports in the collections of the NOAA Central Library, Rockville, Maryland.

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Access to worldwide data directory information

NOAA EARTH SYSTEM DATA DIRECTORY

The NOAA Directory is a tool for locating NOAA data sets. You can access the Directory using your PC.

Terminal settings:
Full duplex, 8 bits, no parity, one stop bit, 1200 baud
Terminal type: VT-100 (preferred)

Via Internet
At the $ prompt, enter: TELNET ESDIM1.NODC.NOAA.GOV
At the prompt USERNAME:, enter: NOAADIR

Via direct dial (1200 baud):
In the Washington, D.C. area
and outside the United States, dial: 202-606-4665, 202-606-4666, or
                              202-234-7123, -7143, or -7033
In other areas of the United States, dial: 1-800-722-5511
At the prompt XT_COMMAND, enter: C ESDIM1
(If you do not see the XT_COMMAND prompt, enter the break key several times until it appears.)
At the prompt LOGIN:, enter: NOAADIR

When you end the session, enter the BREAK key.
At the XT_COMMAND, enter: DIS
This disconnects the link to the Sun workstation, and you can hang up.

A system of menus and prompts guides users through each search session. HELP is available at any point in a session, or call Gerry Barton at 202-606-5012.

Oceanographic data archaeology project endorsed by IOC

The Global Oceanographic Data Archaeology and Rescue (GODAR) Project was endorsed by the Intergovernmental Oceanographic Commission (IOC) at the 17th Session of the IOC Assembly held in Paris, February 25-March 11, 1993. The proposal for this project was initiated at the U.S. National Oceanographic Data Center (NODC) and already approved by the IOC'S Committee on International Oceanographic Data and Information Exchange (see Earth System Monitor, March 1993). Sydney Levitus, Chief of the NODC Product Development Branch and Director of the World Data Center A, Oceanography, has been designated as the GODAR project leader.

Global Change education diskette package demonstrated

The NOAA Office of Educational Affairs recently demonstrated the Pilot (Diskette) Project for Africa from the National Geophysical Data Center (NGDC) during a teacher workshop on March 25, 1993 in Everett, Washington. The annual workshop, hosted by the Snohomish County Public Utility District, presented displays from over a dozen state, local, and Federal environmental and earth resource agencies. The diskette package contains over 41 megabytes (compressed) of environmental data for Africa in IBM compatible format.

The Pilot (Diskette) Project for Africa was produced by the World Data Center-A for Solid Earth Geophysics operated by NGDC in Boulder, Colorado in collaboration with Clark University in Worcester, Massachusetts. The project stemmed from an action plan approved by the International Geosphere-Biosphere Program (IGBP) Scientific Advisory Committee in 1988. The plan called for assembly of monthly vegetation index and other thematic data for the continent of Africa on floppy disk. The Pilot Project uses NGDC's Global Change Data Base to form a scientific database compatible with an existing geographic information system (e.g., IDRISI) to provide a complete analytical package for experimentation and educational use.

The recent teacher workshop provided an opportunity to demonstrate this real-world application of scientific data and means to integrate new technology in the classroom. Uses beyond traditional

News briefs

math and science applications were envisioned by educators seeking to enhance and expand curriculum material. Approximately 200 primary and secondary teachers attended the one-day workshop.

NOAA annual climate assessment for 1992 issued

NOAA's Climate Analysis Center has published Climate Assessment, 1992, the fourth such annual report. The 90-page report presents a summary of recent observations of the global climate system and an early assessment and interpretation of major climate anomalies for 1992. Chapters of the report cover the El Niño/Southern Oscillation, atmospheric circulation, temperature, aerosols, trace gases, precipitation, and the cryosphere. Major surface climate anomalies of 1992 are also described. Copies of the Fourth Annual Climate Assessment, 1992 are available from: Director, Climate Analysis Center, NOAA/NWS W/NMC5, World Weather Building, Room 800, Washington, DC 20233. Telephone: 301-763-8167.

EOSDIS User Services Working Group meets in Boulder, Colorado

The Fourth Meeting of the EOSDIS User Services Working Group (USWG) was held in Boulder, Colorado, May 4-6, 1993, jointly hosted by the National Snow and Ice Data Center and the National Geophysical Data Center. The meeting was held to continue the process of planning and implementing user services aspects of the NASA Earth Observing Satellite Data and Information System (EOSDIS).

In conjunction with the meeting, personnel from the National Center for Supercomputing Applications of the University of Illinois conducted a one-day training session on HDF (Hierarchical Data Format) on Monday, May 3. A multi-object file format that facilitates transfer of graphical and floating-point data between different computer platforms and operating systems, HDF has been proposed as the standard format for EOS Version 0 products. It is also being evaluated for other uses in NOAA and NASA data management system.

EOSDIS data services will be provided through a distributed system composed of a group of (primarily NASA) facilities that

will serve as Distributed Active Archive Centers (DAACs), plus several Affiliated Data Centers (ADCs) that will provide ancillary data management support. Each of the DAACs provides data management for specific discipline areas or functions, for example, the Jet Propulsion Laboratory is the DAAC for physical oceanography and the NASA Langley Research Center will serve as the DAAC for radiation budget, clouds, aerosols, and tropospheric chemistry. The first day of the meeting was devoted to reports from the various participating facilities on their roles in providing user services through EOSDIS. The remainder of the meeting focused on development of an implementation plan, a long-range plan, and the status of various individual projects.

Following the conclusion of the EOSDIS User Services Working Group Meeting, representatives from the NOAA national data centers took this opportunity to meet for half a day to exchange information about activities at their centers and to discuss ways of improving access to NOAA environmental data.

Three Indian Ocean sea level stations receive satellite link

The University of Hawaii Sea Level Center has installed satellite transmitting equipment at three additional sea level stations in the Indian Ocean. The stations are located in the Seychelles and on Zanzibar and Rodrigues. Together with the existing stations at Port Louis in Mauritius, Mina Raysut in Oman, and Gan in the Maldives, this effort brings the total number of satellite transmitting stations in the Indian Ocean to six.

Upgrading of these stations was made possible by the generous help of local authorities. In the Seychelles the station was completely rebuilt with the assistance of the Department of Meteorology of the Directorate of Civil Aviation. The station is on Mahe near the airport at Point La Rue. In Zanzibar the Commission for Lands and Environment allowed an upgrading of their recently installed tide station. The station at Port Mathurin on the Island of Rodrigues is the second satellite transmitting station in Mauritius and is operated in cooperation with the Meteorological Service of Mauritius.

The University of Hawaii Sea Level Center is supported by NOAA's National Ocean Service and Climate and Global Change Program.

The TAO Workstation Software

Displaying real-time data from the TOGA-TAO Array

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The TAO Array is a major compo-
nent of the TOGA (Tropical Ocean-
Global Atmosphere) ocean observation
program. The TAO array consists of AT-
LAS wind and thermistor chain moor-

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ings and current meter moorings span-
ning the Pacific Basin from 95°W in the
eastern Pacific to 130°E in the western
Pacific (Figure 1).

TOGA-TAO has a multinational
base of support, which presently in-
volves cooperation between the United
States, France, Japan, Korea, and Tai-
wan. The completed TAO array will con-
sist of approximately 70 ATLAS and
current meter buoys, transmitting data
to a shore-based computer via the Argos
satellite system. The TAO array allows,
for the first time, observationally coher-
ent basin-wide fields of wind and upper

ocean thermal structure to be con-
structed in real-time for assimilation
into numerical models and for diagnos-
tic studies.

The TAO Project Office, located at
NOAA's Pacific Marine Environmental
Laboratory (PMEL) in Seattle, Washing-
ton, has developed an interactive sys-
tem to display real-time data from the
TOGA-TAO array of buoys in a modern,
point-and-click workstation environ-
ment. Automated procedures provide
the newly updated data files to remote
users via the Internet network. The dis-
play software, the real-time data sets,
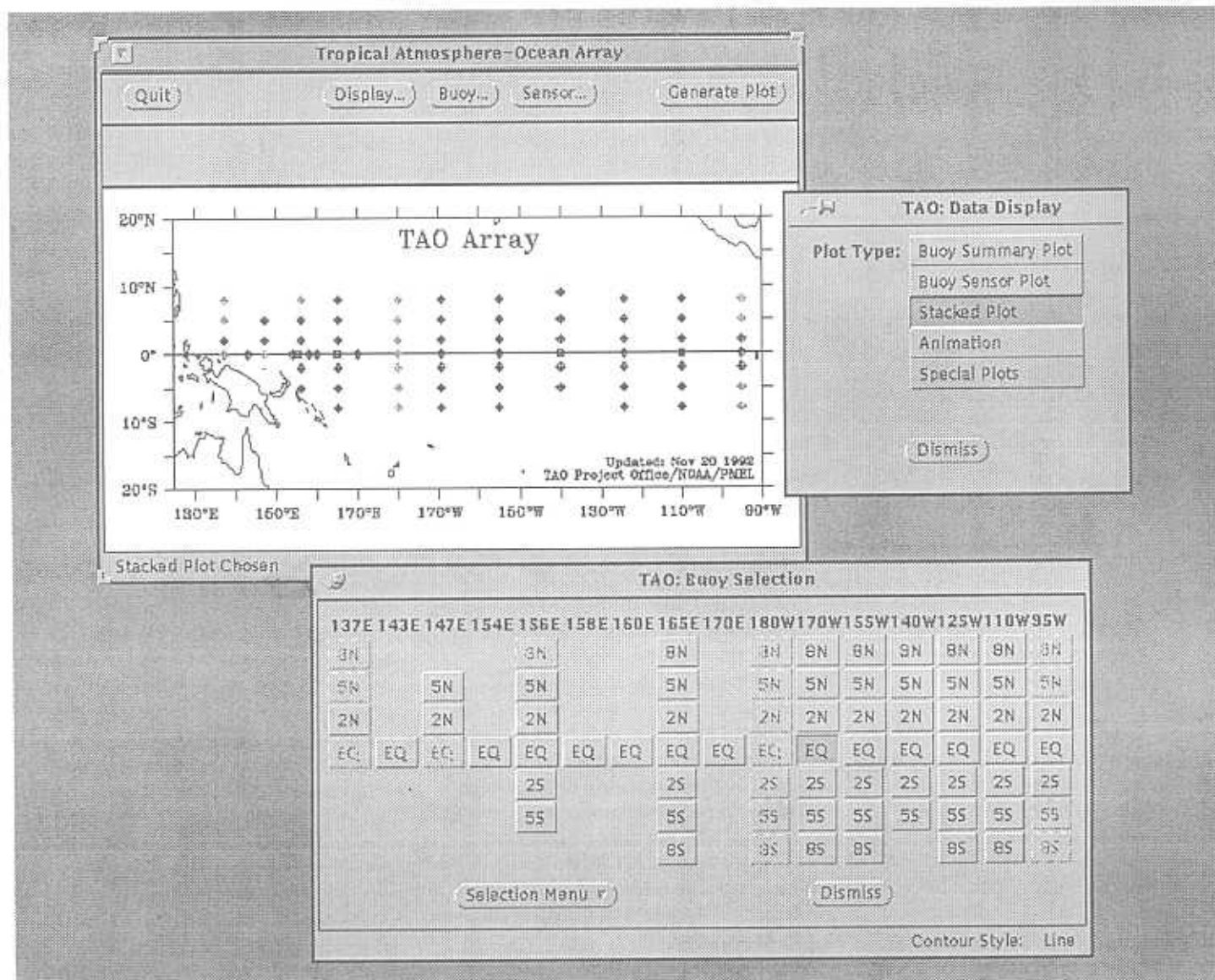
▲ Figure 1. TAO software display option and buoy select menus.
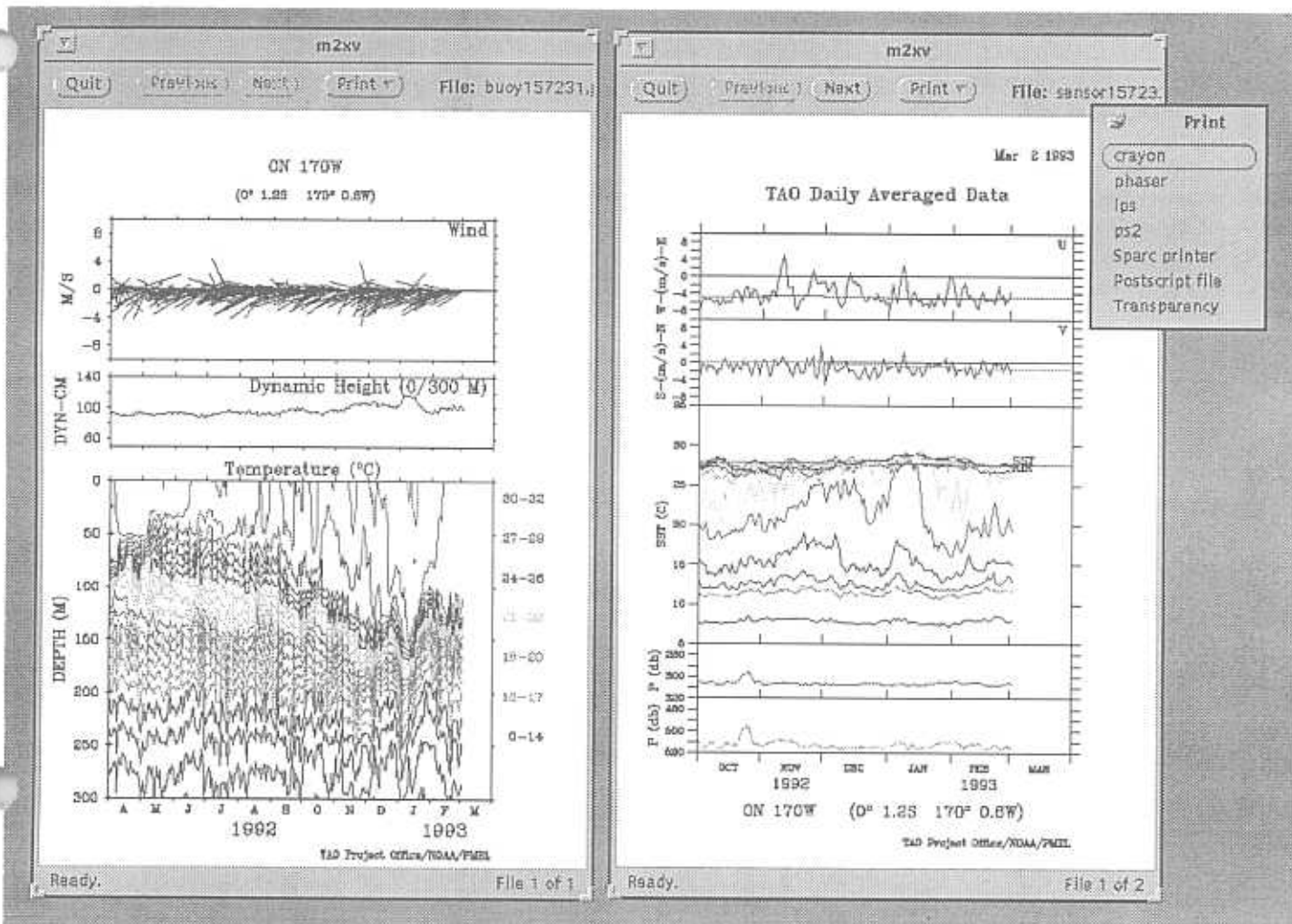
▲ **Figure 2.** TAO buoy summary and buoy sensor plots.

animations and other graphics products are provided on the Internet network, and are in use at many oceanographic and meteorological institutions, nationally and internationally.

TAO workstation display software

The TAO Display Software system addresses the need of the research scientist for easy access to the data sets from the TOGA-TAO array and convenient procedures for display, comparison, and analysis. The software provides users with interactive access to the most recently acquired, real-time TAO buoy data. The user selects buoys and display options in a point-and-click environment on a UNIX workstation or an X Window terminal (Figure 1).

The TAO array map, in the main window, shows deployed ATLAS buoys as dark triangles, deployed equatorial current meters as dark squares, and ATLAS buoys which will be deployed in

the future are shown as light gray triangles. The display and buoy selection menus are shown on the screen image copy in Figure 1. The user selects display type, desired buoys and sensors by clicking in the displayed menus. The plot is displayed when the user clicks on the "Generate Plot" button.

Data display choices include a buoy summary plot with wind sticks, calculated dynamic heights and temperature isotherms, a buoy sensor plot with plots of the measurement from each sensor on the buoy (Figure 2), and a stack plot with which the user may select combinations of buoys and sensors for display as a vertical stack of time series plots. TAO data displayed was received from the Argos satellite system and processed at PMEL during the previous night. The TAO data displays provide the scientist with quick and easy access to the buoy data, and they also serve as a useful diagnostic tool for monitoring buoy sen-

sor performance characteristics.

Displays include animations of the data fields measured by buoys as well as those generated by real-time operational analysis models at the NOAA National Meteorological Center (NMC). Comparisons of these fields are also animated. Animations include surface winds and sea surface temperature (SST), 20-degree isotherm depth, calculated dynamic heights (surface referenced to 300 m), and upper ocean heat content, as well as anomaly fields, calculated from the observed buoy data and from the NOAA/NMC model.

Upper ocean (0-300 m) heat storage, calculated from the TAO buoy data and the NMC model, is also animated. A single frame from this animation is shown in Figure 3, where the top panel shows two time series (points every two weeks), the model, and the data. These time series are the areal averaged upper
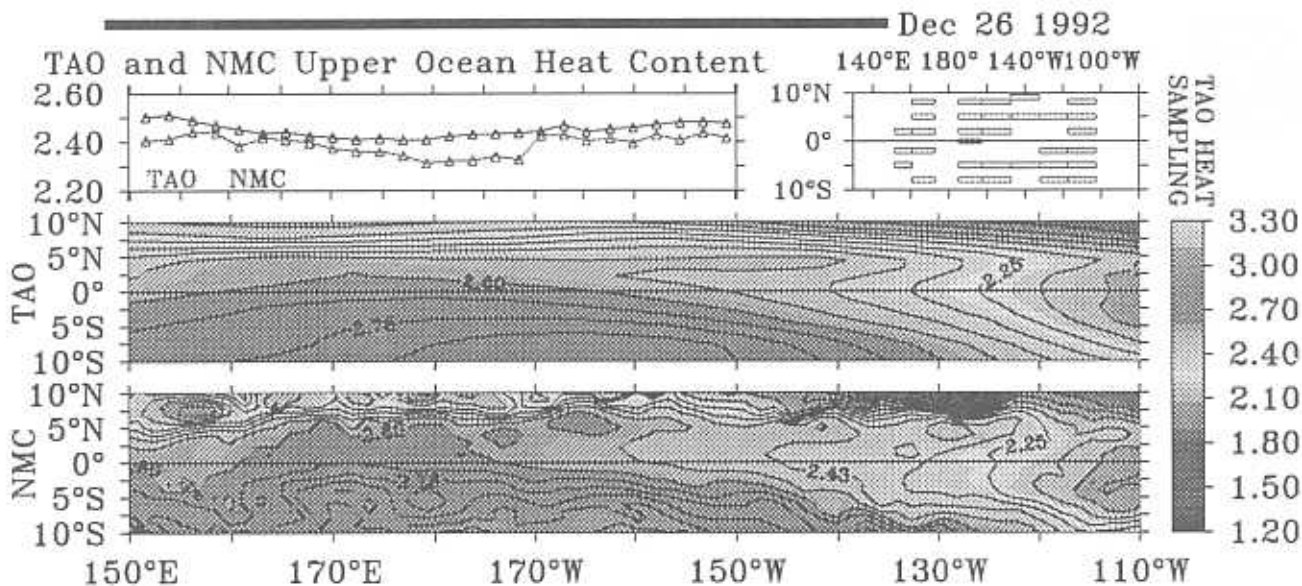
▲ **Figure 3.** Animation frame showing upper ocean heat content (0-300 m) from the observed and NMC model data.

TAO workstation software, from page 5

ocean heat content in the band 10°N to 10°S and the depth 0-300 m. The stopping point of these time series indicates the time at which the x-y heat storage shown in the lower panel was computed. The little diagram in the right hand corner indicates which buoys were present in the given 2 week period where the x-y distribution is plotted.

Time-longitude plots are available for SST, dynamic height, upper-ocean heat content, depth of the 20-degree isotherm depth, zonal and meridional winds, and anomaly fields of these variables. Figure 4 is a time-longitude diagram of monthly mean SST and SST anomalies measured by the TAO buoys. Anomalies are calculated with respect to the NMC COADS/Ice SST climatology. A user can obtain a paper or transparency

of any of these plots with a single mouse-click.

Future releases of the software will include access to the historical TAO data sets. We plan to incorporate gridding algorithms—and gridded TAO data fields—to provide increased user control of the graphics displays and to include computational and analysis functions. We also plan to provide access to data
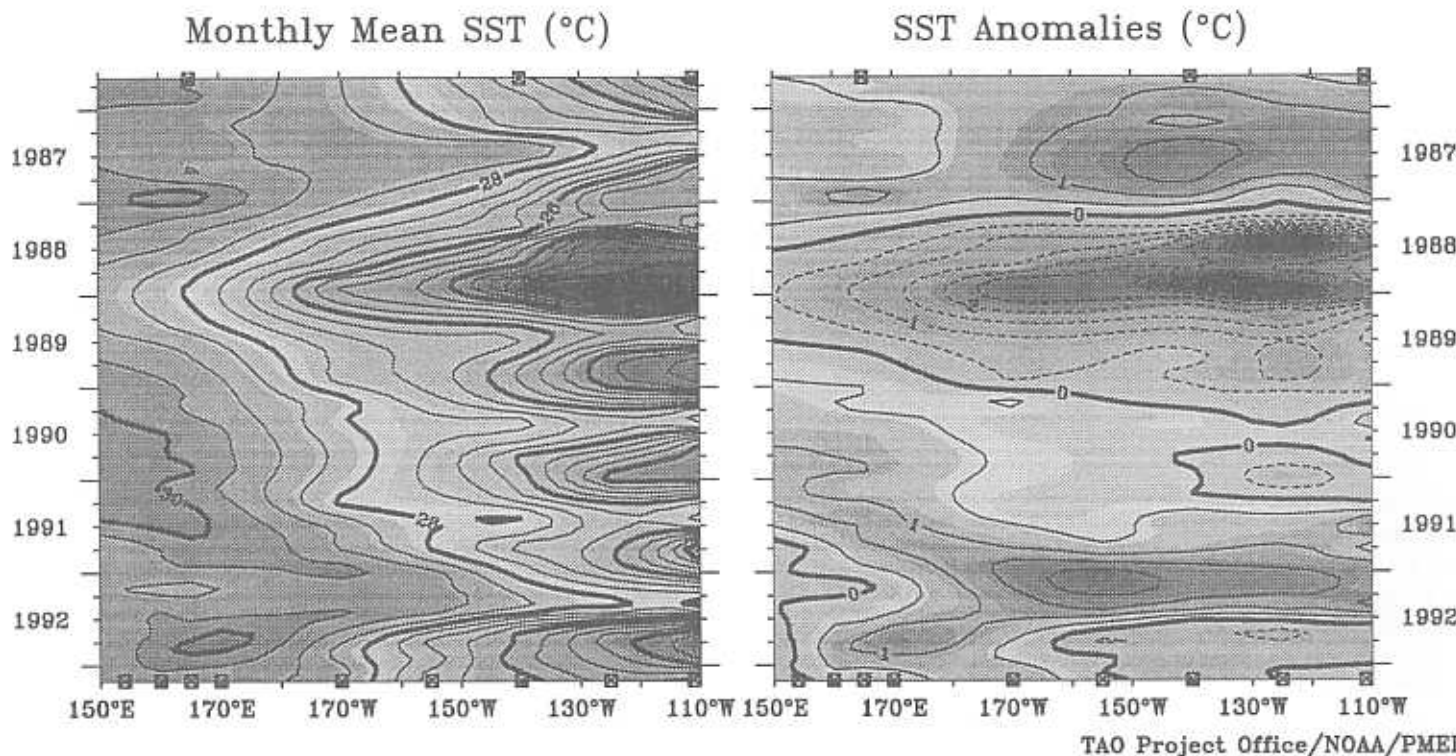
▲ **Figure 4.** TAO monthly mean SST and SST anomalies.

NEONS: A database management system for environmental data

This Navy-developed system finds wide application

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The Naval Research Laboratory (NRL) in Monterey, California, has developed a powerful database management system for environmental data called the Naval Environmental Operational Nowcasting System (NEONS). The system was developed to manage the three basic types of environmental data: observations, images, and gridded data. NRL uses NEONS to support research and development programs such as the development of satellite data processing software. A typical application of the system at NRL is the development of "virtual sensor" information based on combinations of satellite data from several different satellites to emulate observations from a single satellite. It is the design of NEONS, however, and not the NRL applications that makes this system of interest to others including NOAA facilities.

Unlike most data management systems, which are developed for a specific application, NEONS was developed to be very flexible and versatile. As a result other institutions have found the system to be useful. Through the Navy's Technology Transfer program, NRL has been very cooperative in making the software available.

Recently the Navy announced that NEONS will be used for operational database management on Cray supercomputers at the Fleet Numerical Oceanography Center (FNOC) in Monterey and the Naval Oceanographic Office at Stennis Space Center, Mississippi. Within NOAA the NEONS software was first installed at the Ocean Applications Branch (OAB) of the National Ocean Service. OAB was established in Monterey to support Navy/NOAA cooperative programs and NEONS is being used to support civilian

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distribution of FNOC data, analyses and forecasts via the Navy/NOAA Oceanographic Data Distribution System (NODDS). OAB later contacted other NOAA offices to make them aware of the availability of NEONS and to promote sharing of software and data resources between Navy and NOAA.

In late 1991 OAB arranged for the installation of NEONS at the National Climatic Data Center (NCDC) in Asheville, North Carolina for support of the Global Climate Perspectives System (GCPS). Other participants in GCPS are the NOAA Climate Monitoring and Diagnostics Laboratory (CMDL) in Boulder, Colorado and the Climate Analysis Center (CAC) in Washington, D.C. In February 1992 OAB helped install NEONS at CMDL and in August 1992 at CAC. In December 1992 there was a second installation in Boulder at the Forecast Systems Laboratory where NEONS will be used in the MADER (Management of Atmospheric Data for

Table 1. Data being loaded into NEONS databases by major NEONS users

U.S. Navy/NRL	FNOC gridded fields, DMSP satellite data.
Mississippi State University/ Center for Air Sea Technology	Ocean research model data.
U.S. Navy/FNOC	Real-time global weather and ocean analyses and forecasts.
U.S. Navy/NavOceanO	North Atlantic and global ocean data and products; MOODS global profiles of subsurface temperature and salinity.
NOAA/NOS/OAB	FNOC weather and ocean analyses and forecasts for the past 30 days.
NOAA/NESDIS/NCDC	Global Historical Climatological Network (GHCN) data set (monthly global surface temperature, precipitation, and station and sea level pressure); Global Precipitation (GCPC) data set; Cooperative Summary of the Day (TD3200) (daily maximum and minimum air temperatures, precipitation, snow fall and snow depth); the Comprehensive Aerological Reference Data Set (CARDS); and metadata (station histories) from the STORM wind profiler program.
NOAA/OAR/CMDL	Gridded climate data, Comprehensive Ocean Atmosphere Data Set (COADS) data.
NOAA/NWS/CAC	Global climate data and outlooks.
Atmospheric Environmental Service (Canada)	Canadian weather observations and products.
Bureau of Meteorology (Australia)	Australian and Southern Hemisphere weather observations and products.
International Center for Scientific Culture (Switzerland)	European Center for Medium-range Weather Forecasts global products; high resolution wind models for the Mediterranean region; coastal circulation models; and simulations of hazards such as flooding and the Chernobyl radioactive fallout.

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Evaluation and Research) project. In addition to installations in the Navy and in NOAA, the system has been provided to other organizations including the Canadian Atmospheric and Environmental Services in Toronto and Vancouver, the Bureau of Meteorology in Melbourne, Australia, the South Dakota School of Mines and Technology, Woods Hole Oceanographic Institution, and Cray Research, Inc. Table 1 lists some of the major facilities using NEONS and the types of data being loaded into NEONS databases.

NEONS technical design

NRL designed NEONS for fast, efficient operation and compatibility with computer industry and international data exchange standards. NEONS uses the two binary formats being adopted by the World Meteorological Organization (WMO) for global exchange of real-time weather data: Binary Universal Format for data Representation (BUFR) for observations and GRIB for GRIdded Binary numerical fields. The system is built around a commercial database management system (Empress from Empress Software, Inc.) and operates on a variety of computers from UNIX workstations to Cray supercomputers. Computer industry standards used in the design of NEONS include UNIX and SQL.

NEONS stores data in variable length binary strings. This is important because environmental data comes in a variety of record lengths. Another important advantage of the way in which NEONS stores data is that the data are addressed only to a minimal level of information. This is in contrast to many other database systems that address data deeply, down to the report or even data value level.

The approach used by NEONS greatly speeds up searches compared to other systems that are often burdened with high system overhead and frequent disk accesses. The third advantage of the NEONS approach is that by using binary compaction, the system takes advantage of the great CPU speed of the new RISC computers while at the same time minimizing I/O time, which is the critical limiting factor in modern database management systems.

A NEONS network

With the expanding use of NEONS within the Navy, in NOAA, and in other countries such as Canada and Australia, NRL and OAB have promoted the concept of a distributed network of NEON systems to facilitate the global exchange of weather and ocean data. In this concept, each office would continue to load and process its own data and in addition, would make the data easily available to others over Internet. Users can browse files and download data of interest over Internet.

NRL is developing an X Windows Data Browser to interactively browse files on NEON systems, search for particular data sets, and download data of interest. Using the browser, a user can specify the time and area where he wishes information. The browser then searches the database, either locally or remotely over Internet, to find satellite images, gridded model outputs, or observations that fall in the desired time/space window. The user then interacts with the database to narrow the search to the actual data required.

The data can be downloaded in any of a wide variety of formats, as formatted by a flexible format package, FreeForm, developed by the National Geophysical Data Center. The potential for such a network can be demonstrated by considering the gigabytes of climate data now being loaded by NCDC into their NEONS. Early this year Thomas Karl, Senior Scientist at NCDC, described their work with NEONS as follows: "NEONS is up and running. Sequences and parameters have been defined for the Global Historical Climatological Network (GHCN) data set (monthly global surface temperature, precipitation, and station and sea level pressure), Global Precipitation (GCPC) dataset, Cooperative Summary of the Day (TD3200) (daily max and min temps, precipitation, snow fall and snow depth), and CARDS. We are presently working on tying in the system with the Metadata portion of the STORM system (also an Empress database system) to link the data to the station histories. We are also discussing with INO the strong possibility of working with them on the development of an interactive interface between NEONS and NCAR Graphics for Lat/Lon/Time

data) a system like the one they have developed for gridded data."

To promote the idea of a network of NEON systems, OAB started an Omnet bulletin board for NEONS users and, in cooperation with NRL and FNOC, hosted NEONS Users Conferences in April 1992 and April 1993.

Summary

The Navy, through the Naval Space Warfare Systems Command, has invested over \$4 million in the NEONS program. By using NEONS for appropriate applications, NOAA offices can take advantage of this investment. Offices that want further information about NEONS or that would like to install the system should write to: Ocean Applications Branch, NOAA/NOS, 2560 Garden Road, Monterey, CA 93940. ∎

TAO workstation software, from page 6

from the TOGA drifting buoys, the TOPEX/POSEIDON satellite, and the ERS-I satellite.

Obtaining the TAO display software, data, and animation files

The TAO Display Software, the TAO data, and all graphics products are available on Internet. Automated procedures provide the newly updated data files to remote users via the Internet network, so that all users have access to data from the previous night's acquisition from the Argos satellite.

The TAO software was developed for Sun SPARC workstations, but it is compatible with any UNIX workstation. The displays can be made on a color workstation, X Windows terminal, or a Macintosh or PC with an X Windows package installed. To obtain the TAO Display Software, or to obtain more information about the TAO Display Software, please contact: Nancy Soreide, TAO Project Office, NOAA/PMEL/OCRD, 7600 Sand Point Way, NE, Seattle, WA 98115. Telephone: 206-526-6728, Fax: 206-526-6774, Omnet: TAO.PMEL, Internet: nns@noaapmel.gov or taogroup@noaapmel.gov.

Development of the TAO software is supported by the Climate and Global Change, TOGA, and EPOCS programs. ∎

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accesses on a standard ISO 9660 disc may not have all the features provided by UNIX or Macintosh systems, this format is highly recommended because it provides cross-platform compatibility.

After a data set is formatted in the ISO 9660 standard (premastered), it can be provided on a magnetic medium such as Exabyte tape or on a writeable CD-ROM to a duplicating plant for mastering and production of replicate copies. Commercial vendors offer this service and can provide finished CD-ROMs in just a few weeks. Even for small runs of only several hundred discs, replication of CD-ROMs, including labeling and packaging, costs only about $4 to $5 per disc.

Write Once CD-ROMs

With a Write Once CD-ROM (WO CD-ROM) recorder, one or a few copies of a CD-ROM can be produced quickly without the time and expense involved with external mastering and replication of many copies. As recently as two years ago, the hardware, software, and media for this process were relatively expensive. Since then prices of all three of these components have dropped. They should continue to drop as more vendors enter the market and the demand grows for WO CD-ROMs (also known as "one-off" CDs).

WO CD-ROM systems from major vendors such as Sony, JVC, Phillips, and Kodak are currently priced from $8000 to $15,000 for both the recorder and ISO 9660 formatting software. Pinnacle Micro has recently introduced a WO CD-ROM recorder with software for $4000, and Ricoh and Yamaha are rumored to be releasing systems in the $2000 price range. To create an operational system, a CD-ROM recorder must be connected to a PC, UNIX workstation, or Macintosh with at least a gigabyte of magnetic disk storage.

These systems can write a CD in the standard audio disc play time of about 74 minutes, or at double speed (37 minutes). Newer systems may be able to record at quadruple speed. It typically takes several hours, however, to transfer data from tape, disk, or across a network to the WO system and to reorganize them before the relatively quick writing

process can take place.

In the past year the price of blank Write Once CD-ROMs dropped from $45 to $19. Because the same blank discs are used to write Photo-CDs and standard data CD-ROMs, if the Kodak Photo-CD catches on with the general public, the price should drop even more.

CD-ROM at NGDC

The first NOAA CD-ROMs were produced at the National Geophysical Data Center (NGDC) in 1988. Largely because of CD-ROM, the total volume of digital data distributed by NGDC has increased by more than an order of magnitude over the past 4 years. At the same time, the number of magnetic tapes distributed has steadily decreased.

Table 1. Selected CD-ROMs available from NOAA'S national data centers

National Geophysical Data Center
- Solar Variability Affecting Earth
- Ocean Drilling Program
- Aeromagnetics: Earth System Data
- Gravity: Earth System Data
- Global Ecosystems Data Base
- GOES Space Environment Monitor
- Marine Geophysical Data
- Geophysics of North America
- Marine Minerals
- Global Vegetation Index Data

National Climatic Data Center
- International Station Meteorological Climate Summary
- Marine Climatic Atlas
- Upper Air Climatic Atlas
- Historical Climate Data and Information
- Hourly Meteorological and Solar Data
- Northern Hemispheric Upper Air Observations

National Oceanographic Data Center
- Global Ocean Temperature and Salinity Profiles
- Geosat Altimeter Data (T2 GDRs) from the Exact Repeat Mission
- Geosat Altimeter Crossover Differences from the Geodetic Mission
- Geosat Altimeter Data from the Geodetic Mission, 30°S-72°S
- Oceanographic Station Profile Time Series

Rapid acceptance of CD-ROM has been the common experience of all three NOAA national data centers, which now offer users a growing list of environmental data products on CD-ROM (Table 1).

At NGDC some CD-ROMs have been distributed with NGDC developed software for data access, display, and analysis. Others have been distributed with commercial software or a combination of commercial and in-house software. Still other CD-ROMs are distributed without any software at all. Initially NGDC developed unique software, packaging, and handling for each CD-ROM product. Now the center is moving towards a more standard method of distribution. A general software package that can access and display different data types is being developed.

NGDC currently distributes about 20 sets of mass replicated CD-ROMs. Data on these discs span the range of disciplines at the center and also include data from outside agencies. Data from other NOAA elements, from other U.S. government agencies, and from universities have all been incorporated on CD-ROMs produced by NGDC. Development of these products has been funded by many sources both within NOAA and from outside agencies.

Some NGDC CD-ROMs contain single types of data, but most contain multiple integrated data sets and software. Unlike a sequential access medium such as magnetic tape, CD-ROM provides both large data volume and random data access. This feature—and the expectations and demands of personal computer users—has promoted CD-ROM data products with integrated data sets and data access software.

Developing data access and display software that can do everything for everybody and run on any computer is very labor intensive, time consuming, and expensive. For some of the NGDC CD-ROMs, the only software ever used with the data is the NGDC software provided. In many cases though, scientists want to input the data into their software for display and analysis and are interested in NGDC software only for easy retrieval of the correct files.

NGDC has been using an in-house Write-Once CD-ROM system for almost two years. This system adds versatility

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to our operations and allows us to provide more customized data services. About 500 single copy CDs have been written for a variety of purposes. They are used to deliver data to the commercial replicating companies, quality control data before duplicating, test access and display software, test new concepts for data products, provide desktop data base management, reorganize data sets, and fill individual customer data requests. This last task is the fastest growing use for WO CD-ROMs at NGDC and again demonstrates the role of CD-ROM as a successor to magnetic tape as a data distribution medium.

CD-ROM at NCDC

The National Climatic Data Center (NCDC) produced its first CD-ROM in 1990 as a cooperative effort among all the climate agencies based in Asheville, North Carolina. This initial disc—with data equivalent to a 70-foot stack of paper weighing 1.5 tons—contains detailed climatological summaries for 640 global sites and less detailed summaries for 5000 other sites. Approximately 500 additional detailed summaries are added to each annual update, with the intent to cover the entire globe by the mid-1990s. Given its immediate success, development of additional CD-ROMs was funded either as NOAA initiatives or as joint efforts with other NOAA offices, Department of Defense organizations, or other government agencies.

NCDC has traditionally provided climatological data and products in both paper and digital form. Over 80,000 customer requests are currently handled each year. CD-ROM is a convenient, inexpensive medium for providing customers with access to very large data volumes or varied multi-parameter climate analyses. In 1992 an estimated 2 terabytes of climate data were distributed by NCDC on CD-ROM.

All NCDC CD-ROMs are self-contained with the requisite software and

help documentation included on the disc. They are developed to be as user-friendly as possible. Through an object-oriented methodology, a suite of modules for access and display of both data and data analyses has been created. Since many of NCDC's CD-ROMs are designed to replace existing paper atlases, these CD-ROMs include modules for displaying, contouring, printing, and exporting data analysis products. Global CD-ROM atlases for the marine and upper air environments are already available. A global tropical/extratropical atlas will be available by mid-summer 1993 and an Arctic/Antarctic ice atlas will be available by spring 1994.

To meet the needs of researchers who require access to the basic data, a second set of modules was developed to provide access to orginal data on disc by specific location, month, year, period of record, element, and atmospheric level. The capability to export data to a user-defined file is also provided. Developed initially for hourly meteorological and solar data, this system enables users to browse through selected observations from any of NCDC's climatological observation data sets. By mid-summer 1993 NCDC will issue a disc of global daily data, with Russian historical hourly data available by the end of the year.

Nearly all of NCDC's CD-ROMs have been produced using an in-house Write-Once CD-ROM system. In addition to premastering discs for delivery to a replicating company, this system is used to produce beta test copies for user evaluation, software development and testing, and management of large data volumes that may exceed 10 gigabytes. Applying the methodology used for distribution of original data, by August 1993 the NCDC will be able to handle individual requests for data on CD-ROM.

CD-ROM at NODC

The first CD-ROM produced at the National Oceanographic Data Center (NODC) was a test disc of Pacific Ocean temperature and salinity profiles. Distributed in 1990 to selected researchers for testing and evaluation, this CD-ROM was so well received that it prompted demand for further ocean data CD-ROMs from NODC. The first major release was a global ocean temperature and salinity data set on two CD-ROMs. Containing over 3 million temperature and salinity profiles (Atlantic and Indian Oceans on disc 1 and Pacific Ocean on disc 2), this is NODC's most popular CD-ROM data set. Numerous copies of these CD-ROMs along with NODC-developed data access and display software provided on floppy disk have been sent to researchers around the world. Other data sets issued by NODC to date include three multi-disc sets of altimeter data from the U.S. Navy Geodetic Satellite (Geosat) and one disc of Oceanographic Station Profile Time Series data.

When NODC initially began CD-ROM production, data sets were converted to ISO 9660 format (premastered) and placed on 8mm Exabyte tapes. These tapes were then sent to a vendor to be mastered to CD-ROM. Before replicates of the CD-ROM were produced, two prototype discs (one-offs) were sent back to NODC to be checked for errors. Only after this quality check were replicates ordered, delaying receipt of the finished discs by several weeks. Since acquiring a desktop CD-ROM recorder and associated mastering software in December 1992, NODC has been able to master prototype discs in-house. These one-offs can be tested for errors before they are sent for replication, saving time and money. With this desktop CD-ROM recorder NODC is also able to service individual data requests on CD-ROM. The first customized CD-ROM holding data sets selectively retrieved from NODC archive data files was completed in March 1993. As NODC users become aware of this new capability, WO CD-ROMs will un-

Oceanographic station profile time series on CD-ROM

The National Oceanographic Data Center (NODC) and the World Data Center A, Oceanography (WDC-A) have compiled from the NODC Oceanographic Station Data File a set of oceanographic data having repetitive samples at the same locations for long time periods. These oceanographic time-series data, including temperature, salinity, density, and nutrients, are available on a single CD-ROM.

The data set includes 27 North Pacific sections; 56 North Atlantic sections; sections along coastal California taken as part of the California Cooperative Oceanic Fisheries Investigations (CALCOFI); 19 sections from other ocean regions; and observations from the 10 Ocean Weather Stations. A preliminary list of reference citations associated with these time-series data sets is also provided on the CD-ROM. A data conversion module provided on the CD-ROM enables these data to be used with the ATLAST oceanographic data display software developed by Dr. Peter Rhines of the University of Washington.
Contact: NODC

Blizzard of '93 report and data

The Research Customer Service Group of the National Climatic Data Center (NCDC) has compiled an extensive report on the March 1993 blizzard that has been labeled the "Storm of the Century." Titled *The Big One!*, the report includes a 4-page narrative on the storm, preliminary damage estimates and casualty reports, and data listings of weather observations taken during and near the time of the storm. In addition, a complete digital file of over 56,000 weather observations is available on magnetic tape, diskette, or over Internet. The report is being updated and expanded as new data are received.
Contact: NCDC (Climate Services)

Seismic reflection profiles from the Gulf of Mexico

During the winter of 1982 and the summer and early fall of 1985, the U.S. Geological Survey (USGS) collected approximately 30,508 line kilometers of seismic reflection data in the U.S. Gulf of Mexico Exclusive Economic Zone. This effort was part of a USGS program to map the EEZ in cooperation with the Institute of Oceanographic Sciences of the United Kingdom. Survey line spacing was about

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25 km in water depths exceeding 3000 m and gradually decreased to about 5 km in 250 m water depths. No areas shallower than 250 m were surveyed. Tracklines were generally parallel to the trend of the bathymetric contours. The data are from four cruises of the R/V Farnella.

Digital bathymetric and magnetic data collected during the cruises are also provided to complement the seismic data. The data are in the standard MGD77 format and are available on magnetic tape or as part of the NGDC's entire collection of digital geophysical data on the GEODAS CD-ROM data set.
Contact: NGDC

GEODAS CD-ROM update disc

The National Geophysical Data Center has released an update to its GEODAS CD-ROM set of underway marine geophysical data. The GEODAS Update Disc Version 2.0 is now included with all new purchases of the GEODAS set. It is also available separately as an update to previously

purchased GEODAS CD-ROM sets. The GEODAS Update Disc contains new data acquired and archived by NGDC during 1992. The total amount of new data covers 759,000 nautical miles of bathymetry, magnetics, gravity, and seismic shot-point navigation from 354 cruises and includes over 3.5 million additional digital records. The GEODAS CD-ROM data set comes with access software that enables users to search for data by a combination of the criteria: data type, institution, platform, year of cruise, cruise identifier, and date the cruise was added to the system.
Contact: NGDC

Climatic summary of the Red Sea and adjacent waters

The National Climatic Data Center has completed the *Regional Study of the Red Sea and Adjacent Waters.* Funded by the U.S. Navy, the Study is the second in a three-volume series of marine climatic summaries for Southwest Asia. The first volume covering the Persian Gulf is already available; the third volume covering the Gulf of Aden and offshore Somalia will be available later this year. The Red Sea study includes monthly analyses of air and sea temperature, cloudiness, ceiling/visibility, wind, wave height, and surface currents for the marine environment as well as climatic summaries for 11 coastal sites.
Contact: NCDC (Climate Services)

Solar data on CD-ROM

The National Geophysical Data Center has issued CD-ROMs that contain solar radio noise burst data and neutron monitor data. Solar radio noise bursts are emissions from the sun that are measured in radio wavelengths. Since 1960 ground observation stations have been recording these solar emissions at both discrete and sweep frequencies. The NGDC has assembled their holdings of these data (62.8 megabytes) grouped by year and written as ASCII text files on one CD-ROM.

Neutron monitor counts observed on earth vary inversely with the sunspot cycle and provide an indirect way to track solar activity. Some detectors have been recording since 1953 providing data sets that span nearly four solar cycles. All neutron monitor data currently held by NGDC, which were collected at stations over a wide range of latitudes and longitudes, are now available on a single CD-ROM.
Contact: NGDC

Second NOAA Data Quality and Continuity Workshop

The Second NOAA Data Quality and Continuity Workshop was held in Rockville, Md., on April 19-20, 1993. The workshop was organized by Tom Karl, Senior Scientist, and Dave Easterling of the National Climatic Data Center. Objectives were to continue discussions begun at the First NOAA Data Quality and Continuity Workshop held in April 1991 (*Workshop on the Quality and Continuity of Environmental Data*, R. Reeves and V. Derr, eds.), to review the status of problems identified at the first meeting and to outline possible solutions to both old and new problems.

Data quality and continuity problems typically arise when data collection or data processing procedures change. All observing systems are potentially subject to these types of problems. Serious questions about instrument and field experiment design, operating environment, and sampling techniques need to be addressed early in the life cycle of a project. Anticipated applications of the data may also have a bearing on data quality requirements, e.g., weather versus climate applications.

Workshop presentations were given on ASOS (Automated Surface Observing System), the Cooperative Network, NEXRAD, radiosonde observations, National Meteorological Center model reanalysis, satellite monitoring, trace gas monitoring, solar monitoring, living marine resources, sea level measurements, ocean buoy data, XBT (expendable bathythermograph) data, and COADS (the Comprehensive Ocean-Atmosphere Data Set). The workshop identified "NOAA Champions" to promote solutions or interim measures for each of the outstanding issues. Their contributions will be used in NOAA initiatives and brought to the attention of senior NOAA management. A report of the workshop will be issued.

Since the workshop, the Climate Research Committee of the National Academy of Sciences has agreed to sponsor a 12-18 month Panel study to develop a National Data Quality and Continuity Policy for climate-related data. ∎

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doubtedly become a more important data distribution medium.

CD-ROM data sets planned for future release include an updated version of the Global Ocean Temperature and Salinity Profiles with associated nutrient data. NODC also plans to issue CD-ROMs of the large Marine Environmental Buoy (wind/wave) database, monthly mean sea level data sets, and new ocean climatology data sets being prepared by NODC's research group under the direction of Sydney Levitus. Furthermore, NODC plans to substantially reduce the size of its paper archives by digitizing documents and putting them on CD-ROM for in-house use.

Conclusion

CD-ROM has many advantages. Each disc contains large volumes of spatial and temporal data that can be taken off the shelf and sent to a customer quickly and easily. Disadvantages are that the data may not be the most current, and an individual disc may contain more data than a customer really wants.

In addition to their dissemination through the mail, CD-ROMs are also contributing to the NOAA effort to place large volumes of data online for direct user access. Servers with attached CD-ROM drives can easily be accessed through bulletin boards and other system interfaces via modems and wide area network connections.

Technology, pricing, customer acceptance, and customer demand all drive the CD-ROM market. Over the next few years the NOAA national data centers expect to make increased use of both Write Once CD-ROMs and mass replicated CD-ROMs to provide users with low cost access to their environmental data archives. Each of the centers has projects underway to place their most heavily used data files on CD-ROM. As they are released, new CD-ROM data sets will be announced in the *Earth System Monitor*.

Further information about CD-ROM data products of NOAA's national data centers is available from the centers at the contact points listed on page 11. ∎