



Earth System MONITOR



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A Guide to NOAA's Data and Information Services

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Networking NOAA's National Marine Fisheries Service

Tying together a far-flung organization with a Wide Area Network

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NOAA's National Marine Fisheries Service (NMFS) is responsible for conserving and managing living marine resources (fish, whales, porpoise, sea turtles and other marine mammals and endangered species) for the long-term benefit of the nation. The NMFS is a large, geographically dispersed organization of approximately 1800 employees working at 30 major offices and laboratories around the United States. To enable these many individuals and elements to carry out their research and regulatory functions more efficiently, the NMFS is launching an ambitious networking plan. The first phase of this network connects existing hardware and is currently being installed to improve data communications. A second phase, called Information Technology-1995 (IT-95), is planned

for implementation beginning later in 1991 and will connect new hardware.

FTS 2000-based WAN

The NMFS recently placed an order for Packet Switched Service (PSS) with AT&T under the FTS 2000 contract to meet its data telecommunications needs. Cutover is currently scheduled for the second quarter (January-March) of FY 1991.

NMFS will use X.25 and TCP/IP protocols to link to existing major scientific networks and to support interoperability. Over time, NMFS plans to move towards full implementation of the OSI model under the government-wide contract.

The wide area network (WAN) design will link all NMFS regions including

the various research laboratories and headquarters to the fiber optic-based WAN with speeds up to 56 KBPS initially. This means that the WAN will be used to link all existing major computing sites. When the IT-95 procurement for large computers and scientific workstations is implemented, then NMFS will simply connect those new computers to the existing WAN. Some of the major sites include Gloucester and Woods Hole, Mass.; Sandy Hook, N.J.; Narragansett, R.I.; Silver Spring and Oxford, Md.; Beaufort, N.C.; Charleston, S.C.; Miami and Panama City, Fla.; Pascagoula, Miss.; Galveston, Tex.; La Jolla, Monterey, Santa Rosa, and Tiburon, Calif.; Honolulu, Hawaii; Portland, Oreg.; Seattle, Wash.; and Juneau, Alaska. After a fiber optic link has been installed to Alaska, Kodiak and Auke Bay will be added to the WAN.

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NOAA Buoy Data Attracts Diverse User Community

Which NOAA data set can claim the following users? Southern Californians wanting to know surf conditions, European scientists validating spacecraft measurements, biologists researching red tide off South Carolina, meteorologists forecasting for the Space Shuttle launch, civil engineers building structures to prevent beach erosion in the Gulf of Mexico, and oceanographers studying El Niño in the tropical Pacific. The answer: Measurements obtained from the National Data Buoy Center's (NDBC) network of moored buoys, drifting buoys,

and Coastal Marine Automated Network (C-MAN) stations.

The moored buoy stations provide one of the few sources of oceanic data from a fixed point over a relatively long time period. Approximately 14 of these stations have provided more or less continuous service since 1976. Archived data elements include wind speed, direction, and gust, sea level pressure, air temperature, sea surface temperature, significant wave height, dominant and average wave period, and wave spectrum. Some recently developed capabilities include directional wave measurements and the ability to measure winds continuously. Currently, 56 of these buoy sta-

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NMFS Network, from page 1

The WAN design allows easy expansion of the number of sites; sufficient line speeds to accommodate growth or changing requirements; and will provide offnet access via an 800 number beginning in early 1991. The design allows NMFS to give access to their network to traveling scientists or enforcement agents; and to their partners such as Regional Fisheries Management Councils, State Fish and

Game agencies, and university-based researchers.

The design team from AT&T offered two designs to meet NMFS technical requirements. One design involved AT&T-provided network packet assemblers/disassemblers (PADs) at NMFS locations to interface asynchronously with various hosts and terminals used at existing sites. The other design used NMFS-provided local area networks (LANs) or PADs to access the X.25 network.

Under the first design, AT&T would supply, configure, and maintain the PADs and provide network management from a demarcation point on the user side of the PAD, across the network to the exit demarcation point. Under the second design, NMFS provides the PADs or LAN access to the network, and maintenance of that equipment. AT&T would provide operation, administration and maintenance to the demarcation point on the NMFS site. NMFS selected the second design to preserve managerial flexibility and save money since NMFS has such a large installed base of Ethernet LANs.

To start the stream of expected benefits as soon as possible, the WAN linking existing computer systems will be installed during the period January thru March 1991. The WAN will then incorporate the new IT-95 systems as soon as they are installed beginning in September 1991.

IT-95 System

On August 31, 1990, the NMFS released a request for proposals (RFP) for its Information Technology-1995 computer system. The RFP culminates several years of hard work on requirements analyses, systems design, cost studies, and all the other steps associated with procurement of major information systems in the Federal government. The procurement has several components including:

- up to 9 "systems" using a minimum 32-bit CPU and data path;
- peripherals such as laser printers, plotters, tape and cartridge drives;
- up to 200 UNIX workstations using X Windows and OSF/MOTIF;
- a common suite of software including

a relational database package, and mathematical, statistical, and graphics software;

- services such as training, maintenance, and some software conversion;
- a TCP/IP gateway and software for use in conjunction with the FTS 2000-based X.25 wide area network (WAN) that is currently being implemented; and,
- numerous hardware, software, and other options.

The nine major NMFS sites targeted for systems include Seattle, Wash.; Miami, Fla.; Silver Spring, Md.; La Jolla, Calif.; Honolulu, Hawaii; Auke Bay, Alaska; Woods Hole, Mass.; Monterey, Calif.; and Montlake, Wash. The workstations will be distributed to these sites as well as other NMFS locations nationwide. Most of the "hosts" will be connected to ethernet LANs. Most of the workstations will also be connected to the LANs.

Ecological Data Centers

The IT-95 system, composed of top-end computers and Unix-based workstations, combined with the FTS 2000-based WAN, will greatly expand NMFS's capability to manage biological and environmental data in support of its mission of protecting and managing living marine resources. These data are distributed among the various NMFS research facilities under the purview of five Science Directors, who manage the data as part of an Ecological Data Center. The Directors are responsible for providing access to the data by Federal and state resource managers, and by scientists for developing a better understanding of living marine resource relationships.

The use of IT-95's common suite of hardware and software will facilitate the use of standards, making it easier to share data with others in the NOAA community.

The increased data processing and data sharing capabilities provided by IT-95 and the WAN will also enable NMFS to provide expanded support to NOAA-wide initiatives such as the Coastal Ocean Program and the Climate and Global Change Program. ■

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303-497-6958

National Oceanographic Data Center (NODC)

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NOAA Earth System Data Directory

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202-673-5548

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202-673-5636

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Reference Services:
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Report from an international workshop

Oceanographic Data Archaeology

Finding historical data for climate and global change research

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Progress in climate and global change research depends critically on the availability of oceanographic data with sufficient global coverage and long time span. Substantial resources are presently being allocated for various global ocean programs (such as TOGA, WOCE, and JGOFS) and for the establishment of a true global ocean observing system. Researchers dealing with long-term changes in the ocean will have to wait many years (even decades), however, before a long enough data set from this system has accumulated. Our only recourse, therefore, is to take full advantage of data that have been collected over the past decades.

Unfortunately, it has been estimated that perhaps half of all historical global ocean data may not presently reside in any of the maintained data archives around the world and thus are not available to climate and global change researchers. Many of these data may be at risk of being lost forever. This critical juncture, when interest in climate and earth history is high and funds are available, may be our last chance to save many of these valuable old data. It is time to put forth an ambitious integrated effort to recover these data before it is too late.

The term used to describe efforts to salvage historical ocean data is "oceanographic data archaeology". A report to the NOAA Panel on Climate and Global Change by the Working Group on Data Management defines "data archaeology" as "the reconstruction of past climate and other aspects of global change from existing data. It involves a mix of seeking out, restoring, evaluating, correcting and interpreting past data sets."

On September 13-14, 1990, the U.S. National Oceanographic Data Center hosted an international workshop on oceanographic data archaeology, funded by the NOAA Climate and Global Change Program (as a result of a reviewed FY90 proposal). The participants included scientists and data managers from seven countries (USSR, Japan, Korea, Chile, Australia, Denmark, and the USA) who have an understanding of the needs of the research community and a broad knowledge of the availability of historical data and possible methods for finding and acquiring that data. The participants collectively provided coverage of most regions of the globe.

A month prior to the workshop a working draft plan for an Oceanographic Data Archaeology Project was sent to each workshop participant (as well as to other interested individuals who were unable to attend), in order to provide a framework for discussions at the workshop and to help stimulate ideas. Responses to and ideas stimulated by the draft plan were incorporated into the workshop.

The main objective of the workshop was to obtain enough information from the participants in order to design an integrated data archaeology approach for the efficient and extensive acquisition of historical global oceanographic data for use by the climate and global change research community. A second objective was to gain an initial sense of priorities, specifically what are the areas where data are most needed, and what aspects of data archaeology are most important to pursue, so that an archaeology program can begin right away and take advantage of whatever funding can be obtained.

An integrated approach to oceanographic data archaeology includes activities such as:

- setting priorities based on the geographic and temporal needs of the researchers,
- summarizing existing archived data sets,
- discovering the existence of additional data,

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Discovering "Treasure" in the ICES Cellar

In preparation for the Oceanographic Data Archaeology Workshop, Dr. Harry Dooley, Hydrographer of the International Council for the Exploration of the Sea (ICES), compiled a report which summarized, country by country, a century of hydrographic data stored at ICES. In the process of putting together this report, Dr. Dooley discovered in the cellar of ICES 200,000 cards of hydrographic data.

These cards were all originally thought to be included in the ICES computer database, but that database was found only to include data from the *Bulletin Hydrographique* (which ICES published from 1902 to 1956) and these

cards were found to contain considerably more data, including data from the *Rapport Atlantique*, which the ICES Atlantic Slope Committee published from 1921 to 1935. The cards contained deep-water data, down to 3000 meters, from the eastern Atlantic, an area where historical data have been scarce.

In the basement of Charlottenlund Castle (the former ICES headquarters), Dr. Dooley also discovered another 20,000 cards of geographically sorted Danish data that were also found not to be in the computer database. Some of these cards contained data from the 1896 Ingulf Expedition in the Norwegian Sea.

Data Archaeology, from page 3

- acquiring data (preferably digitized) and the necessary documentation,
- digitization (optical or manual) of manuscript or analog data,
- performing data quality control,
- making the data accessible to the scientists who need them, and
- increasing communication among international scientists and data managers about global oceanographic data sets and data archaeology efforts.

Each of these topics was discussed in detail at the workshop.

In addition, the participants provided information on historical data in manuscript form that they already knew about and felt should be digitized. A significant immediate benefit of the workshop was the discovery of a few data "treasures" as a result of these discussions (see box).

Workshop participants agreed that initially the archaeology effort should concentrate on hydrographic profile data, including nutrient data. It was felt that the data archaeology approach developed

with these initial data types would be applicable to other data types. It was also agreed that certain high priority activities should begin as soon as possible. For example, the U.S. NODC and its collocated World Data Center A (WDC-A) for Oceanography agreed to begin producing data distribution maps of its hydrographic data holdings on a country by country basis. Where heavy data density obscures cruise tracklines, these plots may be broken down into decadal or smaller time periods (see figure). These maps will be sent to data centers and data gathering institutions in every country. From these maps, those institutions will be able to tell whether all their data are in the U.S. NODC/WDC-A archive (and what data may be in that archive that they don't have).

An inventory will be compiled of manuscript and analog data sets that the workshop participants are aware of now. With this information priorities for expending resources to digitize data can be decided on. By distributing this list to various data centers it can also be determined if any of these data may have

already been digitized. This inventory will be continually updated as new data sets are discovered.

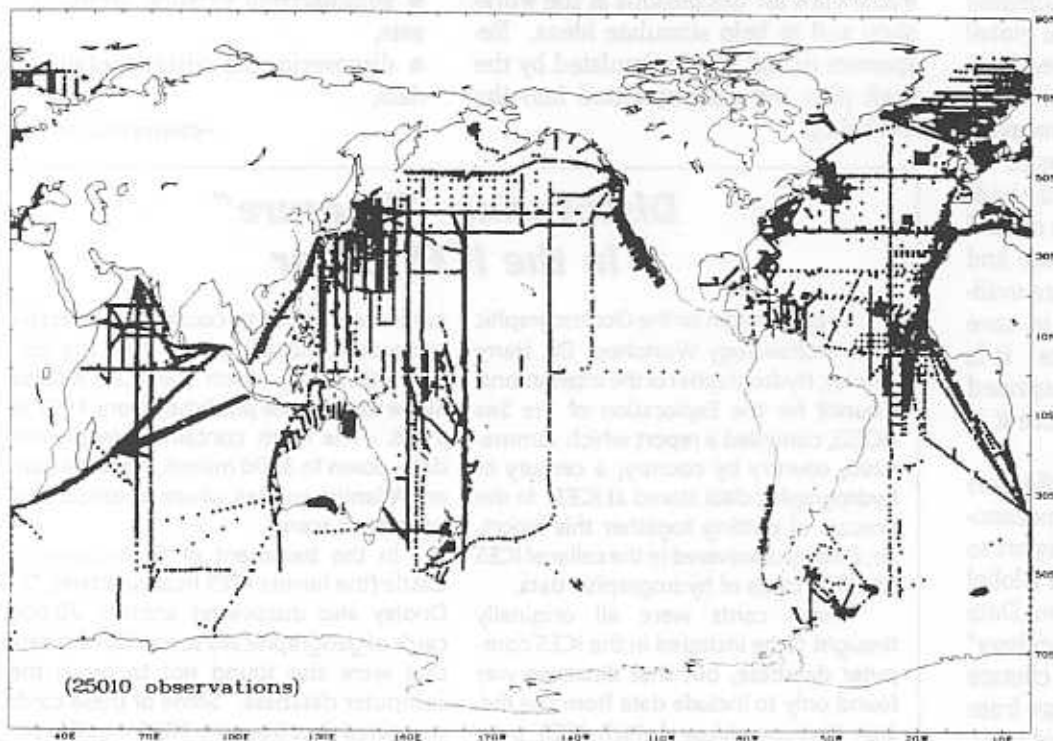
The participants felt that data archaeology was an activity that would benefit from a newsletter and teletext bulletin board. A frequently published Ocean Data Archaeology Newsletter would help to make the scientific and data management communities aware of data archaeology efforts and would provide the kinds of information that would stimulate the discovery of unarchived historical data sets, such as: data distribution maps, lists of known manuscript and analog data, updates on newly discovered data, rumors and leads that need substantiation, articles about research and archaeology projects at various institutions, and even interesting historical articles relating to cruises and data. The teletext bulletin board (and/or mailbox) would allow for rapid communication on archaeology issues and potential data sets.

These techniques will play an important role in discovering and acquiring historical data sets. Many other techniques were proposed and discussed including:

use of an automated ROSCOP/cruise report system, use of the WDC-A *Catalogue of Data* and *Catalogue of Accessioned Publications*, compilation of researchers and data managers working with particular data types, visiting scientist programs and joint research projects, monetary and ADP support of institutions and "regional archaeology centers," the development of a PC program for easy quality-controlled data entry and format conversion, and a compilation of instrumentation and quality control methods used over the years for particular data types.

For a copy of the Report of the Oceanographic Data Archaeology Workshop or to get on the mailing list for the newsletter, call (202) 673-5571. ■

USSR Nansen cast data in NODC archives (1970-74)



Sample NODC data distribution plot prepared in support of the Oceanographic Data Archaeology Project.

NOAA's Library and Information Network: The CD-ROM Connection

Carol Watts
Chief, Library and Information
Services Division
National Oceanographic Data Center
NOAA/NESDIS

The NOAA Library in Rockville, Md., begun in 1871, serves as the hub of a network of more than 35 field libraries located throughout the United States. In addition to providing a comprehensive back-up collection of journals, books, technical reports, and local meteorological data for these libraries, the Library and Information Services Division (LISD) has published a union catalog of the Network's book holdings on CD-ROM, updated monthly. Twenty-seven locations have the CD-ROM workstation, called the NOAALINC (NOAA Library and Information Network Catalog), for searching this bibliographic data base.

As of January 1991 the NOAA Library in Rockville has 30 CD-ROM data and information products available for use on-site. These include *Aquatic Sciences and Fisheries Abstracts*, *Arctic and Antarctic Regions*, *Climatedata*, *Computer Library*, *Gloria-Gulf of Mexico*, *Hourly Precipitation*, *NODC-01 Pacific Ocean Temperature-Salinity Profiles*, *Selected Geomagnetic and Other Solar-Terrestrial Physics Data of NOAA and NASA*, and *World Weatherdisc*. A complete description of the data bases on CD-ROM at the Rockville site is found in *A Precip of the NOAA Library's CD-ROM Holdings*.

The CD-ROM holdings at the Rockville site are very modest in comparison to the hard copy collection of one million books, 9,000 serial titles, 1,500 current journal subscriptions, and 35,000 reports. Of special concern

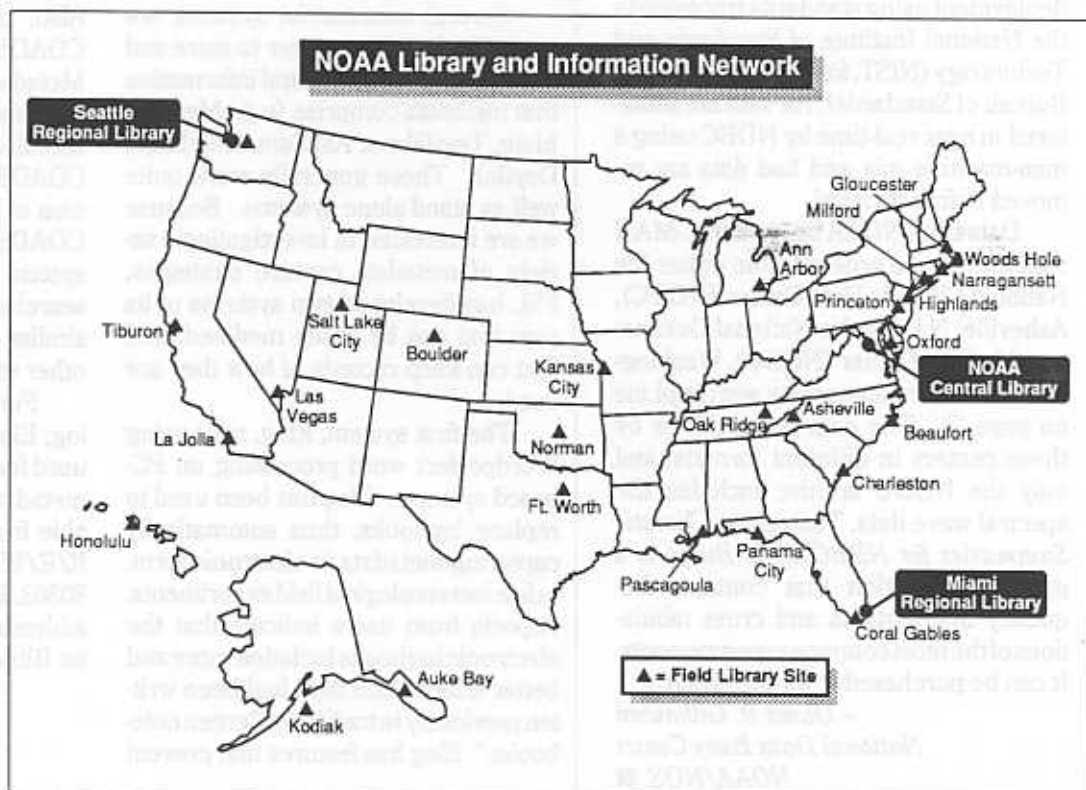
are the older Weather Bureau and Coast and Geodetic Survey collection and foreign data. Text, data, and maps are often found within a single bound volume—all published before the computer age. On-line access to more than 600 data bases via systems such as DIALOG, BRS, OCLC and Westlaw enables NOAA Libraries to identify what is relevant in these hard copies to any topic on which a search is requested. In addition to on site access, NOAA and other Department of Commerce personnel may receive services via telephone, inter-office mail, Fax, Omnet, U.S. mail, and special courier (for rush requests.)

Recently LISD received a planning grant to determine what should be done with the foreign meteorological data collection, both to preserve it and to make it more accessible. A Scientific Advisory Committee has been appointed to review this collection and make recommendations on its future to NOAA management. There are 2,645 volumes of weather maps from 47 countries. The earliest vol-



ume is from 1859 and the latest, 1983. LISD is coordinating this review in consultation with the National Climatic Data Center and the Environmental Technical Applications Center Library at Scott Air Base, both of which also have foreign meteorological data collections.

To obtain library services contact the Central Library Main Desk, 301-443-8330, or Fax 301-443-0237, or a NOAA field library. The Central Library's address is 6009 Executive Boulevard, (E/OC4), Rockville, MD 20852. The library's Omnet address is NOAA.LIBRARY. For information on obtaining a NOAA-LINC CD-ROM workstation, contact Carol Watts, Library Director, 301-443-8288. ■



NOAA Buoy Data, from page 1

tions are maintained from "Maine to Maui" with 34 of them located in the vital coastal zone.

Forty-seven C-MAN stations are also located in the coastal zone at lighthouses, beaches, jetties, and offshore platforms around the contiguous United States and Alaska. Most measure winds, sea level pressure, and air temperature, although some also measure waves, sea surface temperature, tides, and humidity. The drifting buoys measure sea level pressure, air temperature, and water temperature and have been deployed mostly in the Southern Hemisphere. These drifting buoys are aiding the study of interannual variability of the oceans and atmosphere in support of the Tropical Ocean-Global Atmosphere program.

The quality of the data is considered to be better than ship data for a number of reasons. The location and shielding of each sensor was carefully considered to avoid exposure problems. Long averaging periods are used to remove the effects of buoy motion. New sensors undergo extensive field evaluations before being qualified for operational use. All sensors are calibrated before and after deployment using standards traceable to the National Institute of Standards and Technology (NIST, formerly the National Bureau of Standards). All data are monitored in near real-time by NDBC using a man-machine mix and bad data are removed before archival.

Data from NOAA buoys and C-MAN stations may be ordered from either the National Climatic Data Center (NCDC), Asheville, N.C. or the National Oceanographic Data Center (NODC), Washington, D.C. (for contact points, see HelpLine on page 2). The data are archived by these centers in different formats, and only the NODC archive includes the spectral wave data. The report *Climatic Summaries for NDBC Data Buoys* is a useful compilation that contains frequency distributions and cross tabulations of the most common measurements. It can be purchased from the NCDC.

— David B. Gilhousen
National Data Buoy Center
NOAA/NOS ■

Working Group on Metadata Capture and Maintenance

Many historical environmental data are not as useful as they might be, and in some cases are not useful at all, because they lack critical descriptive information. This information includes the conditions under which the data were gathered, the properties of the sensors, known flaws and limitations in the data, and processing to which the data have been subjected. Because this information is data about data, we call it metadata.

Unfortunately, even current data sets are often gathered without adequate attention to the capture and maintenance of the metadata that researchers 20 or 100 years from now will need to understand the data sets.

To make both historical and current data sets more useful, NOAA's Forecast Systems Laboratory, in cooperation with the Wave Propagation Laboratory and the Climate Monitoring and Diagnostics Laboratory, is investigating, developing, and deploying systems to capture and manage environmental metadata.

Several commercial systems are available that allow a user to store and retrieve the kind of textual information that metadata comprise (e.g., Memory Mate, TextDbms, AskSam, Notebook, Dayflo). These generally work quite well as stand-alone systems. Because we are interested in investigating a variety of metadata capture strategies, FSL has developed two systems of its own that can be easily modified, and that can keep records of how they are used.

The first system, Elog, runs using Wordperfect word processing on PC-based systems. Elog has been used to replace logbooks, thus automatically capturing metadata in electronic form, in five meteorological field experiments. Reports from users indicate that the electronic logbooks included more and better information than had been written previously in traditional "green notebooks." Elog has features that prevent

the loss of metadata during power failures and allow easy copying and electronic transmission of the metadata.

The second system, Metalog, is a more extensive metadata management system. In Metalog, comments can be loaded from Elog or other electronic files or entered directly, given pointers to data, and retrieved in several ways. Prototype versions of Metalog run on VAX/VMS, Unix, and Macintosh computers. Metalog keeps records of user commands; we use this information to study how researchers use metadata in their work.

To study how a large body of historical metadata is used, we plan to capture metadata about COADS, the Comprehensive Ocean Atmosphere Data Set. This data set consists of more than 70 million ship reports of global marine data taken over the past 136 years, and is used by more than 100 laboratories worldwide. Metadata about COADS have been gathered during the past several years, but they are not yet in easily retrievable form. Also, there are several experts on COADS who carry large amounts of Metadata in their heads. By working with these experts, and with the assembled literature, we will encode the COADS metadata into an expanded version of Metalog to build an automated COADS "help" system. We believe the system will be valuable to COADS researchers, and it will be a prototype for similar systems to be developed for other valuable historical data sets.

Further information about Metalog, Elog, vended systems that can be used for metadata management, or the metadata project in general, is available from William Moninger; NOAA, R/E/FS; 325 Broadway; Boulder, CO 80303. Phone 303-497-6435. Electronic addresses: on Omnet: W.MONINGER; on Bitnet: Moninger@Colorado.

— William Moninger
Forecast Systems Laboratory
NOAA/OAR ■

NGDC: Geophysical Data for Research

Michael Chinnery, Director
David Clark, Assistant Director
National Geophysical Data Center
NOAA/NESDIS

Data holdings of the National Geophysical Data Center (NGDC), located in Boulder, Colorado, complement and complete the description of the Earth system provided by data from the National Climatic Data Center and the National Oceanographic Data Center. Thus, NGDC looks beyond the Earth's lower atmosphere to phenomena in the upper atmosphere, the space environment and the sun, and looks downwards from the land surface and ocean floor into the Earth's interior. And through its National Snow and Ice Data Center, operated by the University of Colorado, it addresses the cryosphere, those cold regions covered by ice, snow, and permafrost.

NGDC was established in 1965 as a part of the Environmental Science and Service Administration (ESSA). When NOAA was formed, NGDC merged with the Aeronomy and Space Data Center, formerly in the National Bureau of Standards, added the marine geology and geophysics activity that used to be at NODC, and began the evolutionary path that has led to the present-day Center. The snow and ice activity was added in 1976, and became the National Snow and Ice Data Center in 1982. In 1990, NGDC proudly celebrated its 25th Anniversary

NOAA's National Data Centers Last in a series of three articles

as one of the premier data management institutions in the world.

NGDC sees the Earth as a planet and is largely concerned with global processes. For this reason, it has always been heavily involved in international data exchange. The World Data Center System began as part of the International Geophysical Year in 1957-59, and continues today as one of the most effective mechanisms for international data exchange. NGDC houses discipline centers of the U.S. World Data Center A in each of its major areas: solar-terrestrial physics, solid earth geophysics, marine geology and geophysics, and glaciology (snow and ice). An additional discipline center has recently been proposed for NGDC's newest major area, paleoclimatology.

The wide variety of disciplines covered by NGDC is perhaps its most characteristic feature. Not only does NGDC handle many different types of geophysical data, but NGDC staff are to be found associated with many different national and international organizations. Following are some high-

lights of the primary discipline areas.

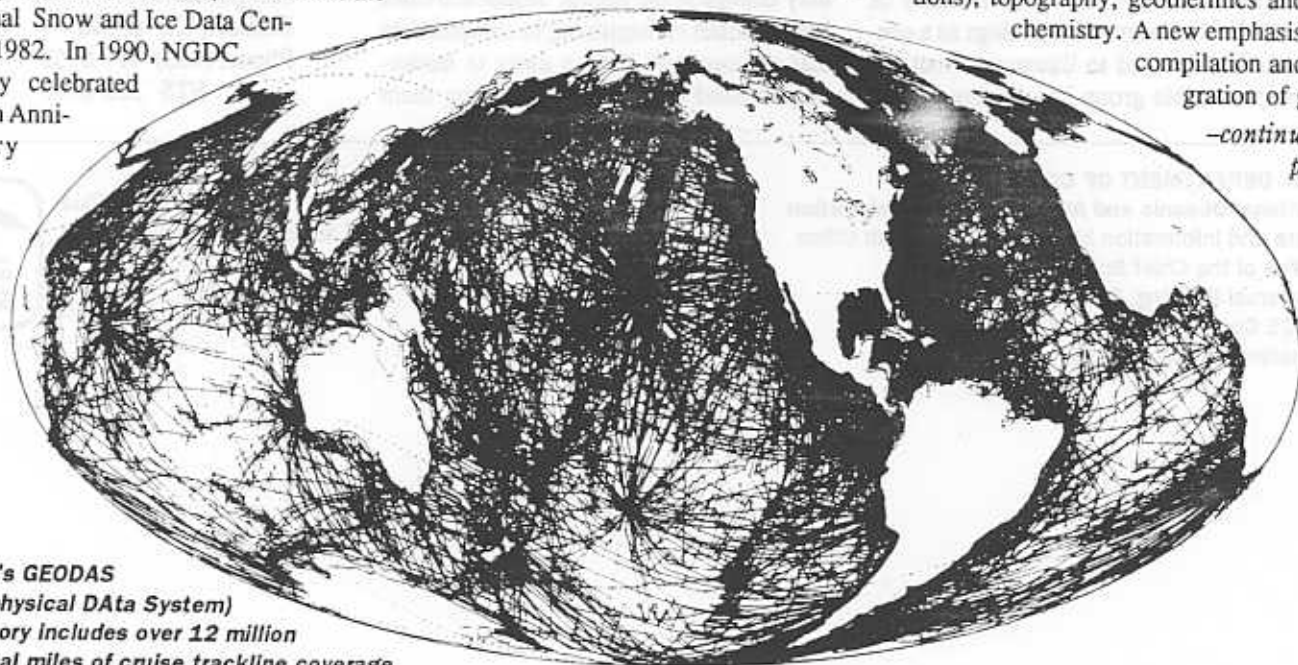
Solar-Terrestrial Physics

This area focuses on the effect of solar activity on the Earth system. NGDC plays a leading role, both nationally and internationally, for data and information about sunspots and solar flares, the interplanetary medium, and the near-Earth space environment. A monthly journal, *Solar Geophysical Data*, is sent to scientists all over the world, and is the main source of information in this field. NGDC collects and compiles data concerning the ionosphere and changes in the geomagnetic field, and, working with the academic community, is developing models of the processes active in the Earth's upper atmosphere. Increasing interest in the effects of solar activity on satellites in orbit, on mankind, and on climate are opening up many new areas of research.

Solid Earth Geophysics

This is the most diverse of all NGDC discipline areas. In natural hazards, NGDC has active programs in earthquake studies, tsunamis, and volcanoes. Natural resource programs include measurements of the Earth's gravity and magnetic fields (including ground, airborne and satellite observations), topography, geothermics and geochemistry. A new emphasis is the compilation and integration of global

—continued on
page 8



NGDC's GEODAS
(GEophysical DATA System)
Inventory includes over 12 million
nautical miles of cruise trackline coverage.

NGDC, from page 7

data bases for the study of global change and the application of these systems to research and education, especially in the developing countries. Special emphasis is being placed on developing software to make these global data bases easily accessible to scientists.

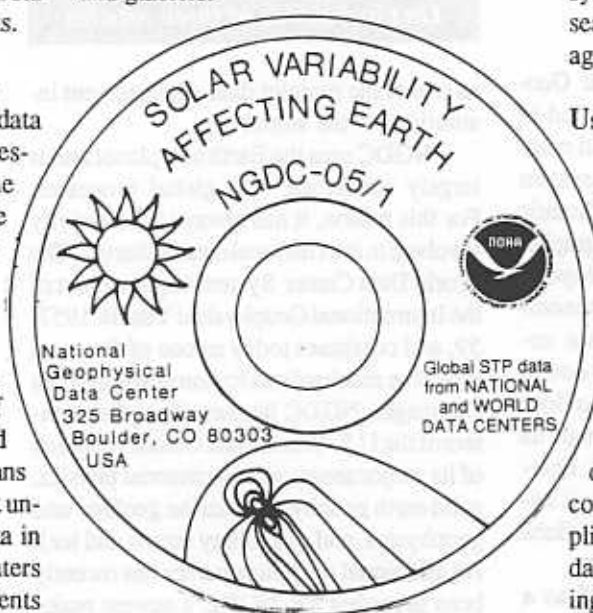
Marine Geology and Geophysics

Over the years, the amount of data collected at sea by research and other vessels has grown enormously. The marine geology program manages data from the Deep Sea Drilling Project, and its successor, the Ocean Drilling Program, together with many other data sets resulting from sampling of the sea floor. The marine geophysics program maintains one of the largest collections of public-domain gravity, magnetic, and seismic data collected over all the oceans of the world. NGDC also has the largest unclassified collection of bathymetry data in the world, ranging from the coastal waters of the U.S. to deep water measurements worldwide. Recently, NGDC was designated as the International Center for Digital Bathymetry by the International Hydrographic Office.

National Snow and Ice Data Center

The National Snow and Ice Data Center (NSIDC) and its affiliated World Data Center A for Glaciology (Snow and Ice) are operated for NGDC by the University of Colorado. From small beginnings as a center mainly devoted to literature about the cryosphere, this group has developed into

one of the most important centers for both satellite and ground data relating to all aspects of land, sea, and polar snow and ice. The range of topics covered include sea ice extent, permafrost, avalanches, ice cores, and glaciers.



Paleoclimatology

Begun only two years ago, NGDC's program in paleoclimatology is expanding into a major effort and an integral part of NOAA's Climate and Global Change Program. Developing an understanding of how the Earth's climate has changed in the past is essential to attempting to predict how it may change in the future. Initial activities have focused on beginning to compile data that are currently hidden away in institutions around the world and making them

available to the research community. Future activities will aim at developing a four-dimensional, space-time record of past climates and using this record as input to global circulation models of the climate system. These activities will involve research and modelling as well as data management.

Use of Modern Technologies

To carry out all these programs, NGDC has taken the lead in developing and applying new computer technologies. In particular, NGDC has been a pioneer in the development and use of CD-ROM (Compact Disk - Read Only Memory) for both the storage and the dissemination of data. We have developed a series of innovative software packages that allow users of our CD-ROMs to display and access the vast amount of data contained on each disk. The low cost of duplication makes this an ideal medium for data dissemination, and the day is approaching when research scientists can have personal libraries of CD-ROMs which will contain all the data they will need in their research.

For more information about the many types of data and information that are available at NGDC, please contact:

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Phone: (303) 497-6958
FTS 320-6958

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