Vol. 8, No. 1 ● September 1997

EARTH SYSTEM MONITOR

NODC Altimetry Lab tracks 1997 El Niño

Operational program improves NWS seasonal forecasts

A guide to NOAA's data and information services

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U.S. DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration

Bob Cheney
Chief, Laboratory for Satellite Altimetry
National Oceanographic Data Center
NOAA/NESDIS

The TOPEX/POSEIDON (T/P) altimeter satellite, which was launched in 1992 as a research mission of the American and French space agencies, has recently become an integral part of NOAA's operational satellite system for monitoring the oceans. The transformation was achieved through the efforts of NODC's newest division, the Laboratory for Satellite Altimetry (LSA), working together with the Jet Propulsion Laboratory (JPL) and the Naval Oceanographic Office (NAVOCEANO). Since late 1996, the highly-accurate sea level observations provided by T/P have been available with a delay of only two days—fast enough to be included in the weekly ocean model run of the National Weather Service—and just in time to follow development of the 1997 El Niño (Figures 1 and 2).

NOAA's experience with satellite altimetry dates back to Geos-3 in 1975. At that time altimeter data were viewed largely as a means of determining the marine gravity field, and the program was thus sponsored by the National Ocean Service's (NOS) National Geodetic Survey. But as other altimeter missions were flown (Seasat in 1978; Geosat during 1985-89) and new applications were developed, the work expanded to include aspects of physical oceanography such as the Gulf Stream, sea level variability, and tropical ocean dynamics. In

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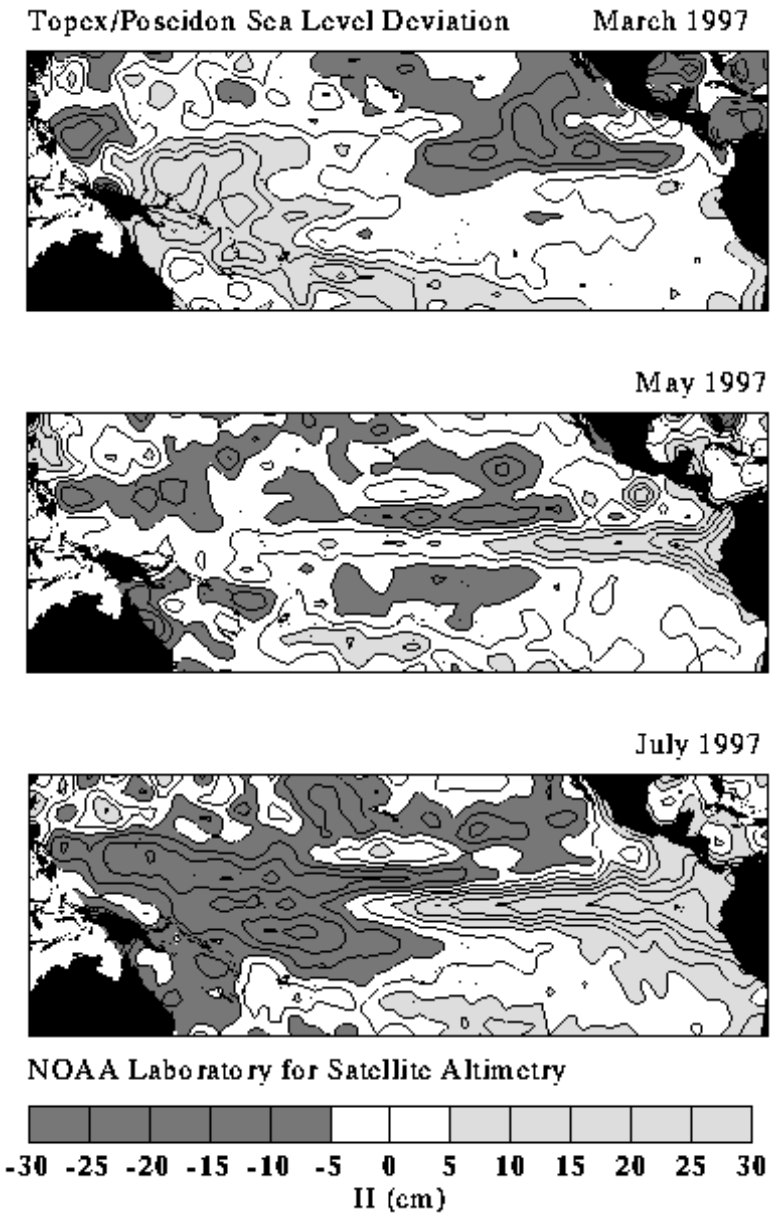
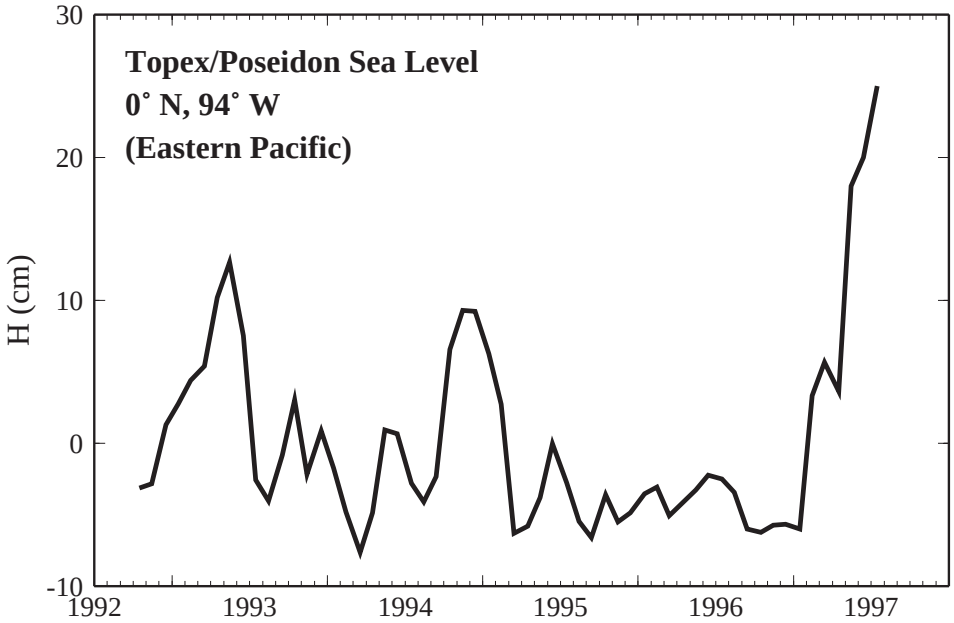


▲ **Figure 1.** A sample series of sea level deviation maps from TOPEX/POSEIDON showing evolution of the 1997 El Niño. The data are provided in near-real time (2-day delay) by the NODC Laboratory for Satellite Altimetry. Because of their high accuracy (5 cm), the T/P data are being assimilated in the NOAA/NCEP model to improve seasonal forecasts. Sea heights shown are relative to the 1992-95 mean. This sequence shows the ocean's response to changes in tropical winds. Sea level drops in the west and rises in the east, producing changes in ocean circulation and sea surface temperature which ultimately alter global patterns of rain and atmospheric temperature. For color maps at 10-day intervals, see *http://ibis.grdl.noaa.gov/SAT/near_rt/enso/topex_97.html*



▲ **Figure 2.** Sea level near the Galapagos Islands in the eastern equatorial Pacific measured by the T/P altimeter. The abrupt, 30-cm rise since the beginning of 1997 indicates the beginning of a warm, El Niño event. The July 1997 height of 25 cm is as high as during the 1982 El Niño, the largest warm event of the century.

NODC Altimetry Lab, *from page 1*
1991 the altimeter program was moved to the NOS Office of Ocean and Earth Sciences and finally in 1997 to the National Environmental Satellite, Data, and Information Service's National Oceanographic Data Center. The LSA is now a leader in many facets of altimetric applications, providing scientific analyses that range from maps of the ocean floor to determination of global sea level rise.

Most recently, the Lab's focus has been on improving the operational, near-real time flow of altimetric sea level data. The operational value of altimetry depends not only on the turnaround time, but also on the accuracy of the measurements.

For example, altimeter data from the European Space Agency's ERS-1 satellite (1991-96) were processed by NOAA in near-real time throughout the mission, but the quick-look satellite orbits contained large-scale errors of up to 1 meter. These data were therefore useful for finding the edges of mid-ocean eddies and fronts like the Gulf Stream, but they were not sufficiently accurate to be used in general circulation models of the ocean.

This is where the T/P satellite has provided a breakthrough. In addition to its precision altimeter, T/P carries a Global Positioning System (GPS) receiver which is capable of quickly determining the position of the T/P satellite to within a few centimeters. Once the JPL team learned how to use the GPS data as part of an automated orbit determination system, a new era in global ocean monitoring began.

The present T/P near-real time system is a model of interagency collaboration. JPL receives the raw altimeter data from the satellite several times a day and forwards them to NAVOCEANO, where an interim data set is constructed and stored. The next day, JPL uses GPS data from a global network of ground stations plus those from the T/P receiver to compute a precise satellite orbit. These refined altimeter observations are provided to NOAA's altimetry lab for further processing. An adjustment is first performed to remove large-scale errors remaining in the data. T/P sea level profiles are then compared to the previous 4 years of data along the same tracks. Finally, 2 days after the

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Laboratory for Satellite Altimetry
National Oceanographic Data Center
SSMC3, 3rd Floor, Room 3620
1315 East-West Highway
Silver Spring, MD 20910-3282
E-mail: rcheney@nodc.noaa.gov

EARTH SYSTEM MONITOR

The *Earth System Monitor* (ISSN 1068-2678) is published quarterly by the NOAA Environmental Information Services office. Questions, comments, or suggestions for articles, as well as requests for subscriptions and changes of address, should be directed to the Editor, Sheri A. Phillips.

The mailing address for the *Earth System Monitor* is:

National Oceanographic Data Center
NOAA/NESDIS E/OC1
SSMC3, 4th Floor
1315 East-West Highway
Silver Spring, MD 20910-3282

EDITOR
Sheri Phillips
Telephone: 301-713-3280 ext.127
Fax: 301-713-3302
E-mail: sphillips@nodc.noaa.gov

U.S. DEPARTMENT OF COMMERCE
William M. Daley, Secretary

National Oceanic and Atmospheric Administration
D. James Baker,
Under Secretary and Administrator

News briefs

New Lake Erie bathymetry to be displayed in museum

A new bathymetric map of Lake Erie will be displayed in the Great Lakes Science Center in Cleveland, Ohio, during the Ohio Lake Erie Conference, September 18 through September 20. The Conference will be hosted by the International Joint Commission for the Great Lakes and the Ohio governor's Lake Erie Commission. Focus will be geared toward environmental organizations, researchers and Great Lakes representatives, along with public officials from local, state, Federal and Canadian governments. The full color Lake Erie map will be available from NGDC in October, along with a CD-ROM containing downloadable imagery and data used in the compilation of the bathymetry.

NOAA seeks entries for a Bering Sea ecosystem metadatabase

This inventory of physical and biological data will help researchers, managers, students, fishermen, and the general public investigate and understand the complex ecosystem of the Bering Sea. The inventory will be presented in an indexed, annotated catalog (metadatabase) available through various mechanisms, including the World Wide Web (WWW). Those seeking more information or having knowledge of data that would enhance the metadatabase are urged to register through the WWW at URL *http://www.pmel.noaa.gov/bering/mdb/*, or contact Dr. Bern Megrey, NOAA/AFSC, 7600 Sand Point Way N.E., Seattle, WA 98115, USA, 206-526-4147, *bmegrey@afsc.noaa.gov*.

When completed, the metadatabase will address a serious deficiency identified in 1996 by the National Research Council. In their report on the Bering Sea ecosystem, the council flagged the lack of such a database as the one major impediment to studying the Bering Sea. Many different types of physical and biological data have been already collected, such as: single-point and gridded time series, repetitive observations from earth orbiting satellites, ocean surveys of physical and biological oceanographic significance, specimen collections, and historical records of animal population changes.

Data are available from at least the last century, and in the last two decades the Bering Sea has been the subject of close scrutiny by such major research programs as the Outer Continental Shelf Environmental Assessment Program (OCSEAP) and Processes and Resources of the Bering Sea Shelf (PROBES). What is needed, and what NOAA Environmental Services Data Information Management has funded through this project, is a single, stand-alone resource that will reference as much historical data as can be located.

Benefits will be immediate and continuous. Recently the Bering Sea's economic and biological significance has provided impetus for the proliferation of a number of active regional studies including: the joint North Pacific Marine Sciences Organization/GLOBal ocean ECosystems dynamics Climate Change and Carrying Capacity (PICES/GLOBEC CCCC) study and the Bering Sea Impacts Study; national studies (Bering Sea Fisheries-Oceanography Coordinated Investigation, Southeast Bering Sea Carrying Capacity, Bering Sea Ecosystem Study); and international research efforts (PICES/GLOBEC, and Japanese and Russian programs); these investigations are directed at understanding the dynamics of the Bering Sea ecosystem. All of these current programs have field and data collection components associated with them and are in a position to contribute to, and benefit from, the metadatabase.

ACCESS Project status

The development of the Accelerated Coastal Community Environmental Science Service (ACCESS) Project continues to progress. Discussions with Dr. Paul Dammann of NOAA's Atlantic Oceanographic and Meteorological Laboratory (AOML) have focussed on the details of the instrumentation and the implementation of the data operations structure. Dr. Dammann will draft the list of instruments and Michael Crane of the National Oceanographic Data Center (NODC) will prepare the text of the data capture, data processing, data distributing and data managing elements. The model for this project is the NASA Pathfinder Program with the active promotion of data distribution to constituents via the Web and other Internet pathways. The U.S. Environmental Protection Agency is funding this project to assure the protection of the reef track off the Port of Miami.

NGDC leads successful field expedition in Greenland

Dr. Jonathan Overpeck of the National Geophysical Data Center (NGDC) recently returned from southwest Greenland, where he led a successful effort to survey and sample lakes for use in reconstructing past variability in the circum-Labrador Sea region. This work, carried out in collaboration with the Geological Society of Denmark and Greenland, focussed on lakes that will yield annually-dated paleoclimate time series stretching back centuries. These series will allow the testing of key hypotheses regarding ocean and atmospheric variability in the North Atlantic region. The new time series should also provide the first definitive answer to the question of whether Norse settlements disappeared around AD 1500 in response to climate.

NSSDC agrees to participate in GOIN

Dr. Joe King, director of the National Space Science Data Center (NSSDC), and Dr. Herbert W. Kroehl of the National Geophysical Data Center (NGDC), recently held discussions at the NSSDC on the mutual benefit obtained through joint participation in the Global Observation Information Network's (GOIN) space environment pilot projects. Dr. King agreed to send data from the WIND satellite in near real-time for inclusion in the retrospective modeling project. The Solar-Terrestrial Environment Laboratory in Japan will then model the Earth's magnetosphere on an hourly basis and share the results with the GOIN partners. This will be the first real use of the GOIN established network connections.

NOAA librarian participates in national forum

The Federal Library and Information Center Committee (FLICC), a division of the Library of Congress, sponsored NOAA librarian Doria Grimes in attending the annual meeting of the White House Conference on Library and Information Services Task Force in Little Rock, AR from August 7-10, 1997. The results were a reaffirmation of decennial White House Conferences on libraries, the next one being in scheduled for 2001. Formal liaisons with other library advocacy groups were the secondary outcome. Mrs. Grimes represented federal libraries at this meeting.

NOAA Laboratory for Satellite Altimetry joins NODC

The National Oceanographic Data Center (NODC) welcomes its newest Division: the Laboratory for Satellite Altimetry. The transfer of this group from the NOAA National Ocean Service to the National Environmental Satellite, Data, and Information Service—the NOAA line office that includes the NODC and the other NOAA national data centers—had been pending for more than a year and finally became official on August 4th, 1997. The Laboratory consists of two groups and several visiting scientists:

Oceanography:
Robert Cheney (Division Chief)
Laury Miller, John Lillibridge,
C. K. Tai, John Kuhn

Geophysics:
Dave McAdoo, Karen Marks,
Walter Smith

Visiting scientists:
Carl Wagner, Femke Vossepoel, Jim Carton

The oceanography group specializes in sea level variability as it relates to ocean circulation and climate change, production of high-quality altimeter data sets (such as the new Geosat CD-ROMs), and operational assimilation in ocean models to improve El Niño forecasts. The geophysicists use the same data to derive maps of the marine gravity field, study the dynamics of the Earth's crust, and estimate global ocean bathymetry. Graphics, publications, data sets, and analyses can be found at the Lab's home page (*http://ibis.grdl.noaa.gov/SAT*), which is already linked to the NODC Web site (*http://www.nodc.noaa.gov*).

NODC Altimetry Lab, *from page 2*
observations were collected, a global record is constructed providing sea level deviations accurate to about 5 centimeters.

This operational system provides an effective monitoring tool for following phenomena such as El Niño, but the real payoff is using the T/P data to improve forecasts of oceanic and atmospheric conditions several seasons in advance. This long-sought NOAA goal has finally been achieved after years of developmental work by the LSA and NCEP (NOAA's National Centers for Environmental Prediction). Once processed to the level of sea level deviations, the T/P data are transmitted to NCEP where they are combined in a numerical ocean model with other observations such as wind, sea surface temperature, and upper ocean thermal profiles. Ocean conditions are updated each week and, when coupled to an atmospheric model, provide the basis for seasonal forecasts of sea surface temperature.

Assimilation of data from ships and buoys has been ongoing for several years but operational use of satellite altimeter data was only initiated at NCEP in early 1997. The altimeter data keep the ocean model from deviating too far from reality and result in more accurate forecasts. A specific example was during 1995-96, when salinity in the western Pacific was unusually low. Because little salinity data are available, the model drifted off substantially, causing sea level errors in the model of up to 10 cm. But tests showed that assimilation of the altimeter measurements would have corrected the situation, yielding a more accurate depiction of the surface circulation and better seasonal forecasts of sea surface temperature. Color maps of sea level from T/P and forecasts of sea surface temperature through early 1998 can be viewed at *http://ibis.grdl.noaa.gov/SAT*. Click on "1997 El Niño Viewed by TOPEX".

TOPEX/POSEIDON is not the first satellite altimeter to monitor El Niño. That distinction belongs to Geosat, which captured a dramatic sequence of events in the 1980s when the tropical Pacific oscillated between El Niño (warm) conditions in 1987 to a strong La Niña (cold) event the following year. The Geosat data were initially classified secret, so the NOAA altimeter lab was forced to operate in a secure environment at the John Hopkins Applied Physics Lab. Only after converting the secret altimeter data into unclassified measurements of relative sea level

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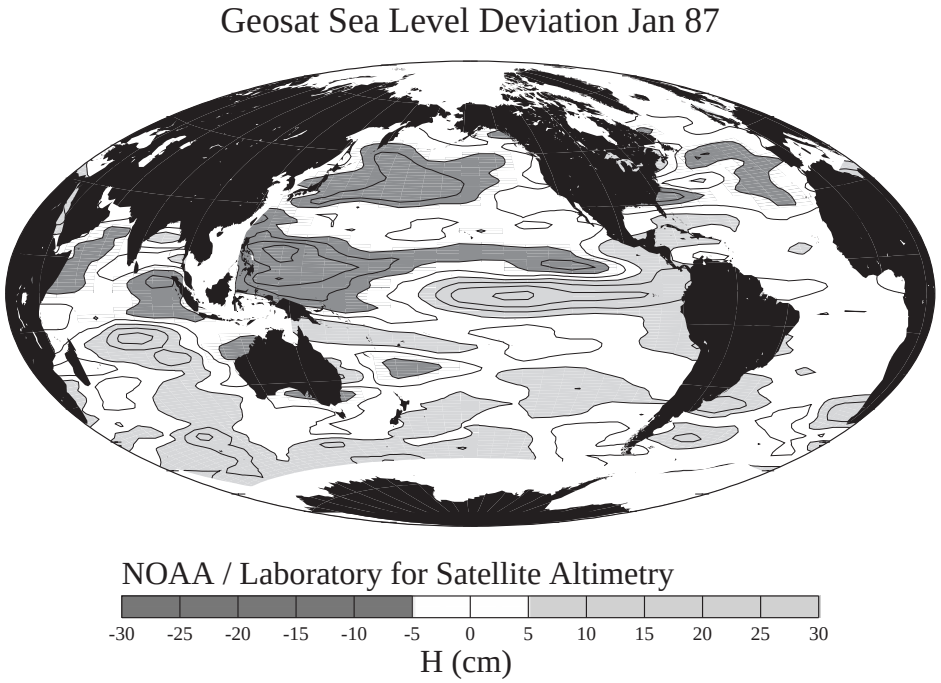


▲ **Figure 3.** A view of the Pacific Ocean on January 1987 constructed from Geosat altimeter data. High sea level extends 10,000 km along the equator with values up to 20 cm above normal for January. This is the signature of downwelling Kelvin waves, the ocean's response to anomalous westerly winds in the western Pacific which initiated the 1986-87 El Niño.

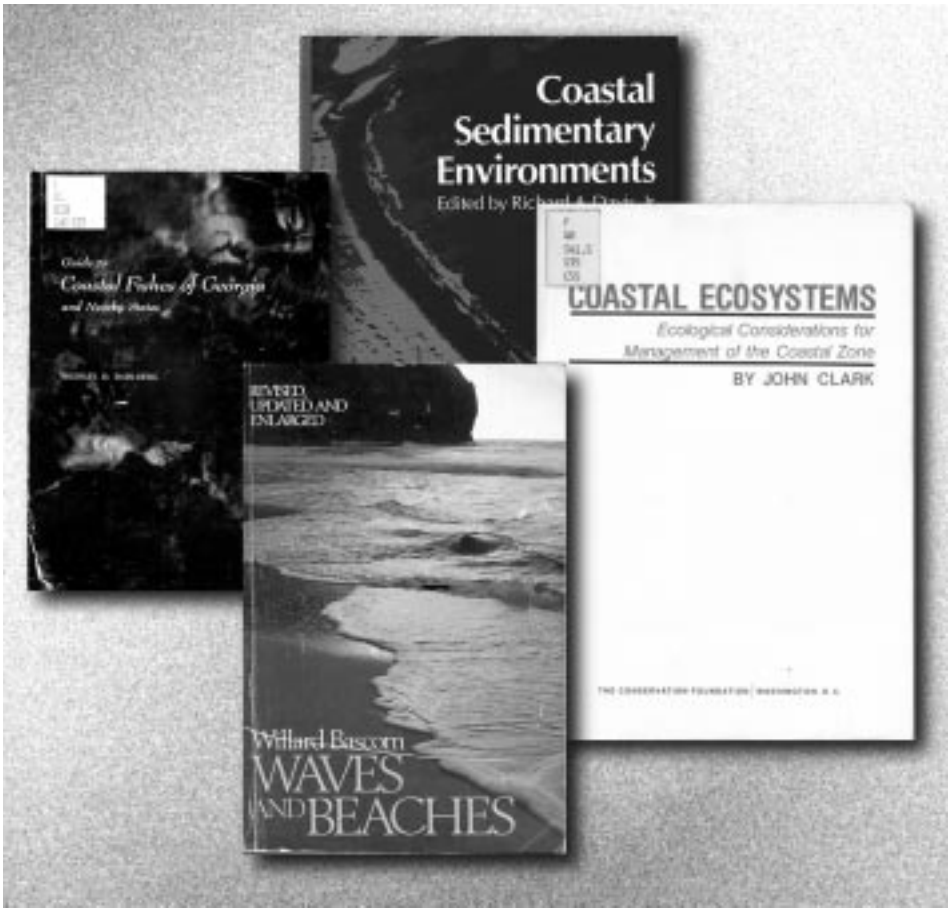
The NOAA Central Library and coastal ocean information

Unique historical and modern collections provide a wide variety of coastal information

Albert E. Theberge
NOAA Central Library
NOAA/NESDIS

The NOAA Central Library serves as a clearinghouse for sources of information for NOAA staff and researchers in the subject fields of oceanic and atmospheric research. On any given day, NOAA Reference Librarians field questions about hurricanes, tornadoes, yesterday's weather in Sioux City, Iowa, marine fisheries, coastal policies, or marine mining, for example. Some of these questions are answered in-house and others are referred to the appropriate agency or individual for response. As the coastal ocean initiatives gain momentum, the information resources of the NOAA Central Library and the satellite libraries of the NOAA-wide library system will play a key role in assisting those searching for this information. The NOAA Central Library can also serve as a focal point to expedite the flow of information among universities, industry, and other government agencies seeking to collaborate on coastal ocean projects.

The NOAA Central Library is the direct descendant of the first major technical library in the United States, the Coast and Geodetic Survey Library. It is the flagship library of the NOAA Library System and is uniquely situated to provide researchers and policy-makers with information concerning the coastal ocean on an unprecedented scale. Its collections cover the National Ocean Survey, the National Weather Service, the National Marine Fisheries Service, and the Office of Oceanic and Atmospheric Research. The NOAA Library is one of the few libraries in the world that is capable of meeting the needs of integrated research teams concerned with the physical, biological, geological, chemical, and meteorological aspects of the coastal ocean (Figure 1).



▲ **Figure 1.** The NOAA Central Library contains thousands of publications from the oceanic, atmospheric, and fisheries sciences. The above titles and other coastal science volumes are available from the Library's modern collection.

Not only does the NOAA Library system have the most up-to-date information on many of these subjects, but it also is the only library in the United States whose historic collections cover the inception of the Survey of the Coast, the establishment of national meteorological observing systems, and the beginning of fisheries studies in the coastal waters of the United States. The collection continues in an unbroken chain from the beginnings of the ancestral agencies through the NOAA of today.

The NOAA modern collection

Two copies of all NOAA publications such as NOAA Technical Reports, NOAA Technical Memorandums, and Special Scientific Reports are found in the NOAA modern collection. Principal investigators reports on major projects such as the Outer Continental Shelf Environmental Assessment Program (OCSEAP) and the California Cooperative Oceanic Fisheries Investigations (CalCOFI) are included. Publications from the Army Corps of Engineers Coastal Engineering Research Center, Smithsonian Institution, and Environmental Protection Agency are also found. Other items of interest are hundreds of specialty bibliographies designed specifically for various aspects of

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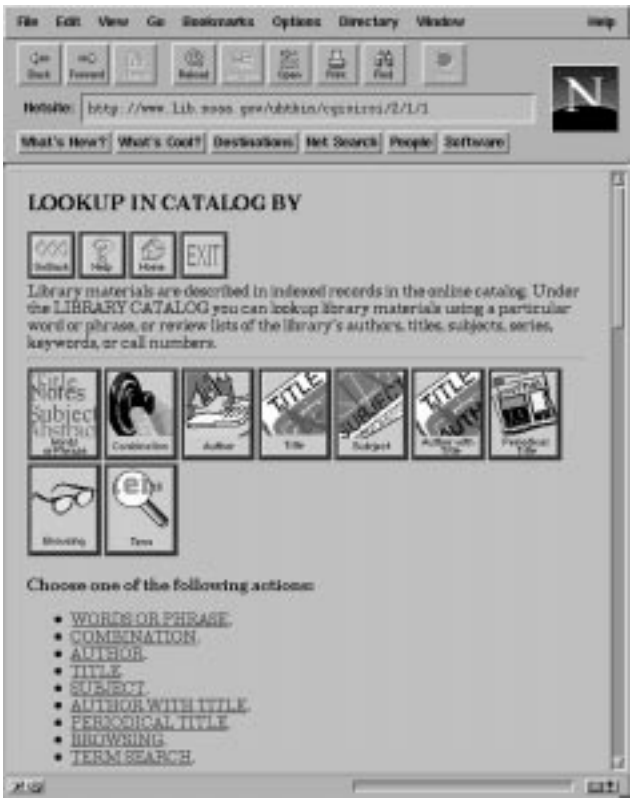
NOAA Central Library
NOAA/NESDIS
SSMC3, 2nd Floor E/OC4
1315 East-West Highway
Silver Spring, MD 20910
E-mail: reference@nodc.noaa.gov
WWW: http://www.lib.noaa.gov



▲ **Figure 2.** Coastal ocean information is readily available through the NOAA Library online catalog, accessible through the NOAA Central Library site at *http://www.lib.noaa.gov*.

NOAA Library, *from page 5*

the physical and biological aspects of the coastal ocean, hundreds of proceedings of annual meetings, specialized symposia, and thematic atlases.

The Journal Collection

The NOAA Central Library presently subscribes to approximately 400 journals. At least half contain information of value for coastal ocean researchers and policy makers. Integrated with the present active collection are over 2000 journal titles that the NOAA Central Library and predecessor agencies have acquired. As with the growing collection of present-day journals, at least half of these are of interest to coastal ocean researchers.

Some series are notable for their historical significance to scientific research. For instance, the *Transactions of the American Philosophical Society* are continuous from Vol. 1 (published in 1789) until the late nineteenth century. A complete set of the *Journal of the Franklin Institute* from Vol. 1, No. 1, published in 1826 extending to 1974 also resides in the NOAA Central Library, as does a nearly complete set of the *Memoirs of the American Academy of Arts and Sciences* which was first published in 1785. Other scientific periodicals dating from the 1800s with long periods of continuity include the *Proceedings of the American Association for the Advancement of Science* and *Science* magazine. Modern titles tend to be subject specific such as the *Journal of Aquatic Animal Health* (Vol. 1, No. 1, 1989,) the *Journal of Coastal Research* (Vol. 1, No. 1, 1985,) and the *Journal of Crustacean Biology* (Vol. 1, No. 1, 1981,) from their beginnings up until the most recent issue.

The available sources of information in the journal collection is virtually overwhelming for investigators desiring to do literature searches prior to commencing field research. The value of the modern journal collection is enhanced by access to various electronic bibliographic services; while for older material, the NOAA Central Library has at least 200 pertinent published bibliographies that can serve as the beginning point for any exhaustive literature search on various aspects of the coastal ocean.

Searching the NOAA Catalog

The wealth of information available in the NOAA Library System as related to the coastal ocean is readily apparent upon performing rudimentary searches of the 200,000+ records in the NOAA-wide automated catalog, NOAALINC. NOAALINC is accessible through the Internet via the NOAA Central Library home page (*http://www.lib.noaa.gov/*). The key words COAST$, ESTUAR$, SEA GRANT, FISHE$, and MARINE POLLUTION produce significant results in displaying the magnitude of the available resources. Searches were also performed on these terms for the 23 libraries in the NOAA System and for the Silver Spring Central Library. The results are impressive for both the total resources available through the NOAA Libraries and the percentage of all titles found in the NOAA Central Library at Silver Spring.

Table 1 displays the number of works found in listed categories searched on within NOAALINC. The column labeled ALL LIBRARIES indicates the number of references found throughout the NOAA Library System

▲ **Table 1.** Results of a selected subject search of NOAALINC. The "$" symbol represents a wildcard.

SEARCH ON	ALL LIBRARIES	SILVER SPRING
FISHE$	12929	8504
COAST$ OR ESTUAR$	9212	6506
SEA GRANT	4056	3584
MARINE POLLUTION	1089	823
GREAT LAKES	1052	642
GULF OF MEXICO	956	675
WOODS HOLE	833	412
CONTINENTAL SHELF OR SLOPE	624	430
CHESAPEAKE BAY	550	370
SCRIPPS	385	271
OIL SPILL	347	252
PUGET SOUND	294	204
COLUMBIA RIVER	268	150
MARINE MAMMALS	259	158
NEW YORK BIGHT	207	169

▲ **Table 2.** Indication of geographic range of holdings. The "$" symbol represents a wildcard.

STATE AND (COAST$ OR ESTUAR$)	NOAALINC ALL LIBRARIES	SILVER SPRING
California	693	414
Washington	554	289
Florida	534	320
Texas	497	428
North Carolina	296	227
Oregon	278	159
Alaska	277	204
New York	251	205
Louisiana	218	171
Mississippi	180	151
Virginia	175	141
Massachusetts	172	122
South Carolina	167	110
Maryland	153	115
Georgia	152	119
Hawaii	146	67
Alabama	120	104
Maine	114	85
Delaware	113	94
Rhode Island	104	81
New Jersey	96	64
New Hampshire	47	43
Puerto Rico	33	21
Connecticut	27	22
Guam	18	11
Virgin Islands	17	14
American Samoa	4	2
Michigan	80	50
Ohio	34	20
Wisconsin	23	18
Illinois	14	11
Indiana	12	10
Minnesota	11	8

while the column labeled SILVER SPRING indicates the number of holdings related to the subject matter found at the NOAA Central Library.

The numbers displayed only represent holdings in the main stacks and do not indicate the wealth of material available within the Journal Collections of the NOAA Library System.

Table 2 illustrates the geographic diversity of the holdings of the NOAA Library System. For Table 2 a search was instituted on the state name and (COAST$ or ESTUAR$) as an example of a possible search for available information regarding a given state. Table 2 is ordered from states with oceanic borders or insular territories with the most information to the least information for the particular search query. The last six entries in Table 2 are Great Lakes states ordered from most available information to least available information for the query used to develop the table. ALL LIBRARIES refers to the 23 libraries in the NOAA System while SILVER SPRING refers to the NOAA Central Library.

Historical and modern academic works

The NOAA Library contains nearly complete collections of ocean-related documents from the Scripps Institution of Oceanography, the Woods Hole Oceanographic Institution, Texas A&M School of Oceanography, Oregon State University, University of Washington, University of Rhode Island, Virginia Institute of Marine Science, the John Hopkins Chesapeake Bay Institute, and virtually every oceanographic school with associated laboratories in the United States. Over 4000 Sea Grant publications reside in the NOAA Library System with about 85% of those titles located at the Central Library.

Historical works on coastal ocean information

- The Central Library houses the complete series of the Superintendent's Reports of the Coast Survey and Coast and Geodetic Survey from 1844 onward; a complete collection of Coast Pilots describing the coast and its peculiarities and anticipated meteorological conditions in given areas from the mid-1850s onward; special reports describing the evolution of instrumentation used within the Coast and Geodetic Survey for hydrography, current studies, and tide studies; and many scientific reports concerning the first scientific estuarine studies in the United States.
- Historic climatological information includes the complete series of U.S. Weather Service annual reports beginning with the Reports of the Army Signal Service in 1871; a complete series of Smithsonian Institution Reports beginning in 1847 which encompass national meteorological observations prior to the establishment of a national weather service; and special publications of the Weather Service detailing the evolutionary trail of weather instrumentation and observing methods. These are invaluable sources of information for those seeking an understanding of coastal changes as related to climatic changes as the parameters being measured today may not be the same as those being measured during the nineteenth century.
- Fisheries researchers will find a complete set of the annual reports and bulletins of the Fish Commission and Bureau of Commercial Fisheries beginning from its inception in 1871. These contain observations on commercial fisheries, coastal ecology, coastal ocean physical oceanography, and information on the evolution of techniques and instrumentation used by fisheries scientists in measuring fish stocks.

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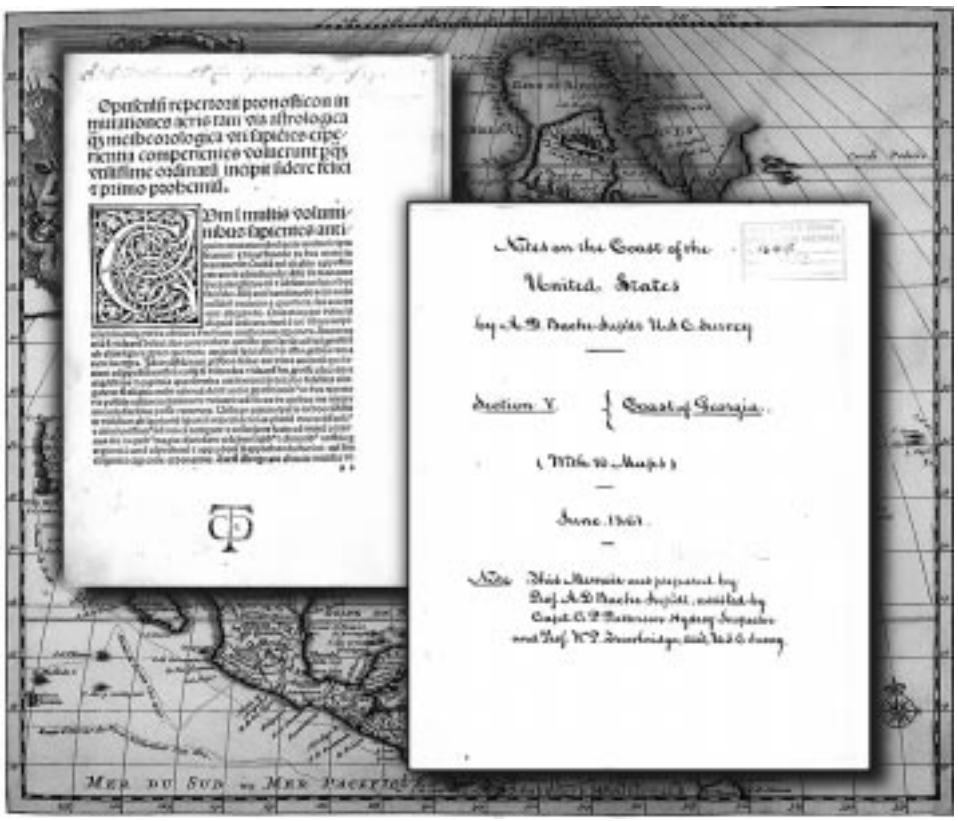


▲ **Figure 3.** Above left is a page from the oldest book in the NOAA Library collection (printed in 1485). *Opusculu repertorii prognosticon* is a Latin translation of the Greek by Hippocrates, in which he describes how weather affects the human body. Above right is a page from *Notes on the Coast of the United States* by the second Superintendent of the U.S. Coast Survey, Alexander D. Bache. These *Notes* provided the naval strategy for the Union blockade of Southern ports during the Civil War.

***NOAA Library**, from page 7*

• As a Federal Depository for NOAA-related topics, the NOAA Central Library contains all current federal laws associated with the use and study of the coastal ocean, supporting the evolution of federal coastal ocean policy and the law of the sea. Publications by other governmental agencies related to the coastal ocean, such as the United States Geological Survey, the Environmental Protection Agency, the Smithsonian Institution, the Army Corps of Engineers, and various elements of the United States Navy are indexed and catalogued. Works of the National Academy of Sciences, the Carnegie Institution of Washington, and state natural resource agencies are also found in the collection.

Summary

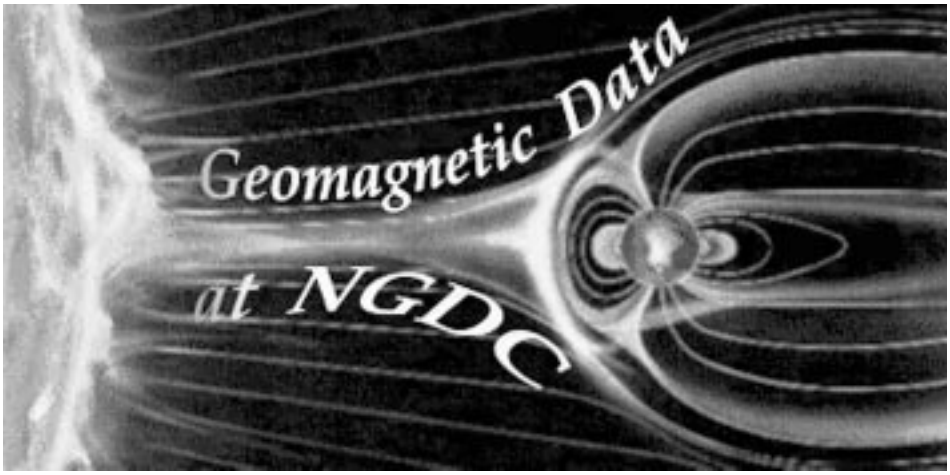
The NOAA Central Library and its satellite libraries comprise a unique resource for studies of the Coastal Ocean. Rare historical documents (Figure 3) and data reside in these libraries as well as up-to-date information regarding coastal ocean physical, chemical, geological, and biological processes. A wealth of information concerning economic, social, and cultural uses of the coastal ocean is included. Time line series of data and information from the earliest inception of oceanic studies in the United States in the early 1800s up to the present day are found in the collection. Books, official series and reports of the main line components of NOAA and their predecessor agencies, legal documents and treaties of the United States, professional journals, atlases, microfilm collections, video collections, and photo collections that have information related to the coastal ocean (Figure 4) are all found in the NOAA Library system. The NOAA Library System, and particularly the NOAA Central Library, is a rich resource with a wealth of information for the coastal ocean investigator. ■

▲ **Figure 4.** Dune grasses at Topsail Beach, North Carolina. Photo courtesy of Janice Beatty, NOAA Central Library.

The Earth's changing magnetic field on record at NGDC

Geomagnetic data bring together a variety of disciplines at the National Geophysical Data Center

Herbert W. Kroehl, Leslie Morris, and Susan McLean
Solar-Terrestrial Physics Division
National Geophysical Data Center
NOAA/NESDIS



▲ **Figure 1.** An artist's illustration showing both internal and external sources of the Earth's magnetic field.

The Earth's magnetic field results predominantly from electrical currents flowing deep within the Earth's interior, in the upper atmosphere, and in the near-Earth space environment (Figure 1). These currents and associated magnetic field values vary dramatically in time and space. External currents may change the total magnetic field by a few percent within minutes and internal currents may change the total field values by a few tenths of a percent per year. The techniques used to measure the magnetic fields resulting from the two sources are essentially independent of the platform carrying the instrument or magnetometer, whether on a ship, plane, satellite or at a ground-based observatory.

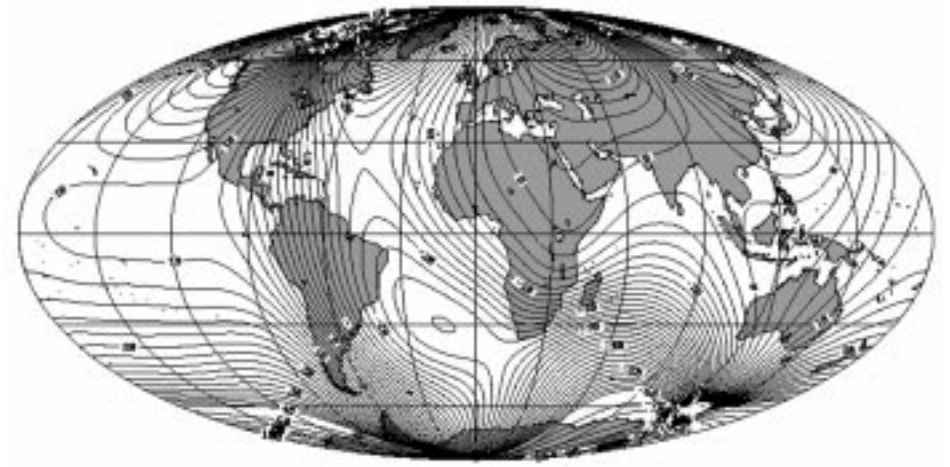
The National Geophysical Data Center collects, processes, analyzes, and services geomagnetic data for NOAA's National Data Center and World Data Center systems. Geomagnetic data bring together the diverse scientific disciplines represented at NGDC. The Solar-Terrestrial Physics (STP) Division focuses on external current systems with high time resolution data from GOES and DMSP satellites, magnetic observatories, and variations stations operated for specific scientific campaigns. The Solid Earth Geophysics (SEG) Division archives magnetometer data from magnetic observatories and repeat stations and from aircraft and paleomagnetic data used in long-term studies of the Earth's main field. The Marine Geology and Geophysics (MGG) Division archives include data from magnetometers operated during marine surveys. The National Snow and Ice Center archives magnetic data from aircraft surveying the Arctic and Antarctic. The following describes the magnetic data archives at NGDC by focusing on their different applications.

Solar-Terrestrial Physics Division
National Geophysical Data Center
NOAA/NESDIS
325 Broadway
Boulder, CO 80303-3328
E-mail: info@ngdc.noaa.gov

Navigation

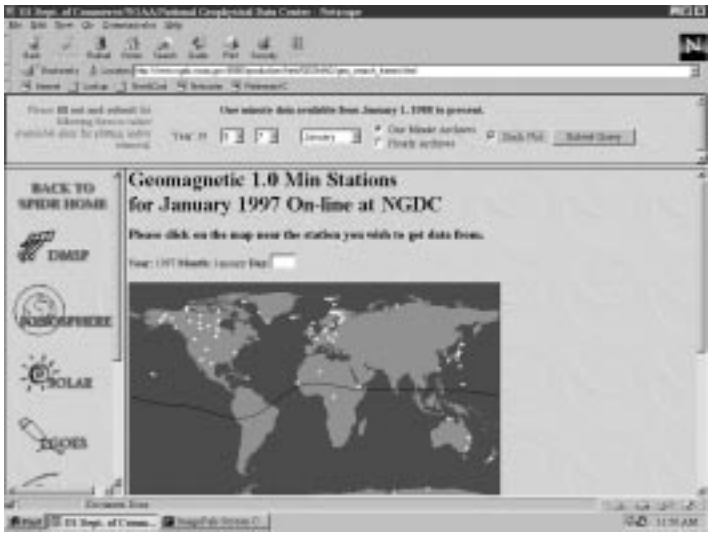
The discovery of the Earth's magnetic field and its application to "compass navigation" can be traced back to the Chinese around 250 BC (Campbell, 1997). Maps or magnetic field models of magnetic declination, i.e. the angle between local magnetic and geodetic north or south, became a valuable national resource until scientists from different countries began sharing data. The first global picture of the Earth's magnetic field as a great magnet was presented by Gilbert around 1600. The first mathematical solution used spherical harmonic analysis and the first application to magnetic field models was done by Gauss in 1848. Similar techniques to those proposed by Gauss were refined by Chapman and Bartels in 1940 and are used today to build the standard International Geomagnetic Reference Field (IGRF) models. Figure 2 shows declination computed from the IGRF 1995 model. These global models and the annual mean and repeat sta-

– continued on page 10



▲ **Figure 2.** Magnetic declination as computed from the International Geomagnetic Reference Field set of coefficients for 1995.

A.



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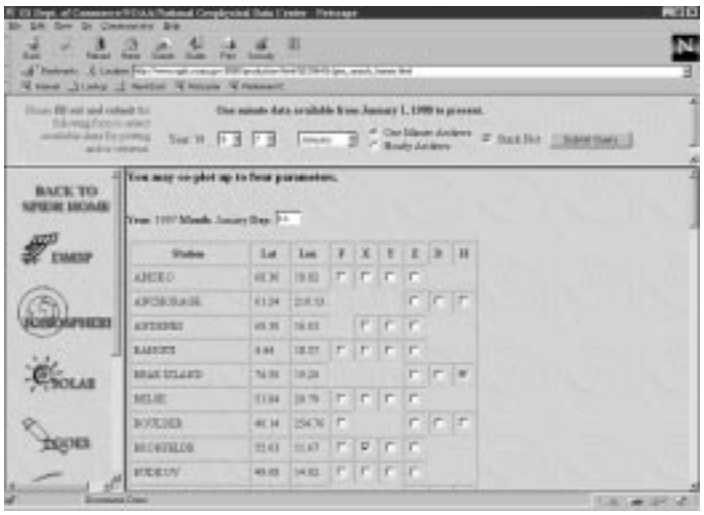

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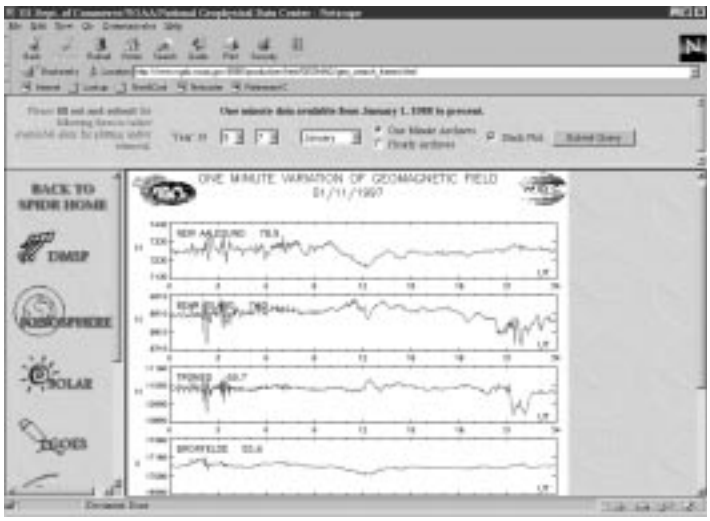

D.

▲ **Figure 3.** A four-panel figure (A through D) showing a session to select and browse one minute geomagnetic data resident in the Space Physics Interactive Data Resource (SPIDR) system from four stations.

Geomagnetism, *from page 9*

tion data used in the model construction are available from the SEG Division.

Today, magnetic field models are used in a variety of applications from resource exploration to antenna alignment. Magnetic field models and onboard magnetometers are used by satellite operators to determine the initial attitude of recently launched satellites, i.e. which way is up? In addition, Global Positioning Satellite (GPS) systems need the electrical state of the upper atmosphere as an input to accurately determine locations and headings on the Earth's surface and in space.

But GPS signals and the derived locations and headings are adversely affected by changes in the external currents. One minute magnetometer data archived by the STP Division are used in the reduction of GPS signals and in the preparation of magnetic activity indices which define times when the upper atmosphere is active or quiet.

Geophysical surveys

For several decades, land surveyors used a compass-based instrument to define the direction of individual property lines. As time elapsed, the magnetic declination changed, as did the property lines unless the proper adjustment was made. Frequently, surveyors query the SE Division archives to correct for annual changes in declination from the initial survey to the current or rerun survey.

Geophysicists use magnetic surveys to assist their exploration for new mineral deposits. "Magnetic anomalies" indicate changes in the Earth's structure near the surface where mineral or oil bearing deposits may have altered the local magnetic field. Since they are looking for "magnetic anomalies", they must remove the fields generated by both internal and external currents. The internal or main field is provided by magnetic field models and external currents are derived from high time resolution geomagnetic variations data archived by NGDC.

Communication

High frequency radio waves can be used to communicate over very long

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GOIN: The U.S.-Japan Global Observation Information Network

Joint project aids in bilateral cooperation in Earth observation networks and data exchange

Gerald S. Barton
Environmental Information Services
NOAA/NESDIS

In June 1997, NOAA hosted the Global Observation Information Network 1997 Workshop. The National Geophysical Data Center organized the Workshop, which was held at the National Center for Atmospheric Research atop the Rocky Mountains in Boulder, Colorado. The Global Observation Information Network (GOIN) is a joint project between U.S. and Japanese organizations to strengthen bilateral cooperation in Earth observation information networks, involving both satellite and *in-situ* data. In 1993 President Clinton of the United States and Prime Minister Miyazawa of Japan implemented GOIN. The GOIN project has made progress in its goals and has demonstrated the results of projects involving networks, and the exchange of atmospheric, oceanographic, land, and solar-terrestrial data (Figure 1).

GOIN is part of the United States-Japan Framework for a New Economic Partnership. The goals of the Framework are "to deal with structural and sectoral issues in order to substantially increase access and sales of competitive foreign goods and services through market-opening and macroeconomic measures, to increase investment, to promote international competitiveness, and to enhance bilateral economic cooperation between the United States and Japan" (Joint Statement on the United States-Japan Framework for a New Economic Partnership, July 10, 1993).

The GOIN initiative is implemented through the Joint Program Working Group (JPWG) with co-chairs Kenji Okuma, Deputy Director General of the Japan Science and Technology Agency (STA), and Gregory Withee, Deputy Assistant Administrator of the U.S. NOAA National Satellite, Data and Information Service. The JPWG is charged with meeting to "identify existing linkages, to develop conceptual architecture, and to suggest implementation strategies for bilateral and global network connectivity. This work will aim to expand links among existing networks on both sides to promote global change research, disaster monitoring, and other applications in support of upcoming U.S.-Japan cooperative space missions, and to facilitate collaboration in analyzing and using satellite and *in-situ* data."

▲ **Figure 1.** The GOIN brochure summarizes program participants, objectives, and projects. The complete brochure is available online at *http://www.ngdc.noaa.gov/stp/GOIN/brochure.htm* (requires Adobe Acrobat reader). Brochure image courtesy of D. Wilkinson, NOAA/NGDC.

NOAA and the STA jointly organized the JPWG. Its first meeting was held in Tokyo in September 1993 to discuss conceptual architecture and existing network components. At this meeting the JPWG established a work plan to identify global observation information networks, to develop estimates of global observation information traffic volumes, and to establish demonstrations to foster implementation of global observation information networks. A goal of the work plan is to provide a degree of crosscutting infrastructure by developing connectivity and interoperability through the use of common approaches, overview software, sharing of technology, and coordination of network policies. The GOIN work plan relies principally upon existing agency resources and systems. It provides the coordination mechanisms and infrastructure required for these existing resources to achieve the goals of the GOIN (Figure 2).

The JPWG pursues the goals of GOIN through the process of developing cooperative test bed network experiments using common requirements, standards, approaches, and technology sharing. The JPWG

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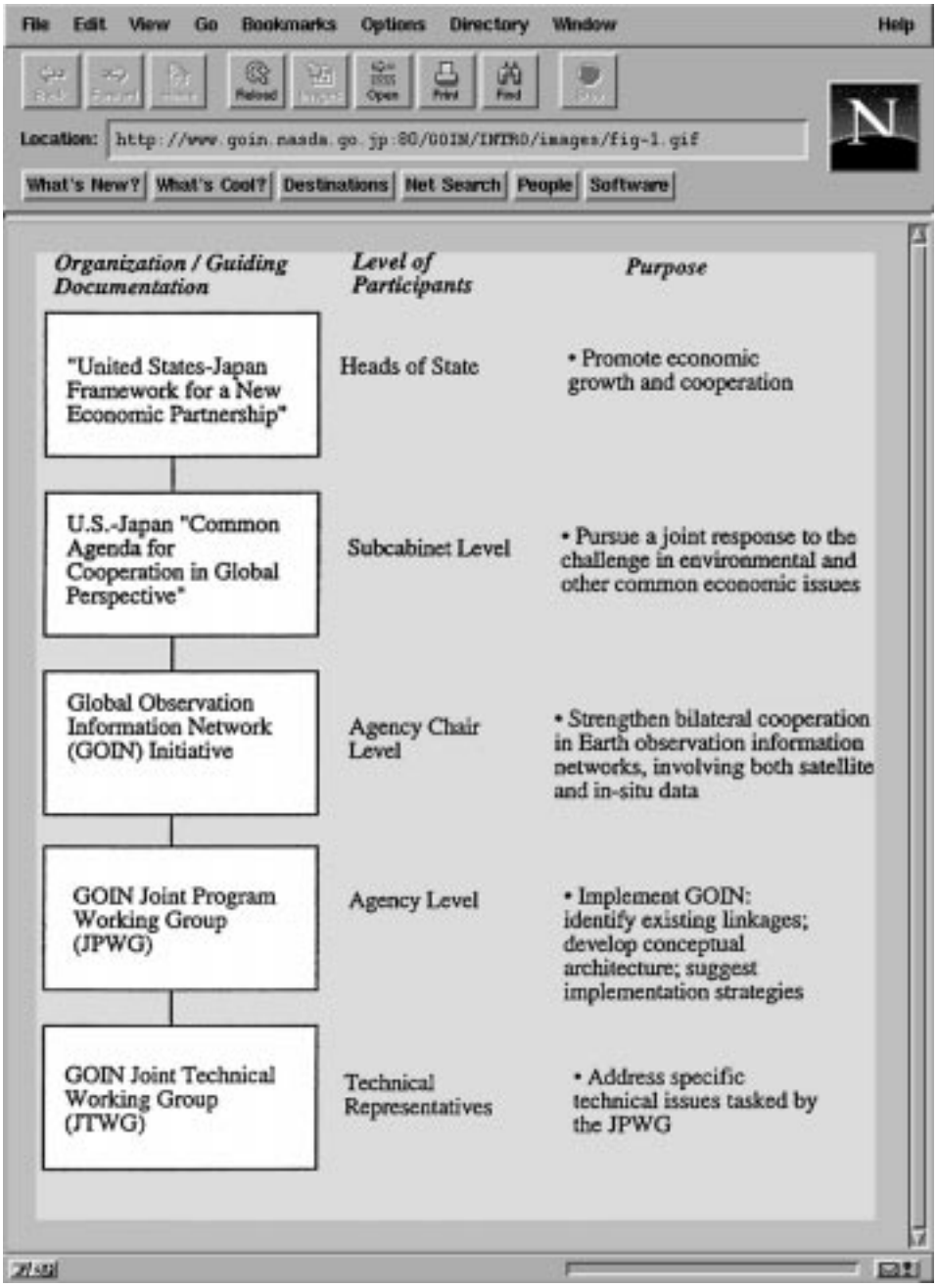
Environmental Information Services
NOAA/NESDIS
SSMC3, Room 15448
Silver Spring, MD 20910
E-Mail: barton@esdim.noaa.gov



▲ **Figure 2.** The organizational structure of GOIN, available online at *http://www.goin.nasda.go.jp:80/GOIN/INTRO/images/fig-1.gif*.

***GOIN,** from page 11*

meets semi-annually to identify existing linkages, to develop conceptual architecture, and to suggest implementation strategies for bilateral and global network connectivity (particularly through demonstrations). This work implements expansion of the links among existing networks on both sides.

The JPWG established the Joint Technical Working Group (JTWG) to address specific technical issues of concern to the JPWG. The JTWG is composed of technical experts from the participating agencies who work together to identify technical issues, approaches, and implementations for specific technical issues, e.g., protocols for network link interoperability. Membership in the JTWG is expected to be flexible and to change over time in order to address the specific technical concerns tasked to it by the JPWG. The JTWG reports its findings at the semi-annual JPWG meetings.

The GOIN initiative is an *ad hoc* coordination process where participation in GOIN and the programs it develops are on a voluntary basis. As an *ad hoc* initiative, GOIN has no direct dedicated funding and emphasizes the use of existing infrastructure and programs in the agencies of the United States and Japan such as existing agency networks and data and information systems.

GOIN Projects are focused in four areas corresponding to the Subgroups of the JTWG: Networks, Atmosphere and Oceans, Land, and Solar-Terrestrial. There are pilot projects in each Subgroup. The GOIN 97 Workshop held in Boulder, Colorado in June 1997 focused on reports of the status of the Pilot Project. The Network Subgroup set up special network connections to assure that online demonstrations of Pilot Projects had good connectivity to systems in Japan and the United States. Pilot Projects included atmospheric and oceanographic *in-situ* data, atmospheric and oceanographic satellite data, solar-terrestrial data, and metadata systems. Several projects showed the scientific applications of many of the instruments from the Japanese Advanced Earth Observation Satellite (ADEOS) such as 700 meter resolution chlorophyll-a and sea surface temperature data. One of several metadata projects makes available 300 Japanese data set descriptions as a separate node on the NOAA Environmental Services Data Directory. The Land Subgroup discussed new cooperative research institutes in Alaska and Hawaii. The Solar-Terrestrial Subgroup presented two pilot projects that concern near-real time detection of geomagnetic storms and modeling of the near-Earth space environment.

The goals of the GOIN agreement are being met. The Projects demonstrated cooperative efforts between many Japanese and U.S. organizations, demonstrated the interchange of data for research uses, and showed increased use of the networks to transfer large volumes of data across the Pacific in a timely manner so that the user can operate in an online, real-time mode. For information about GOIN, see the WWW Page at *http://www.goin.nasda.go.jp:80/*. For information about the GOIN 97 Workshop, see the WWW Page at *http://www.ngdc.noaa.gov/stp/GOIN/brochure.htm*. ■

NASA/NOAA Prototype Long Term Archive Project

The National Oceanic and Atmospheric Administration (NOAA) and the National Aeronautics and Space Administration (NASA) have developed a Technical Implementation Agreement (TIA) between NASA/Goddard Space Flight Center (GSFC) and the National Environmental Satellite, Data, and Information Service's (NESDIS) National Climatic Data Center. The TIA will develop a prototype to demonstrate the functionality of the proposed NOAA/NASA long term, permanent, archive for NASA's Mission to Planet Earth (MTPE) data. The project will assist in understanding the complexity and possible difficulties for NOAA in undertaking the archive and service functions for the MTPE data.

With this scenario, NOAA would have a much greater role in the servicing of the data to NASA MTPE researchers, and the role for NOAA of permanently archiving the MTPE data could be more complex. This prototype is designed to demonstrate the processes involved in acquiring the data and products, in limited interoperability with users, in working collocated with NASA, and in providing rapid access to data and products.

The agreed upon data sets are the Total Ozone Mapping Spectrometer-Earth Probe (TOMS-EP) data set and the Upper Atmosphere Research Satellite-Micro Limb Sounder (UARS-MLS). NOAA will establish a NOAA Prototype Archive Facility at NASA GSFC. NOAA will simulate receiving level 1A data directly from the Goddard servicing facility. NOAA will also simulate receiving satellite derived products from the NASA Distributive Active Archive Centers (DAAC). The NOAA Prototype Archive Facility at GSFC will ingest, archive, and provide access to the data and products. NASA researchers will access the data and products from the NOAA facility. The entire process will demonstrate the functionality of the long term archive to receive and service data and DAAC developed products.

This demonstration complements the NOAA Virtual Data System architecture with a NOAA facility at NASA GSFC and the data being serviced from another location. There will be an evaluation phase to ensure suitable access to and servicing of data and products to meet the general user requirements of the U.S. Global Change Research Program (USGRP), NOAA, and MTPE. NOAA will provide online service to NOAA as well as to NASA users. Under this demonstration proposal, NOAA will not develop and implement a new data archive, access, and/or distribution technology, but will integrate prototypical operations into existing NOAA systems.

At the end of the demonstration, a report detailing the transfer, archiving, and servicing functions will be prepared by NOAA and NASA MTPE. The report will evaluate baseline costs and system needs associated with the archival of the MTPE data by NOAA. The report will also evaluate the benefits of the collocated archive facility and the rapid availability of the MTPE data. The prototype will provide data access to meet initial USGRP requirements. The report will use the prototype experience to reanalyze these USGRP requirements and the success of the prototype to fulfill those requirements.

Additionally, projections for various levels of long-term archive effort and associated costs will be refined by NOAA and MTPE. These will be presented as additional costs above baseline, for providing enhanced data management support services for the MTPE.

—Wayne M. Faas
National Climatic Data Center
Federal Plaza
151 Patton Ave
Asheveille, NC 28801
Phone: 704-271-4296
E-mail: wfaas@ngdc.noaa.gov ■

Geophysics, *from page 10*

distances. These signals reflect off both the upper atmosphere or ionosphere and the Earth's surface. Disturbances in the ionosphere may result from a change in the electrodynamic structure of the ionosphere. These changes in the external current system are also captured in the magnetic records. A disturbed ionosphere may absorb the radio wave or divert its path resulting in a loss of communication. The higher time resolution records available from the STP Division are used to help determine which frequency to use when communicating between two locations.

Today, satellite communication with ground stations is critical and a disturbed ionosphere can result in a very temporary loss of the signal. The principle problem is a rapid change in density of the ionosphere over very short distances. The equatorial ionosphere is the most problematic. The new "cellular telephone satellite systems" will experience similar problems. The ionospheric signature is recorded in the one minute geomagnetic variations data.

Satellite anomalies

Some of the operational anomalies experienced by satellite systems are due to the external current systems. As the satellite is inundated by a stream of energetic charged particles which carry the external current, one part of the spacecraft may develop a charge relative to other parts and the discharge may cause an operational anomaly. The responsible current system will have a magnetic signature that may be seen by magnetometers on the ground or on other satellites. These signals require very high data rates and are most frequently seen in data from high latitudes.

Scientific research

The unique feature of magnetic data is that it can record the effects of all electrical currents that may be a very long distance away from the magnetometer. This is both its blessing and its curse, because the exact location of the current is very difficult to ascertain.

Space physicists use high time resolution geomagnetic variations from satellites and ground-based observatories to study the occurrence frequency and electrodynamic structure of external current systems flowing in the near-Earth space environment. Figure 3

– continued on page 16

The NODC's Internet Security System

As part of the ongoing effort to upgrade and improve the National Oceanographic Data Center's (NODC) computing and communications system, the NODC implemented an Internet "firewall" security system in June 1996. The IBM Internet Connection Secured Network Gateway (SNG) installed at the NODC serves as a filter between NODC's internal network (secure) and other networks (non-secure) on the Internet. The purpose of the firewall is to prevent unauthorized access to internal NODC servers.

To provide access to NODC data and information for the general public, the NODC mirrors certain data resources and systems on external servers outside the firewall. The NODC's system is a bastion firewall, a machine that is placed between the secure (NODC internal) and the non-secure (Internet) network where the Internet Protocol (IP) forwarding is broken, which means no IP packet can go through this machine. As the routing is broken, the only place from which you can access both networks is the bastion itself. Therefore, only users who have an account on the bastion, with a double identification (one for the bastion and one for the remote host), can use services on both the networks.

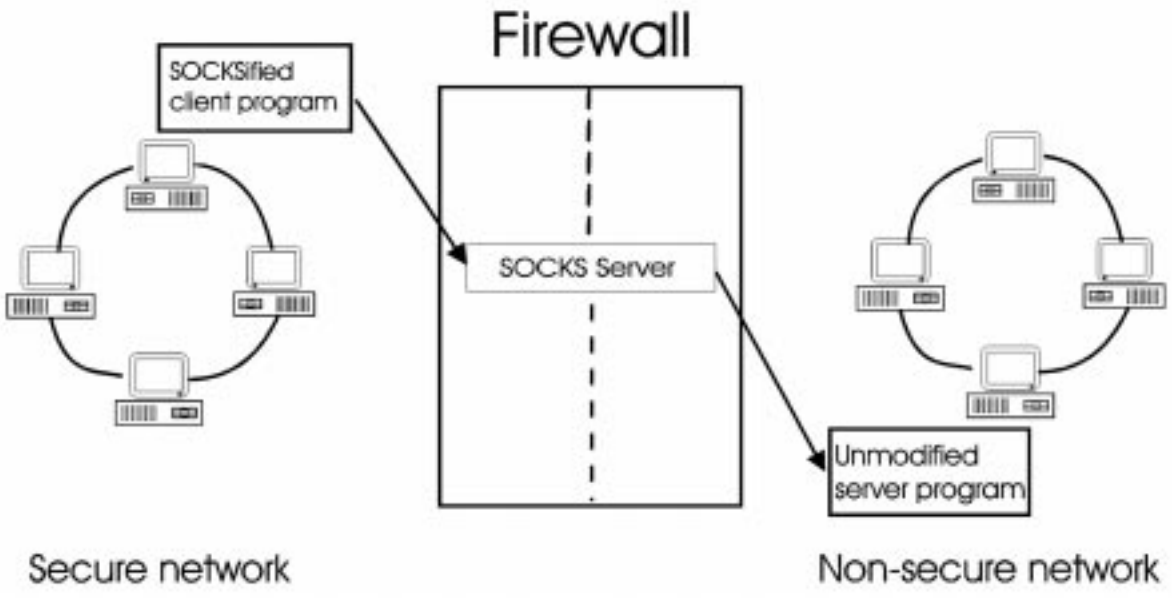
There are three ways to use the IBM Firewall software, SNG. The NODC's design considerations included:
1. Filter Rules only - allows all traffic to pass freely subject to specific rules that can allow or deny specific IP packets.
2. Proxy - telnet and ftp sessions from the secure side "talk" to a telnet'd or ftp'd daemon that controls the non-secure side. From the non-secure side, a telnet'd daemon "talks" to a secure side daemon. Ftp is not allowed from the non-secure net to the secure net. This technique breaks the connection between the secure and non-secure networks. It also means that two daemons are running for each user session thereby increasing the work load on the firewall machine. Proxy is used in conjunction with filter rules.
3. SOCKS - a client-server technology. Client software (e.g. rtelnet and rftp) must be installed on each machine in the secure network that needs access to the Internet. A SOCKS server runs on the firewall machine to handle outgoing telnet and ftp sessions. Telnet and ftp sessions from the non-secure network are controlled by filter rules.

The SOCKS server is an emerging standard for application-level gateways that does not require the overhead of a more conventional proxy server. The SOCKS server is a bastion configuration since the session is broken at the firewall. The NODC chose to use the SOCKS implementation with filter rules and a private (secure) network. SOCKS needs to have new versions of the client code (known as SOCKSified clients) and a separate set of configuration profiles on the firewall. The server machine does not need modification; it is unaware that the session is being relayed by sockd.

The NODC SOCKSified clients were installed on all machines in the private (secure) network. The NODC has an additional RISC 6000 E30 that is configured to replace the firewall machine within a few hours should the firewall machine fail completely.

The NODC also chose to use a Secure Net Keycard for those users who require telnet access to the secure network from the Internet or dial-up. Each authorized user has an account on the firewall machine. When they telnet in, they are to enter their user name; the firewall machine then answers with a "challenge" number (instead of a password) and the user enters the challenge number on their Secure Card. The Secure Card displays an "answer" number on the firewall machine and if it is the number that the firewall machine expects at that instant, the telnet session is established. This does not work for ftp sessions as no incoming ftp sessions are permitted.

—Natalie Wong
ADP Support Division
National Oceanographic Data Center
NOAA/NESDIS
SSMC3, 4th Floor
1315 East-West Highway
Silver Spring, MD 20910-3382
E-mail: nwong@nodc.noaa.gov ■



▲ **Figure 1.** The NODC Firewall

Geomagnetic Data Library online

The National Geophysical Data Center (NGDC) has completed the preliminary imaging process for the Geomagnetic Data Library (GDL). This project began in mid-1996, when approximately 2200 unique charts from locations worldwide were transferred from the U.S. Naval Oceanographic Office to NGDC. NGDC has enhanced the library data base and generated "inventory" images. The general character of the original map is captured but fine details are not recorded. A prototype version of the WWW search engine which couples the inventory image and the associated database parameters has been developed. Approximately 800 of these charts are from U.S. agencies and will be made available on NGDC's Web site. The remaining images will be added as permissions from non-U.S. agencies are obtained.
Contact: NGDC

New service in Seattle

The "Ask a Librarian" service on the NOAA Seattle library web site (*http://www.wrclib.noaa.gov/lib/*) has been revised and is now a referral service to web sites related to marine and atmospheric science topics. Sidney Stillwaugh, NODC Liaison Officer, has agreed to participate in the reference service and will aid in routing users to sites pertaining to marine and atmospheric data (Maureen Woods, E/OC43, 206-526-6241).
Contact: NOAA Seattle Library

NCDC World Wide Web updates

The National Climatic Data Center (NCDC) has implemented a new method for ordering CD-ROM products through a Web-based ordering system located on the Products, Publications, and Services section of NCDC's homepage (*http://www.ncdc.noaa.gov*). Customers can now order all NCDC CD-ROM products through NCDC's website using their VISA, MasterCard, American Express, or NCDC Open Account. CD-ROMs ordered through this Web-based system are at a discount price to those ordered via other means (such as by phone). This summer, NCDC will add their most popular publications to the ordering system, and will place a new NCDC homepage with improved user interfaces online.

NCDC has also expanded its Web page on weather events of 1993-1997. It now provides quick access to 22 reports

Data products and services

covering extreme weather events and storms of the past 5 years. Recent additions for 1997 include the March flooding and tornadoes in the Mississippi and Ohio Valleys, the Northern Plains flooding, and the May tornadoes in Texas. It also links to a complete report on the 1996 hurricane season, and to NCDC's latest update on "Billion Dollar Weather Disasters of 1980-1997." Weather event reports can be located at URL: *http://www.ncdc.noaa.gov/rcsg/weather-events.html.*
Contact: NCDC

Data centers provide new educational resources online

The NOAA Paleoclimatology Program has created a series of Web pages designed to explain the science of paleoclimatology and current global change issues to lay persons. As the Web has become more universal, greater numbers of non-technical users are reaching NOAA and other agency Web pages, making education a necessary function of technical Web sites. This educational site offers a paleoclimatology science primer and access to a collection of other sites related to paleoclimatology, which detail the use of various investigative methodologies from pack rat collections to coral cores to volcanoes and fossil plant material. The URL is: *http://www.ngdc.noaa.gov/paleo/education.html.*
Contact: NGDC

CONTACT POINTS

National Climatic Data Center (NCDC)
704-271-4800
Fax: 704-271-4876
E-mail: *Climate Services - orders@ncdc.noaa.gov*
Satellite Services - satorder@ncdc.noaa.gov
WWW: *http://www.ncdc.noaa.gov/*

National Geophysical Data Center (NGDC)
303-497-6419
Fax: 303-497-6513
E-mail: *info@ngdc.noaa.gov*
WWW: *http://www.ngdc.noaa.gov/*

National Oceanographic Data Center (NODC)
301-713-3277
Fax: 301-713-3302
E-mail: *services@nodc.noaa.gov*
WWW: *http://www.nodc.noaa.gov*

NOAA Environmental Services Data Directory
301-713-0572
(Gerry Barton)
Fax: 301-713-1249
E-mail: barton@esdim.noaa.gov
WWW: *http://www.esdim.noaa.gov/#data-products*

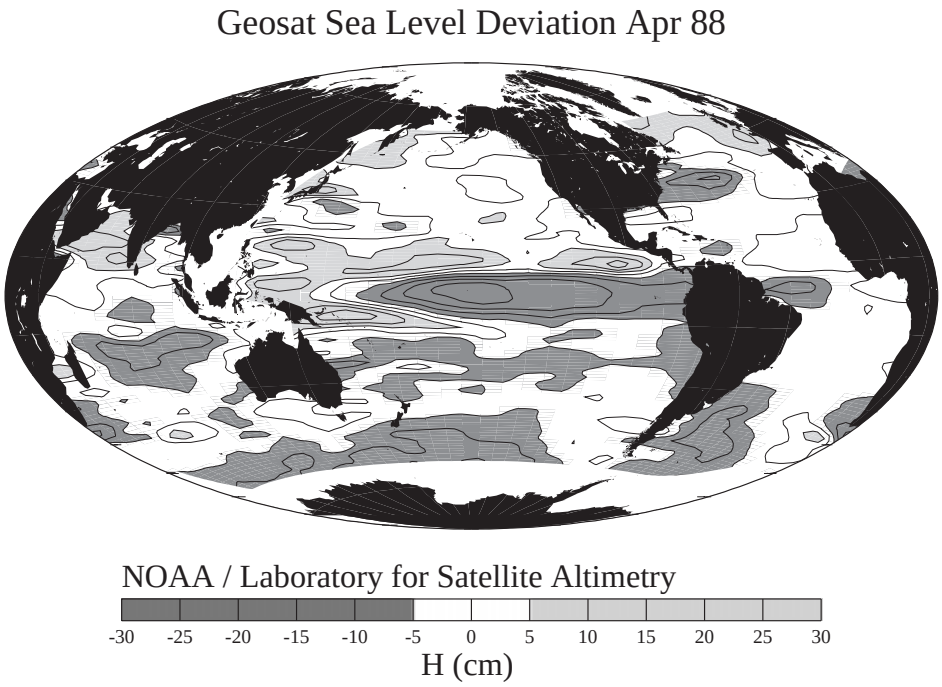
NOAA Central Library
Reference Services:
301-713-2600
Fax: 301-713-4599
E-mail: *reference@nodc.noaa.gov*
WWW: *http://www.lib.noaa.gov/*

Solar Flare Index

Dr. Tamer Atac and Dr. Atila Ozguc, Kandilli Observatory and Earthquake Research Institute in Istanbul, Turkey, have sent the National Geophysical Data Center (NGDC) their daily solar cycle 22 Solar Flare Index, 1986-1996. This index is based on earlier work by J. Kleczek of the Czech Republic. The importance of a flare is multiplied by its duration, giving the total energy emitted by the flare. Daily sums for the northern and southern hemispheres are computed, as well as for the total solar disk. The NGDC-grouped solar flare archive data were used in preparation of the indices. The indices will appear in the next issue of NGDC's publication, *Solar-Geophysical Data*, and reside on NGDC's File Transfer Protocol anonymous account of "Solar Databases" for Global Change Models.
Contact: NGDC

National Radar Mosaic online

The National Climatic Data Center (NCDC) has placed national WSR-88D Doppler Radar (aka NEXRAD) mosaic reflectivity images on line for web users to browse. Images can be reached through the NCDC web site under What's New; or users may go directly to *http://www4.ncdc.noaa. gov/cgi-win/wwcgi.dll?WWNEXRAD~Images*. The images are produced by Weather Services International (WSI) and provided through the Global Energy and Water Cycle Experiment Continental-Scale International Project (GCIP). Mosaic images are available once daily from April 1, 1995 through April 18, 1997, and hourly from April 19, 1997 to the present time. The availability of the most recent images is delayed approximately two days to comply with copyright requirements. Dick Cram of NCDC is the coordinator of this effort.
Contact: NCDC



▲ **Figure 4.** Sea level in April 1988 when values along the equator were 20 cm below normal. Easterly wind anomalies throughout 1988 lowered sea surface temperatures in the equatorial Pacific, creating a cold event known as La Niña. Color versions of Figures 3 and 4 are available online at: *http://ibis.grdl.noaa.gov/SAT/gdrs/geosat.html.*

NODC Altimetry Lab, *from page 4*
change could the Geosat observations be released to the general public. All the work was worth the effort, however, as the images that emerged from NOAA's Geosat project forever changed the way in which El Niño and the ocean in general is perceived. As shown in Figures 3 and 4, El Niño and La Niña are global-scale phenomena whose signatures stretch across the entire breadth of the Pacific, spanning one-third of the Earth's circumference.

The Laboratory for Satellite Altimetry will participate in three upcoming satellite altimeter missions, all of which will have operational aspects. The Navy's Geosat Follow-On (GFO) satellite in late 1997 will be followed two years later by Jason-1 (the follow-on to T/P) and the European Space Agency's Envisat. Based on the success of the T/P assimilation project, the near-real time flow of altimeter data to NCEP and other international weather centers will continue to be a priority. ■

Geophysics, *from page 13*
illustrates a selection and browse session conducted from the Space Physics Interactive Data Resource system. Some of those studies are conducted by scientists at NGDC. Geophysicists use magnetic data from ground-based and satellite data to study the Earth's magnetic field and its extension into space. Geologists use magnetic data to study the structure and evolution of the Earth's crust.

Conclusion

Geomagnetic data are unique and are used in numerous applications requiring magnetic models or direct measurements; high temporal or low temporal resolution; polar or equatorial regions; ground-based or satellite-borne measurements, etc. The national archives at NGDC are able to meet most requirements for the stated applications. NGDC's geomagnetic data can be accessed on the Web at *http://www.ngdc.noaa.gov/seg/potfld/geomag.html* or in specific topical areas at *http://www.ngdc.noaa.gov: 8080* and *http://www.ngdc.noaa.gov/mgg/geodas/ geodas.html.* ■

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