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EARTH SYSTEM MONITOR

A guide to NOAA's data and information services

INSIDE

Oceanographic data archaeology project receives international support

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At the 14th Session of the Committee on International Oceanographic Data and Information Exchange (IODE), held in Paris in December 1992, delegates endorsed a U.S. proposal for a Global Oceanographic Data Archaeology and Rescue Project. The proposal was presented by Sydney Levitus, an oceanographer with the U.S. National Oceanographic Data Center (NODC), who is Director of World Data Center A (WDC-A) for Oceanography. The IODE will in turn forward the proposal for this project to its parent body—the Intergovernmental Oceanographic Commission (IOC)—for approval at the 17th Session of the IOC Assembly, to be held February 25-March 11, 1993, in Paris.

The goal of this project is to augment the historical oceanographic digital data archives by seeking out and recovering manuscript and digital ocean data not yet included in the digital ocean databases accessible to the world research community. The term "data archaeology and rescue" describes this two-part process of first identifying and locating data and then performing the steps required to merge them into a digital database.

The enhanced historical ocean data archives resulting from this project will enable improved ocean climatologies to be constructed and will support more complete studies of ocean variability of heat, salt, and nutrients. Diagnostic studies of the variability of the world ocean are critical for understanding the role of the ocean in the earth's climate system. In addition, these data will be valuable to numerical modelers for use in preparing fields of initial and boundary conditions.

The initial phase of the Oceanographic Data Archaeology and Rescue Project was launched at an international workshop organized by the NODC and held in Washington, D.C., in September 1990 (see *Earth System Monitor*, January 1991). Workshop participants included scientists and data managers from around the world. These specialists brought to the workshop an understanding of the needs of the research community and broad knowledge of the availability of historical oceanographic data. Collectively, they represented nearly all regions of the world.

Following the workshop, data archaeology

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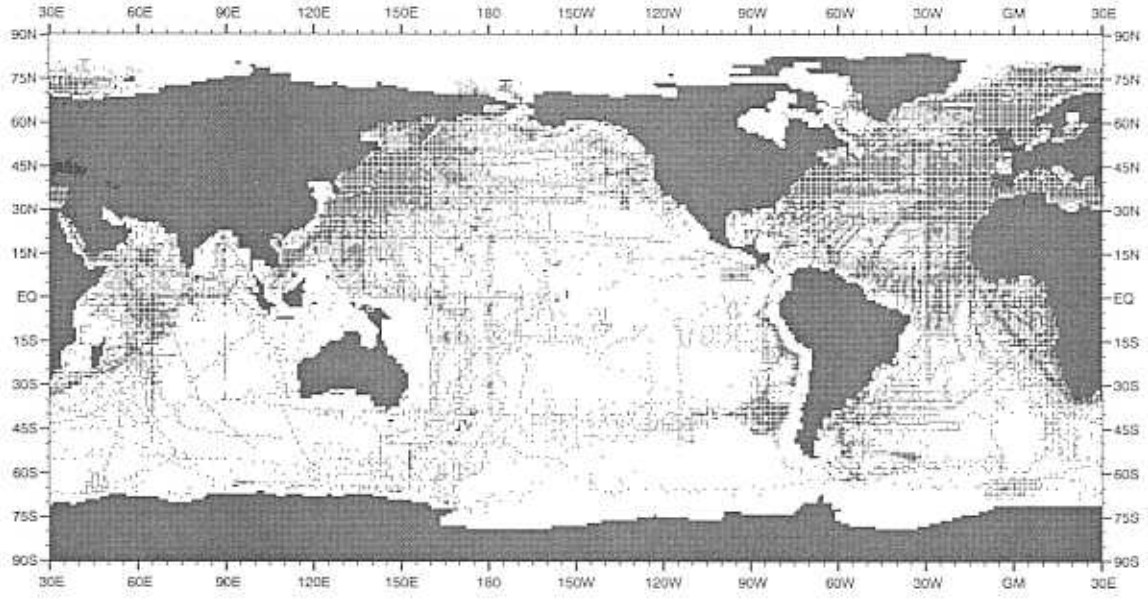

▲ **Figure 1.** Global distribution of 220,000 MBT ocean temperature profiles received by the U.S. NODC from Russia as a result of initial efforts of the Oceanographic Data Archaeology and Rescue Project.

U.S. DEPARTMENT OF COMMERCE
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Ocean data archaeology, from page 1

and rescue activities were begun at the three World Data Centers for Oceanography—WDC-A in Washington, DC; WDC-B in Obninsk, Russia; and WDC-D in Tianjin, China—as well as at the International Council for the Exploration of the Seas (ICES), Denmark, and the Japan Oceanographic Data Center (JODC). These institutions are coordinating their data archaeology and rescue activities to avoid duplication of effort and to maximize their resources.

In priority order, the Global Oceanographic Data Archaeology and Rescue Project seeks to:

- prepare catalogs of data available only in manuscript or other analog form, as well as digital data not currently available at one of the ocean data centers around the world,
- digitize data that now exist only in manuscript or other analog form,
- ensure that all oceanographic data available for international exchange are archived in digital form at two or more data centers,
- perform quality control on all data,
- make all data readily accessible.

An important first step in this project is summarizing the data held in the world's maintained oceanographic data archives. This will enable researchers and data managers to see what data are available, to locate gaps in data coverage, and to identify data they have or know about that are not in the archives. As the holder of the world's largest unclassified oceanographic data archives, the U.S. NODC has assumed a special responsibility for providing the worldwide oceanographic research community with information on its data holdings.

Data distribution plots of observations in the NODC's global physical-

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Table 1. Data sets received by the NODC through Data Archaeology activities.

COUNTRY/ INSTITUTION	DATA TYPE*	NO. OF PROFILES	PERIOD OF OBS.	REMARKS
AUSTRALIA				
CSIRO	OSD	24,427	1973-1990	
ICES	OSD	2,681	1971-1974	CINECA Project
	OSD	432	1948-1990	Ocean Weather Station L
	OSD	1,171	1983-1990	Ocean Weather Station C
	OSD	7,989	1948-1988	Ocean Weather Station M
	OSD	245	1925-1930	Atlantic Slope Experiment
	OSD	12,182	1970-1992	Denmark
	OSD	15,144	1934-1988	Iceland
JAPAN				
Japan Oceanog. Data Center	OSD	47,171	1964-1985	Japan Fisheries Agency
	DBT	196,762	1965-1985	Japan Fisheries Agency
	CURM	28,487	1964-1985	Japan Fisheries Agency
	ADCP	3,082	1990	
	CTD	1,836	1990	
	DBT	193	1990	
	GEK	98	1990	
	OSD	1,076	1990	
	XBT	1,974	1990	
RUSSIA				
Pacific Oceanog. Institute	OSD	3,148	1966-1988	S. China Sea
WDC-B	MBT	140,000	1954-1989	Russian Navy
	MBT	80,000	1951-1986	Russian Navy
	OSD	12,600	1969-1991	
SOUTH KOREA				
Korea Oceanog. Data Center	OSD	30,218	1961-1990	
USA				
Scripps Inst. of Oceanography	OSD	500	1973	Tasaday Expedition
	MBT	56,000	1942-1960	

*(*OSD = Oceanographic station data; DBT = Deep bathythermograph; CURM = Current meter data; ADCP = Acoustic Doppler current profiler; CTD = Conductivity-temperature-depth recorder; GEK = Geomagnetic electrokinetograph; XBT = Expendable bathythermograph; MBT = Mechanical bathythermograph)*

EARTH SYSTEM MONITOR

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Data center scientists named Fellows of the AGU and AMS

Scientists at two of NOAA's national data centers have been honored by election to Fellowship in major scientific societies. Bruce C. Douglas, Director of the National Oceanographic Data Center, has been elected a Fellow of the American Geophysical Union (AGU). AGU Fellowship is awarded to scientists who have attained acknowledged eminence in a branch of geophysics. It is one of the few honors that AGU confers, and the number of Fellows elected each year is limited to 0.1 percent of the total AGU membership. Douglas is the author of numerous scientific papers in the fields of satellite geodesy and oceanography and has served as an editor of the *Journal of Geophysical Research*. He will receive his Fellow's certificate at the honors ceremony to be held during the AGU spring meeting in Baltimore, Maryland, in May.

Thomas R. Karl, recently named Senior Scientist at the National Climatic Data Center, has been elected a Fellow of the American Meteorological Society (AMS). This lifetime honor is bestowed on AMS scientists who have made long-term contributions to the fields of meteorology, hydrology, or oceanography. A well-known authority in the area of climate change, Karl has served on various governmental advisory and scientific panels related to climate research, data management, and global warming. The author of hundreds of articles, books, and reports, he also serves as an associate editor of the journal *Climate Change* and the AMS's *Journal of Climate*.

Improved global terrain model under development

An improved, research-quality global terrain model is being developed at the NOAA National Geophysical Data Center (NGDC). Called TerrainBase, the model will provide complete coverage of land elevation and ocean depth values for the entire earth. The global model is being created using many of the best regional relief models available in the public domain. Many of the data being used in this model were previously unknown or inaccessible to the general research community. NGDC is obtaining the data through cooperative exchange agreements with academic, governmental, and commercial organizations throughout the world.

News briefs

TerrainBase will be a complete 5-minute global relief model created by resampling each regional model into 5-minute grids and incorporating these grids into a single continuous model. TerrainBase will supersede ETOPO5, a 5-minute relief model developed in 1985, that has been the most widely used public-domain global relief model. TerrainBase will provide considerable improvements in quality and resolution over ETOPO5 for areas covering the United States, Africa, Australia, and Greenland, as well as portions of South America and Europe. TerrainBase will be released on CD-ROM later in 1993.

NOAA to host IAMSLIC '93

The NOAA Library will host the 19th annual conference of the International Association of Aquatic and Marine Science Libraries and Information Centers (IAMSLIC). The conference will be held at the Hyatt Regency Hotel in Bethesda, Maryland, October 11-15, 1993. IAMSLIC is a worldwide professional society of individuals and institutions involved with marine and aquatic science information. About one-third of the membership is from outside the continental United States, and last year's meeting was held in Bremerhaven, Germany.

For further information about IAMSLIC '93, please contact Janice Beattie. Telephone: 301-443-8288, Fax: 301-443-0237, Omnet: J.BEATTIE, Internet: beattie@nodc2.nodc.noaa.gov

IODE-XIV meeting in Paris

Bruce Douglas, Sydney Levitus, and Ronald Moffatt represented the National Oceanographic Data Center/World Data Center A for Oceanography on the U.S. delegation to the 14th Session of the Committee on International Oceanographic Data and Information Exchange (IODE), a subgroup of the Intergovernmental Oceanographic Commission (IOC). IODE-XIV was held in Paris, November 30-December 9, 1992.

At this meeting the IODE Committee advanced several initiatives to provide better support for global ocean science and ocean monitoring programs. A proposal by Sydney Levitus that the IOC/IODE establish a Global Data Archaeology and Rescue Program was approved and will be presented to the IOC at the next meeting of the IOC assembly (see article on page 1).

NODC and WDC-A agreed to lead new IODE initiatives to establish *ad hoc* Groups of Rapporteurs on Marine Biological Data Management and on Ocean Chemical and Carbon Dioxide Data Management. The IODE also proposed ways to enhance the integration of new data and information technology within the IODE system and to improve the distribution of metadata, as well as information contained in publications, through the use of electronic communications and CD-ROM.

Planning underway for NOAA's Earth Watch Service

The National Oceanic and Atmospheric Administration has launched a project to create an electronic system (and hard copy summaries) that will improve access to information about environmental changes and environmental indicators. NOAA scientists monitor such phenomena as ozone depletion, changes in coastal estuaries and wetlands, variations in fish stocks, and natural hazards including drought and tropical storms. The main goal of this system—NOAA's Earth Watch Service, or NEWS—is to organize, digest, and disseminate major NOAA research results to the outside world, especially to policy and decision makers.

Planning for this information system, which is being coordinated by Thomas R. Karl of the NOAA National Climatic Data Center, began at the First Annual Scientific Workshop for NEWS held in Silver Spring, Maryland, February 22-23, 1993. The first day of the workshop was devoted to presentations by leading NOAA scientists about the environmental parameters to be reported in NEWS and to discussions by NOAA and invited outside systems specialists on the design criteria for NEWS. On the second day, smaller subgroups met to discuss specific problems related to the contents, scientific integrity, utility, and maintenance of NEWS.

A question and answer session at the start of the second day also provided one of the first opportunities for the recently-nominated NOAA management team headed by D. James Baker to listen to NOAA scientists and staff express their views on agency opportunities, priorities, and directions.

Remote sensing of snow cover and snow water equivalent

NOAA's National Operational Hydrologic Remote Sensing Center

Lt. Cdr. Robert W. Maxson
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The National Operational Hydrologic Remote Sensing Center (NOHRSC) in the Office of Hydrology of the National Weather Service (NWS) creates and distributes a variety of products that use remotely sensed data in support of the hydrologic services mission of the NWS. The NWS issues river and flood forecasts for the United States and provides hydrometeorological data and products to support U.S. water resources managers. The most widely used Center products estimate snow cover properties with data collected by airborne and satellite sensors. The NOHRSC operates two terrestrial gamma radiation detection systems on low-flying aircraft to infer snow water equivalent over a network of more than 1600 flight lines covering portions of 25 states and 7 Canadian provinces.

Additionally, analysts use image data from the Advanced Very High Resolution Radiometer (AVHRR) on the NOAA polar orbiting satellites and image data from the Geostationary Operational Environmental Satellite (GOES) to digitally map areal extent of snow cover for over 4000 river basins in the U.S. (including Alaska) and in Canada. The Center distributes these satellite based snow cover products weekly for regions covering two-thirds of the U.S. and Canada where snow cover is a significant hydrologic variable. The remotely sensed hydrology products are distributed electronically, in near real-time, to NWS and non-NWS end-users in both alphanumeric and image format. Field hydrologists at the NWS River Forecast Centers and other Federal, state, and private agencies use the airborne snow water equivalent data and satellite areal extent of snow cover data operationally when issuing spring flood outlooks, water supply outlooks, river and flood forecasts, and reservoir inflow forecasts for the country.

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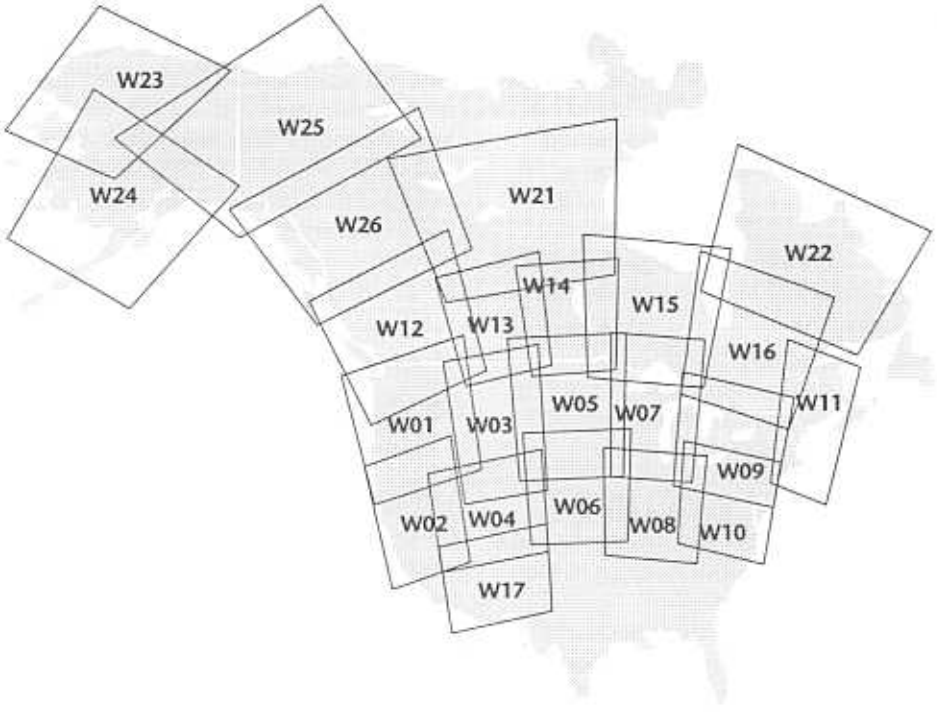

▲ Figure 1. North American satellite snow mapping windows for 1993.

In the future, the NOHRSC will further develop and refine the remotely sensed hydrology products to incorporate information contained in Next Generation Radar (NEXRAD) data sets and in Special Sensor Microwave Imager (SSM/I) satellite data sets. These and other data sets provided by future remote sensing technologies will be incorporated into operational, real-time, hydrology products. All of the remotely sensed estimates of parameters affecting the Nation's water resources are being fully integrated into NWS plans for an enhanced Water Resources Forecasting System (WARFS). As technological advances allow, the Center will continue to enhance and expand its products to meet the Nation's needs for high quality, operational, remotely sensed, hydrologic data.

Airborne snow survey program

Natural terrestrial gamma radiation can be used to make reliable, airborne snow water equivalent measurements. Radiation detection systems onboard low-flying aircraft measure the gamma radiation emitted from trace elements of potassium, uranium, and thorium radioisotopes in the upper 20 cm of soil. Water mass in the snow cover attenuates, or blocks, the terrestrial radiation signal. Consequently, analysts can use the difference between airborne radiation measurements made over bare ground and snow covered ground to calculate a mean areal snow water equivalent value with an error of less than 1 cm.

NOAA Corps Commissioned Officers attached to the NOHRSC serve as airborne snow survey pilots and operate the airborne detection systems. Typical airborne snow survey operations span January through April each year using two aircraft simultaneously. Each flight line is typically 16 km long and 300 m wide, covering an area of approximately 5 km². Consequently, each airborne

snow water equivalent measurement is a mean areal measure integrated over the 5 km² area of the flight line. Analysts at the Center use geographic information systems to process the airborne snow water equivalent data and to calculate mean areal snow water equivalents by river basin. Hydrologists in the NWS River Forecast Centers use the airborne snow data to support spring snowmelt flood outlooks and water supply forecasts.

The airborne gamma radiation technology can also be used to make airborne soil moisture measurements. Once a flight line is calibrated, analysts at the Center use the airborne gamma data to infer soil moisture in the upper 20 cm of soil over the flight line with an error of approximately four percent soil moisture. Hydrologists at NWS River Forecast Centers use airborne soil moisture measurements to support various operational hydrology programs. Moreover, researchers from various Federal agencies use airborne soil moisture data to support a number of interdisciplinary research projects.

Satellite hydrology program

The Center's NOAA polar orbiter satellite receive station in Minneapolis captures the live AVHRR data as the satellites fly over at approximately 800 km above the earth's surface. From Minneapolis, the receiving station can capture AVHRR data from satellite passes over both the east and west coasts of the U.S. The data are then radiometrically calibrated and geographically registered to one of 24 "windows" for the U.S. (including Alaska) and Canada, each of which is approximately 1000 km by 1000 km (Fig. 1).

Satellite data analysts at the Center use bands 1, 3 and 4 of the AVHRR data to classify the image into snow, no-snow, or cloud. The classified image is then exported to a geographic information system where digital elevation model (DEM) data and hydrologic basin boundary maps reside. Automated procedures calculate percent snow cover in each of approximately 5 elevation zones for each of more than 500 major river basins in the western U.S. and Alaska. Additional windows contain basin boundary data sets and are used to map snow cover for the upper Midwest, the Great Lakes, New England, and Canada.

Airborne and satellite snow cover products

The NOHRSC generates national and regional snow cover products weekly during the snow cover mapping season (Table 1). Analysts at the Center use ground-based snow data from various Federal and state agencies, airborne snow water equivalent data, and satellite areal extent of snow cover data to generate snow cover products used by field hydrologists. Automated procedures distribute the alphanumeric and image snow cover products derived from the airborne and satellite data over both the National Weather Service computer network and other electronic mail networks. Field hydrologists receive the airborne and satellite snow cover products approximately two hours after the snow survey aircraft land anywhere in the country or two hours after either the

– *continued on page 12*

Table 1. Data products of the National Operational Hydrologic Remote Sensing Center.

PRODUCT	DATA TYPE	AREA	FREQUENCY
Satellite Snow/No-Snow Reclassified Image	Image	All Windows	Each Image
Satellite Snow/No-Snow Slide Show	Image	All Windows	Each Image
U.S. Satellite Snow Cover Map	Image	U.S.	Wednesday
West-wide Snow Water Equivalent (SWE)	Image	11 Western States	Wednesday
West-wide SWE Deviation From Normal	Image	11 Western States	Wednesday
Average Weekly Surface Temperature	Image	U.S.	Wednesday
Seasonal Melting Degree-Days	Image	U.S.	Wednesday
Upper Colorado River Basin SWE	Image	Upper Colorado River	Wednesday
Upper Colorado River Basin SWE Deviation from Normal	Image	Upper Colorado River	Wednesday
Columbia River Basin SWE	Image	Columbia River	Wednesday
Columbia River Basin SWE Deviation from Normal	Image	Columbia River	Wednesday
Satellite Snow Cover	Image	Windows 01, 02 , 04, 12	Wednesday
Airborne SWE Contour Map	Image	Survey	Survey
Airborne SWE Basin Map	Image	Survey	Survey
Airborne SWE/Snow Cover Composite	Special	Lake Superior	Mid-March
Airborne SWE/Snow Cover Composite	Special	Lake Ontario	Mid-March
Satellite Snow Cover by Basin	Alphanumeric	All Windows	Each Image
Airborne SWE by Flight Line	Alphanumeric	Survey	Survey
Airborne SWE by Basin	Alphanumeric	Survey	Survey
Information Statements	Alphanumeric	U.S.	Periodic
Seasonal Historical NOHRSC CD-ROM	Image/ Alphanumeric	All Windows/All Data	Annual

The NOAA Paleoclimatology Program

Using evidence from the past as a key to understanding and predicting future climate change

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Paleoclimate data play a key role in efforts to understand climate processes and the potential for future climate change by extending the long-term baseline of observations of past climate change. These data also provide evidence of how the climate system has operated under boundary conditions (e.g., atmospheric trace gases concentrations, insolation) substantially different from today. The baseline of observations can be extended substantially in both space and time beyond the historical record of written observations, which spans only the last few centuries, by using paleoclimate data derived from ice cores, tree rings, and marine and lake sediments (Fig. 1).

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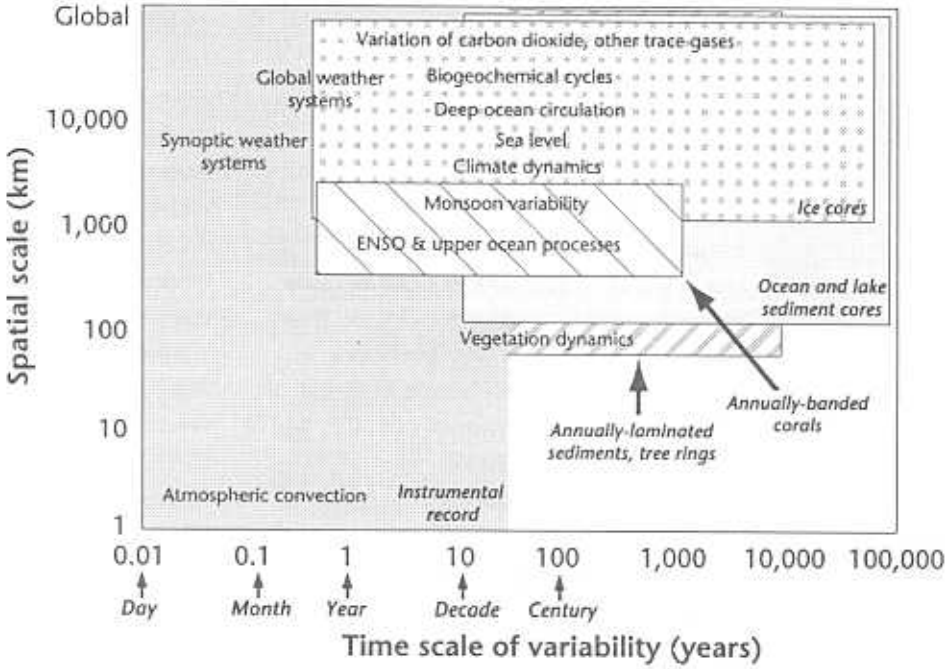
To provide data management and data services for these natural records of climate variability, the NOAA Climate and Global Change Program established the NOAA Paleoclimatology Program as one of its core programs in 1991. Located at the National Geophysical Data Center in Boulder, Colorado, the program is comprised of a small team of research paleoclimatologists, data managers, and computer specialists. In 1992, following recommendations of the U.S. Committee on Geophysical Data, and with the endorsement of the International Council of Scientific Unions, the NOAA Paleoclimatology Program was designated as the World Data Center-A for Paleoclimatology.

A primary goal of the NOAA program is to facilitate the development of a science-driven data management system that integrates all types of paleoenvironmental data. These data are needed by the international global change community to identify the patterns, processes, and causes of past climate and environmental change. To accomplish this goal, the Paleoclimatology Program works closely with the International Geosphere-Biosphere Program (IGBP) PAGES office in Bern, Switzerland (see box, facing page) and with other organizations that manage paleoclimate data.

In the United States the program works closely with the U.S. National Science Foundation, the U.S. Geological Survey, and components of the NOAA Climate and Global Change Program to assure that all data generated with U.S. federal assistance can be placed in the public domain quickly and in a form that is easy to share.

The program actively encourages formal efforts to coordinate with specific proxy data communities to build new or expanded databases. Examples of compilation efforts already underway include those for fossil pollen data, packrat midden data, plant macrofossil data, ice-core data, coral data, tree-ring data, paleosol data, paleovegetation data, past sea-surface data, lake level data, and climate model boundary conditions and simulations.

Characteristic space-time scales of earth system processes



▲ Figure 1. The spectrum of climate variability for different earth system processes. The boxes (labeled in italics) show the approximate range of resolvable variance for four different types of proxy paleoenvironmental data. The shaded area on the left represents the range of resolvable variance of the instrumental record. Since this record is only 150 years long, it can only resolve cycles with periods of less than about 30 years.

Climate changes of the last 2000 years

To improve the baseline of natural climate variability needed to unambiguously separate natural from anthropogenic (i.e., greenhouse) climate change, the Paleoclimatology Program places particular emphasis on the record of the last 2000 years. Over this interval, quantitative reconstructions of climate variables can be used to extend the climate record farther back in time well beyond the limit of the instrumental record.

In addition to organizing and making available existing data sets, the

NOAA Paleoclimatology Program sponsors an extramural program of data cooperatives and research. Data cooperatives are designed to improve the organization and distribution of essential data within the paleoclimate community. Extramural research projects are funded to focus additional effort in climatically sensitive areas, geographic regions where data coverage is poor, or on types of proxy data that are particularly valuable in efforts to understand climate processes and predict future climate change.

The IGBP Past Global Changes Program

Recognizing the importance of paleoclimate data in the study of earth system processes, the International Geosphere-Biosphere Program (IGBP) established the Past Global Changes Program (PAGES) as one of its five core programs. Initially, PAGES will focus on two temporal data streams, each designed to improve our understanding of the causes and effects of natural climate change.

Stream I concentrates on the paleoclimate record of the last 2000 years. This interval includes the Little Ice Age (an interval when surface temperatures in Europe were colder than today), and is particularly useful in extending the baseline of natural climate variability.

Stream II spans the last 20,000 years of earth history, and includes the last glacial maximum when large ice sheets covered parts of the continents. By analyzing the last 20,000 years, scientists can observe two extreme states in earth climate and determine how the climate system responds to large abrupt changes in climate forcing.

As a data repository for PAGES and as World Data Center-A for Paleoclimatology, the NOAA team is committed to sharing data sets and working with the international scientific community.

Further information about PAGES is available in *The PAGES Project: Proposed Implementation Plans for Research Activities.* Global Change Report 19, International Geosphere Biosphere Program, Stockholm, 1992)

The Paleoclimate Model Intercomparison Project

Paleoclimate observations are also used in process-oriented studies, to improve numerical climate models. One test of a good numerical model is its ability to simulate not only the present climate, but past climate when boundary conditions such as insolation and atmospheric trace gases were different. A good model has the correct sensitivity to changes that we know have occurred, for example, the 70 ppm increase in atmospheric carbon dioxide that occurred between 15,000 and 10,000 years ago (Fig. 2).

By comparing model simulations with paleoclimate observations we can assess and improve the performance of climate models. Toward this goal, a large international effort has been established to compare the ability of 12 major climate models to simulate known climatic conditions at selected times in the past. The NATO-sponsored Paleoclimate Model Intercomparison Project (PMIP) has recently designated the Paleoclimatology Program to archive and distribute its digital boundary conditions data sets (e.g., sea surface temperatures, terrestrial ice sheet height and extent, land surface properties) for model simulations of 6000 and 18,000 years before present. The data center also will work closely with PMIP to provide paleoclimate estimates that can be used in assessing the simulations.

Improving the database of paleoclimate observations

Types of data archived and distributed by the NOAA Paleoclimatology Program include quantitative estimates of climate variables such as temperature, precipitation, and atmospheric compo-

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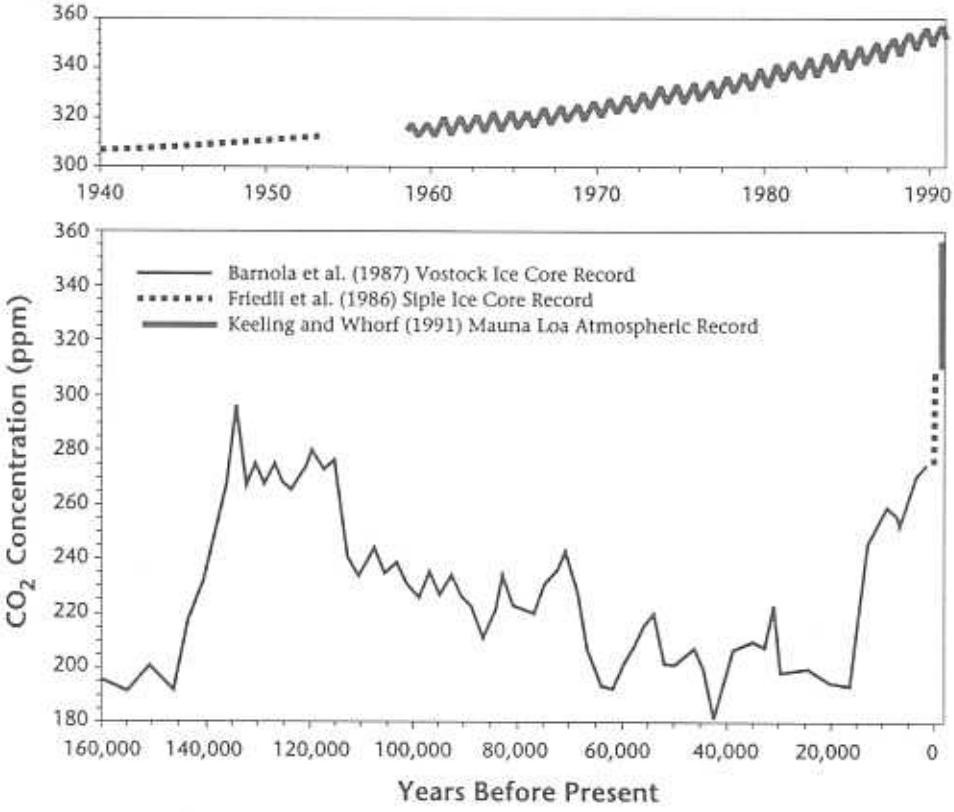

▲ **Figure 2.** The long-term "baseline" of changes in paleo-atmospheric carbon dioxide concentration over the past 160,000 years from the Vostok Ice Core Record (lower window only), and the post-industrial changes in carbon dioxide from the Siple Ice Core and Mauna Loa Atmospheric Record (lower window and expanded view in upper window). [Barnola, J.M. et al., 1987. *Vostok ice core provides 160,000-year record of atmospheric CO_2,* Nature 329:408-414; Friedli, H. et al., 1986. *Ice core record of $^{13}C/^{12}C$ ratio of atmospheric CO_2 in the past two centuries.* Nature 324: 237-238; Keeling, C.D. and T.P. Whorf, 1991. *Mauna Loa atmospheric CO_2 - Modern record.* In T.A. Boden, R.J. Sepanski, and F.W. Stoss (eds.), Trends '91: A Compendium of Data on Global Change. ORNL/CDIAC-46, 12-15.]

Paleoclimatology program, from page 7

sition (trace gases and aerosols), and the raw data from which the estimates were derived. Recognizing the importance of providing raw as well as derived data sets, NOAA paleoclimatologists have organized the data archives to distinguish:

- primary data (e.g., raw tree-ring measurements, fossil counts, isotopic measurements);
- secondary data developed from the raw data (e.g., tree-ring chronologies, fossil percentages, isotopic ratios as a function of age); and
- tertiary information inferred from the primary and secondary data (e.g., paleoclimate estimates, sea-surface temperature or paleovegetation reconstructions).

Also archived are some modern calibration data needed to convert primary and secondary data into quantitative estimates of past climate, ocean, or biosphere conditions; time series of hypothesized climate forcing (e.g., solar, volcanic, trace-gas, or astronomical changes); climate boundary conditions through time (e.g., ice extent and height, land surface characteristics); and output from atmosphere, ocean, and biosphere models.

Online access to paleoclimate data

A primary goal of the NOAA Paleoclimatology Program is to make up-to-date versions of its data sets readily available to the scientific community in easy-access formats at minimal cost. In some cases this involves the distribution of data diskettes and tapes. Because the research community works on several different types of computer platforms, the Paleoclimatology Program regularly distributes ASCII data diskettes in DOS, Macintosh, and UNIX formats.

In the fall of 1992, the program began to experiment with anonymous FTP as a means to distribute data rapidly at the lowest possible cost. Paleoclimate data are particularly appropriate for electronic transfer because the data sets are relatively small. Small data sets are easily stored online and transferred rapidly. At present, 98% of the data sets are available online via the Internet (see sidebar). The response from the community so far has been enthusiastic, and already the electronic flow of data has matched the rate at which data are transferred through the mail.

Using the expertise of NGDC's Information Services Division, NOAA has installed an improved version of anonymous FTP (developed at Washington University in St. Louis) that provides users accessing the system with additional information and help, and provides NOAA with accounting information to determine when the system is being used, what types of data are being transferred, and to what locations. The Paleoclimatology Program is experimenting with platform independent compression utilities that will make the storage and transfer of data even more efficient as the volume of data increases.

PaleoVu: A tool for accessing and visualizing paleoclimate data

To help meet the scientific community's need for access to data in a format that is easy to use and analyze, the Paleoclimatology Program is developing a data access software package called PaleoVu. A graphical tool for data access and display, PaleoVu will enable users to browse through and visualize all archived paleoclimate datasets. Versions of PaleoVu for different platforms are being developed. The version for Microsoft Windows is nearly completed, and versions for the Macintosh and for workstations running Open Look (the X Window-based graphical user interface for UNIX) will follow soon afterward.

PaleoVu will display data geographically as maps of site locations and/or mapped reconstructions of paleoenvironmental conditions for select time intervals. The user will be able to select data by data type, region, or temporal coverage; preview data as graphs; and then extract data for export in user-prescribed formats. A prototype of PaleoVu will be released later in 1993.

For further information about the products and services of the NOAA Paleoclimatology Program, please contact: David Anderson, NOAA Paleoclimatology Program, National Geophysical Data Center, NOAA/NESDIS E/GCx3, 325 Broadway, Boulder, CO 80303. Telephone: 303-497-6237, Fax: 303-497-6513, Omnet: PALEO.WDCA, Internet: dma@mail.ngdc.noaa.gov ■

Connecting with the NOAA Paleoclimatology Program

To look at some of the data sets offered by the NOAA Paleoclimatology Program, or to examine the FTP server developed by Washington University, try connecting to NGDC's anonymous FTP server via Internet.

At a computer connected to Internet, type:

FTP NGDC1.NGDC.NOAA.GOV
-or-
FTP 192.149.148.121

Enter login name: **anonymous**
Enter password: **(your e-mail address)**
(If you are operating an older system without a full screen display, or encounter problems, enter a minus sign before your e-mail address)
You should now see the prompt: **FTP>**

Sample commands:
FTP> cd paleo
(change to /paleo directory)

FTP> ls
(display data file list on screen)

FTP> cd climap18
(change to the CLIMAP 18,000 BP data directory, one of the data sets archived by the Paleoclimatology Program)

FTP> get climap18.readme
(copy readme file to your computer. This file contains summary information about the structure, organization, and sources of the data)

FTP> mget sst*
(copy all sea surface temperature (SST) data files to your computer)

FTP> cd
(change back to the root directory)

FTP> cd pub
(change to the public directory, where you have write permission to put files on NGDC's computer)

FTP> put mydata
(send to NGDC your file "mydata", containing data that you want to contribute to NGDC.)

FTP> quit
(end FTP session)

The NOAA National Data Centers/ Centers of Data Workshop

A review of NOAA environmental data holdings and services

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NOAA/OAR

Toward the Year 2000 NOAA Data System

During the first week of December 1992, NOAA's data management community gathered in Bethesda, Maryland, to continue planning the modernization of NOAA's environmental data and information management system. This National Data Center/Centers of Data Workshop was a follow-on to the Data Management Workshop held in spring 1992 in Boulder, Colorado, that laid the groundwork for an agency-wide upgrade of the data management infrastructure.

In response to increasing needs for accurate, reliable, and documented environmental data sets, NOAA is developing plans for applying modern information technologies to make its vast treasury of long-term Earth system measurements more readily available. In addition to safeguarding these valuable national assets for future generations, NOAA's data system modernization will enhance the quality of its data holdings and ensure that researchers, educational institutions, the commercial sector, and the general public can find and access the environmental data and information they need.

Since the spring meeting, NOAA's line offices and major crosscutting programs have been developing an agency description of current scientific data management activities and future requirements. The goal of this meeting was to define organizational entities that could provide these advanced data services to the wide variety of present and future users.

Captain Carl Fisher, Executive Officer of the Earth System Data and Information Management (ESDIM) Program, opened the meeting and presented the program background and the workshop goals. He also was moderator of the workshop.

Gregory Withee, Acting Assistant Administrator for the National Environmental Satellite, Data, and Information Service (NESDIS), provided an overall vision of the NOAA Data System to be in place by the end of this decade. He was joined in this presentation of future data services by senior managers from the other NOAA line offices: Ned Ostenso, Assistant Administrator for the Office of Oceanic and Atmospheric Research (OAR), Bob Landis, Deputy Assistant Administrator for the National Weather Service (NWS), Mel Briscoe, Deputy Assistant Administrator for the National Ocean Service (NOS), and Glen Flittner, Senior Scientist of the National Marine Fisheries Service (NMFS).

Each line office representative reiterated the importance of scientific data in their operations and in the future performance of their mission. Each speaker provided a unique view of how future data management might be accomplished in their scientific discipline. They all recognized the need for greater interactions among Earth science disciplines, and that the distinction between real-time and retrospective data is rapidly disappearing.

Vernon Derr from the Office of the Chief Scientist reviewed NOAA policy on scientific data management. He identified the key aspects of the policy and the impact on NOAA scientists. First, observations of the Earth system must support future generations as well as the immediate work; second, scientists must make the data available to the general community within a reasonable length of time; and last, NOAA must make its data available without cost to NOAA scientists and for the cost of reproduction to others. The remainder of the workshop was structured to suggest organizational entities that could provide a broader set of services to an increasing number of users with more sophisticated requirements.

The management of NOAA's extensive environmental data is currently the responsibility of all elements of the agency. Presentations were made to describe the current and projected services to be provided by NOAA's three National Data Centers—the National Climatic Data Center (NCDC), the National Geophysical Data Center (NGDC), and the National Oceanographic Data Center (NODC). The speakers described the types of environmental data currently under their responsibility and the many data services provided to numerous and diverse data user groups.

Many of NOAA's line offices provide data services for more focused interests. Representatives from each of these Centers of Data made presentations on their role in NOAA data management, the users of the services, and the types of services they provided. In aggregate, the holdings of the Centers of Data operated by the NOAA line offices match the volume and in some instances the longevity of those of the National Data Centers. For example, the Tides and Water Level Center of NOS and the Fisheries Statistics Center of NMFS provide ongoing environmental data services based on unique data sets going back in some cases to the early 1880s.

Workshop presentations documented that each NOAA line office and major crosscutting program has as part of its core mission making environmental measurements of the planet Earth. These measurements are the foundation for the execution of NOAA's mission to monitor, understand, and predict the Earth's processes. The records are constantly updated, quality controlled, and safeguarded. These records often are

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Data centers workshop, from page 9

maintained in both the National Data Centers and the line office Centers of Data, which have unique expertise in the particular data or phenomena. All centers continue to enhance the data sets through the scrutiny of scientists working with the data and adding to the quality control information.

The challenge facing NOAA is to make the vast and varied stores of Earth system data available and useful to business interests, environmental researchers, educators, and the general public. The challenge to the workshop participants was to determine the elements of the data management system that would be responsible for providing the access to the users.

Workshop participants separated into four working groups to review the ongoing data management activities presented by the line office representatives. Definitions for Data Centers and Centers of Data were discussed, functional differences between the two entities were debated, and allocations of NOAA-wide versus line organization responsibilities were recommended. The working groups recommended upgrading a number of facilities to the level of National Data Centers to better meet data requirements and to safeguard the data for future generations. They recommended lists of Centers of Data that should be maintained or created, and suggested a list of entities that should remain as line office responsibilities.

The final recommendation of the workshop was that a number of existing and proposed data management facilities be included as elements of the year 2000 NOAA Data System. The consensus was that these facilities could meet the needs of data users both inside and outside the agency that are projected by the end of the decade. These facilities would work closely with the National Data Centers to ensure that both the data needs of the current users and future generations are adequately met.

The final recommendation also included suggested guidelines for the operations of National Data Centers as well as NOAA's Centers of Data. The importance of all facilities in NOAA that maintain the many data sources was recognized, as was the need to include their data assets in some NOAA data servicing entity. Workshop participants expressed concern that many of the current scattered but important environmental activities lack the resources and expertise to service requests for their data. Workshop participants agreed that the modernized NOAA Data System must be designed to ensure that all data are collected, archived, and made accessible according to accepted standards, and that all data requests must be serviced in a timely way.

The workshop was another step in designing NOAA's future scientific data management system. The output from the workshop will become an integral part of modernization planning. In the spring of 1993, ESDIM will sponsor another workshop to bring together the users of the NOAA Data System with the data management professionals proposing to meet those data needs. At that time, the Modernization Plan for NOAA's Earth System Data and Information Management, currently being developed with participation from all line offices, will be ready for general review. ■

Ocean data archaeology, from page 2

chemical data files were produced and sent to 25 oceanographic data centers and collecting institutions around the world. In October 1992, the NODC presented a more comprehensive set of data distribution maps in a publication titled *National Oceanographic Data Center Inventory of Physical Profiles: Global Distributions by Year for All Countries*. This publication shows the geographic and temporal distribution of nearly 3.1 million ocean temperature or temperature-salinity profiles in NODC's data archives as of June 1992. Copies have been distributed to oceanographic institutions and researchers around the world.

As a result of these initial efforts, the U.S. NODC/WDC-A has begun to receive significant new data accessions that enhance the geographic and temporal coverage of NODC's data holdings (Fig. 1). To date these data submissions—primarily oceanographic stations and bathythermograph temperature profiles—have been received from five countries and from ICES (Table 1). Because of the substantial processing time required to check these historical data for duplicates and other problems, some of these data have not yet been incorporated into the NODC master archives.

The U.S. NODC provides users with access to a global oceanographic database that currently totals over 40 gigabytes. About 1.2 gigabytes of *in situ* data are added to the archive each year. The anticipated influx of new data types such as acoustic Doppler current profiler (ADCP) data and increasing volumes of ocean satellite data will boost NODC's data holdings to about 300 gigabytes in 1995. The huge increase in the volume of recent data, however, does not diminish the value of older historical ocean data. A vigorous ocean data archaeology effort can help to significantly enhance the ocean data record in past decades.

These efforts will rely on data exchange mechanisms of the Intergovernmental Oceanographic Commission and the World Data Center system. To meet the ambitious goals of this project, however, the scope and efforts of this system must be expanded and other international exchange mechanisms such as bilateral agreements will be required. The Global Oceanographic Data Archaeology and Rescue Project will build on existing data archaeology programs at WDC-A, WDC-B, WDC-D, JODC, ICES, and other institutions.

The enhanced oceanographic databases that will result from this project will be made available as ASCII files on CD-ROM. This provides the least expensive and most efficient means of distributing these large data sets. The World Data Center-A for Oceanography has volunteered its services to coordinate this activity. WDC-A will work with other ocean data centers and research institutions to compile the most complete oceanographic databases possible and will arrange for the production and distribution of the resulting databases on CD-ROM and magnetic media. ■

Marine minerals bibliography and database on CD-ROM

The National Geophysical Data Center has issued a CD-ROM containing a comprehensive, computerized bibliography and geochemical database of offshore marine mineral deposits. The bibliography and database were a cooperative effort of the Ocean Minerals and Energy Division of NOAA's National Ocean Service and the Office of International Activities and Marine Minerals of the Department of Interior's Minerals Management Service.

The NGDC Marine Mineral Bibliography includes references to present-day marine deposits of ferromanganese nodules and crusts, placers/heavy minerals, phosphorites, and polymetallic sulfides. Citations date from 1831 through 1990.

The Marine Minerals Database contains geochemical analyses and auxiliary information primarily on ferromanganese nodules and crusts, but also contains some data for heavy minerals. Data sources include the Scripps Institution of Oceanography manganese nodule analysis file, a ferromanganese nodule analysis file of the Centre National pour l'Exploitation des Oceans, ferromanganese crust data compiled by the U.S. Geological Survey, and data coded at NGDC from the scientific literature.

The ferromanganese nodule/crust portion of the database contains over 140,000 elemental/oxide analyses. Approximately 1400 heavy mineral analyses coded at NGDC are included, as well as data from the U.S. East Coast contributed by the U.S. Geological Survey. Access software is provided with the disc.
Contact: NGDC

Proceedings of the Ocean Climate Data Workshop

The Proceedings of the Ocean Climate Data Workshop are now available. The workshop was organized by the National Oceanographic Data Center and hosted by NOAA and NASA at the Goddard Space Flight Center, February 18-21, 1992.

Billed as "A dialogue between scientists and data managers," the workshop was held to begin planning for improved data delivery systems needed by researchers studying the role of the oceans in climate change. Copies of the 408-page proceedings are free while supplies last.
Contact: NODC

Data products and services

Geosat Southern Ocean data on CD-ROM

A recently declassified set of data from the Geodetic Mission of the U.S. Navy Geodetic Satellite (Geosat) has been released by the National Oceanographic Data Center on two CD-ROMs. The data are in the Geophysical Data Record (GDR) format. These Geodetic Mission GDRs were produced by the Geosciences Laboratory of NOAA's National Ocean Service.

The data cover the Southern Ocean from 30°S to 72°S and span the period from March 30, 1985 through September 30, 1986. Unlike the Geosat Exact Repeat Mission conducted during 1986-1989, the Geosat Geodetic Mission was designed to produce a tightly spaced ground track pattern (typically 3-4 km at 30°S). Therefore, this data set provides coverage of the ocean surface that is much denser than that produced by other satellite altimeters. Disc 1 of the two-disc set contains the 1985 data; disc 2 contains the 1986 data.
Contact: NODC

CONTACT POINTS

For further details and ordering information about any of the NOAA products or services listed here or elsewhere in this issue of the Earth System Monitor, *please contact the appropriate source listed below.*

National Climatic Data Center (NCDC)
Climate Services: 704-259-0682
FAX: 704-259-0876
Satellite Services: 301-763-8399
FAX: 301-763-8443

National Geophysical Data Center (NGDC)
303-497-6958
FAX: 303-497-6513

National Oceanographic Data Center (NODC)
202-606-4549
FAX: 202-606-4586

NOAA Earth System Data Directory
202-606-4548
(Gerald Barton)
FAX: 202-606-0509

NOAA Central Library
Reference Services:
301-443-8330
FAX: 301-443-0237

Gridded multibeam bathymetric data

The Ocean Mapping Section of the National Ocean Service's (NOS) Coast and Geodetic Survey is producing gridded data sets of multibeam bathymetry in the U.S. Exclusive Economic Zone (EEZ). These digital data sets, which are the same used to create NOAA's 1:100,000-scale published maps of areas in the EEZ, are now available through the National Geophysical Data Center. NGDC currently has 61 of these NOS data sets available and new data sets will be added as they are received.

Each data set covers an area 1/2 degree of latitude by 1 degree of longitude, except in the Alaskan EEZ where the width is 1-1/2 degree. NOAA multibeam vessels survey from depths of 150 m out to the 200-nautical mile EEZ limit. The surveys cover 100% of the seafloor. Depths are accurate to within 1% of true depth and have a positional accuracy of 75 m. The raw data are gridded at 250 m intervals to produce the final data sets. A flier listing available data sets can be provided on request.
Contact: NGDC

Chesapeake Bay land cover classification data

A data set showing changes in land cover for the Chesapeake Bay area over the 5-year interval from 1984 to 1988-89 is available from the National Oceanographic Data Center. This data set is the result of a multiyear effort that has focused on the Chesapeake Bay as a prototype for the CoastWatch Change Analysis Project (C-CAP) of the NOAA Coastal Ocean Program's Estuarine Habitat Studies Program.

The Chesapeake Bay Land Classification Data Set constitutes one of the largest change detection efforts ever attempted, covering an area of approximately 30,000 square miles with a source data resolution of 30 m by 30 m. The data set is held on three magnetic tapes and includes: (1) analysis of four Landsat Thematic Mapper scenes from 1984, (2) analysis of four Landsat Thematic Mapper scenes from 1988-89 for the same area, and (3) analysis of the resulting change between 1984 and 1988-89. The land cover analyses distinguish 14 land cover classes. The change analysis resulted in 81 classes.
Contact: NODC

Remote sensing of snow cover, from page 9

morning or afternoon overpass of the NOAA polar orbiting satellite. For windows in the West, automated procedures in a geographic information system map areal extent of snow cover by elevation zones defined by NWS hydrologists in the River Forecast Centers. Specifically the georegistered, reclassified satellite images are combined with hydrologic basin boundary vector files and digital elevation data to map the snowpack by basin and elevation. Personnel at the Center generate areal extent of snow cover maps from AVHRR and GOES satellite data for all 24 windows approximately once a week, the effect of cloud contamination notwithstanding.

The Center has recently developed the capability to generate and to distribute, in near real-time, raster (or grid-cell) snow water equivalent data sets using: (1) ground-based point snow water equivalent data, (2) airborne flight line snow water equivalent data, (3) satellite areal extent of snow cover data, (4) digital elevation data, and (5) forest canopy cover data sets. By combining these diverse data sources, this new product makes it possible for hydrologists to extract the maximum information from the available data sets and to incorporate the remotely sensed hydrology products into conceptual hydrologic models used in operational and research hydrology programs. The NOHRSC also issues weekly average and seasonal melting degree-day temperature maps of the United States to help hydrologists determine the condition of the snowpack and the potential for snowmelt.

Recently, a spatial, ground-based, snow estimation model has been modified to ingest airborne snow water equivalent data. The addition of the airborne data into the model significantly improves the average snow water equivalent estimate, particularly in the western United States where ground-based snow data are sparse and highly variable. Although the NOHRSC exists primarily to generate and to distribute regular, operational, remotely sensed hydrology products, it also provides support to various interagency research programs and develops new products to meet specific requirements of its users.

Access to Center products

The airborne and satellite alphanumeric and digital image snow cover products are distributed electronically to end-users, in near real-time, and used in operational and research hydrology programs in the U.S. and Canada. Each evening, automated routines send notification to end-user FAX machines of newly generated snow cover maps and products. These data sets are then posted to the NOHRSC's computer bulletin board system. Users can access directly the product database using dial-up telephone lines or the Internet network. Field hydrologists can further analyze the digital, georeferenced, snow/no-snow/cloud images on image processing systems or geographic information systems to support user-specific projects or programs. Maps, databases, and a user's guide are available that give: (1) the current airborne flight line network, (2) the basins and elevation zones mapped by satellite data, (3) the details of the airborne and satellite snow measurement techniques, and (4) the procedures to access electronically the airborne and satellite snow cover products in near real-time.

Each summer, the NOHRSC distributes a CD-ROM that contains the previous season's airborne and satellite snow data and products. The CD-ROM includes: (1) airborne snow water equivalent data and the digitized flight line network, (2) calibrated AVHRR and GOES satellite data used to map snow cover, (3) the classified snow cover images, (4) national and regional snow cover image products, and (5) ancillary data sets including digital elevation data, digitized NWS basin boundaries, and the alphanumeric results of the satellite snow cover mapping by basin and by elevation zone.

The Center is located in Minneapolis, Minnesota, but is administratively attached to the National Weather Service Office of Hydrology located in Silver Spring, Maryland. For further information about the NOHRSC or its products, contact the Center Director, Dr. Thomas R. Carroll, at 612-725-3039 or write: National Operational Hydrologic Remote Sensing Center, Office of Hydrology, National Weather Service, NOAA 6301 34th Avenue South, Minneapolis, Minnesota 55450-2985 ■

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