



EARTH SYSTEM MONITOR

NOAA's new space sentinels

GOES-8 and GOES-9 revolutionize meteorological and Earth system studies

A guide to NOAA's satellite, data, and information services

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

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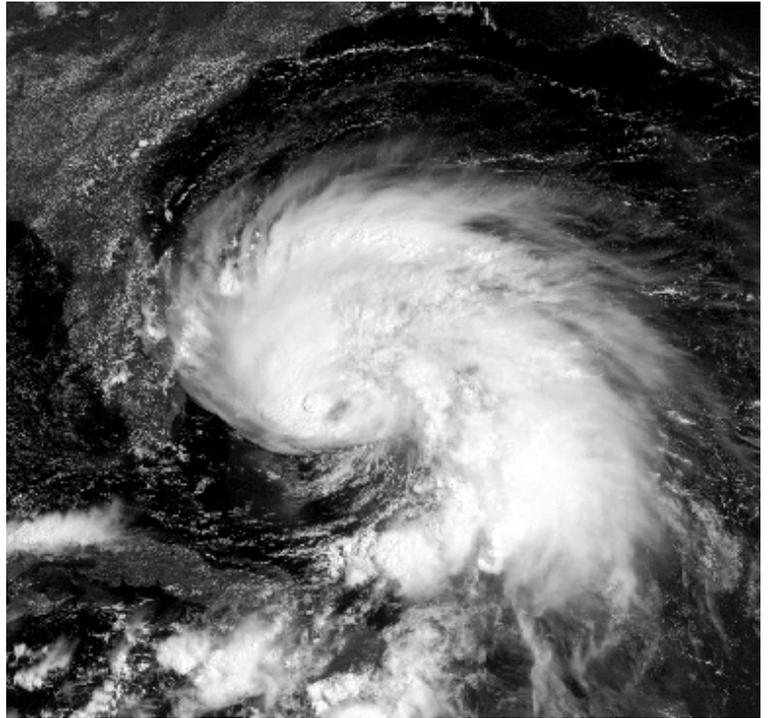
Observations from the National Oceanic and Atmospheric Administration's (NOAA) newest Geostationary Operational Environmental Satellites, GOES-8 and GOES-9, are on the verge of revolutionizing weather forecasting and research in Earth system processes. The new pair of space sentinels are the first in a series of five satellites that will provide a legion of observations (such as the visible image of Hurricane Erin shown in Figure 1) and products through the early part of the next century. The twins represent the most advanced civilian space system ever deployed for meteorology.

Launched April 13, 1994, GOES-I (renamed GOES-8 once in orbit) is now on station 36,800 kilometers above the equator at 75° West longitude, scanning North and South America and the adjacent oceans. GOES-J (now GOES-9) followed on May 23, 1995, and is undergoing an extensive check-out at 90° West. After check-out, due to be completed later this fall, one of the two new spacecraft will be moved west to replace the eight-year-old GOES-7 spacecraft at 135° West to ensure continuity of weather coverage over the Pacific (Figure 2). Geostationary spacecraft orbit the Earth once each day, and thus remain fixed over a predetermined spot above the equator. This configuration allows for repeated observations of storms and other phenomena.

The GOES Imager

The GOES satellites (see Figure 3) carry two primary instruments. The best known and most

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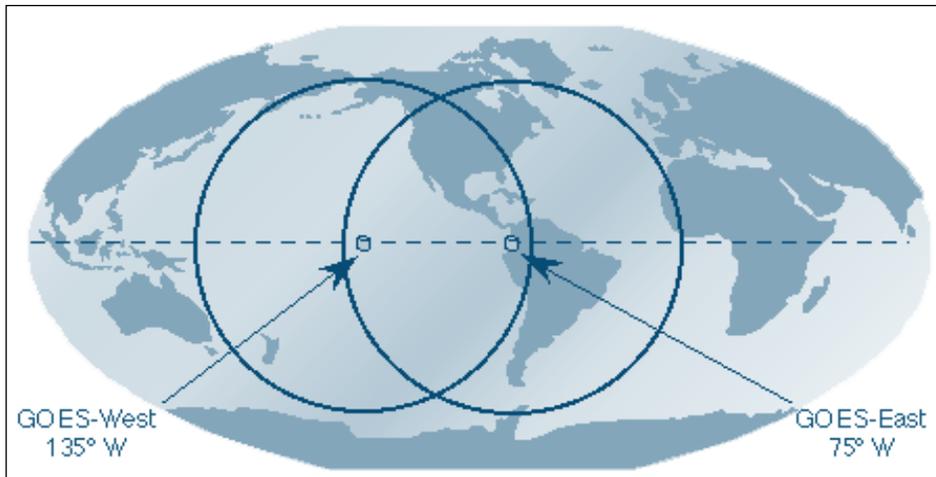
▲ Figure 1. A GOES-8 visible image of Hurricane Erin off the Florida coast at 8:00 AM EDT August 2, 1995.

utilized is the imager. The GOES imager is essentially a telescope that focuses light and infrared radiation from the Earth and its clouds and oceans onto a bank of highly-sensitive detectors. The imager is programmed to scan the full disk of the Earth in about 30 minutes once every three hours. During the intervening two-and-one-half hours, the sensors zoom in to capture smaller portions of the hemisphere, as well as repeated views of the contiguous U.S. to allow forecasters to see rapidly developing storms.

The imager scans the Earth line-by-line, and ground-based computers assemble the scanned lines into a set five images—one for each of five wavelengths of light “seen” by the detectors. GOES visible-light detectors yield a high-resolution black-and-white snapshot from space.

The other detector arrays yield infrared views of the planet 24 hours a day, each revealing unique aspects of clouds, moisture, or land and sea surface. National Weather Service meteorologists in forecast offices primarily use the “window” infrared channel, which senses infrared radiation unattenuated by the clear atmo-

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▲ Figure 2. Area observed by two GOES spacecraft in their operational positions.

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sphere, to scrutinize cloud patterns for various signatures of developing (or dissipating) bad weather. At times forecasters use images of atmospheric water vapor produced by another infrared channel sensitive to upper level moisture. This channel depicts the gyres and waves of atmospheric motion even in the absence of clouds. A third IR channel is tuned to reveal thermal gradients on the Earth's surface, and can be used to examine "hot spots" caused by forest fires, or to see the subtle temperature differences between nighttime fog and surrounding land (see Figure 4). The fourth IR channel is designed to recognize the presence of low-level moisture in an otherwise clear region. Animating successive images, or combining data from different channels yields yet more information about atmospheric structure and motion.

How good is the view?

While swirling loops of fuzzy cloud tops have become the staple of highly-visual weather shows, the quality of the GOES images available to NOAA forecasters and researchers far exceeds what makes it to local TV stations. In fact, the quality difference is staggering.

Stand at home plate in a major league ball park and scan the center field fence. Can you make out a ladybug crawling across the beer advertisement? If you've got the vision of Superman you can, but now describe how dark or light the bug is, on a scale of 1 to 1024. The GOES 8 visible sensors could do it, representing a visual acuity that is the equivalent of 40 times better than that

of their NOAA satellite cousins in lower polar-orbit.

The GOES imager has a visible resolution sensitive enough to spot cloud features roughly 1 kilometer across (the ladybug on the fence) from its perch 36,800 kilometers above the equator (home plate). The infrared resolution is 4 kilometers, except for the 8-kilometer water vapor channel. Why this all matters is a lesson in the demands of weather forecasting.

How did we get here?

Since NOAA began scanning Earth from geostationary orbit operationally in 1975 with GOES-1, the science of weather forecasting has entered a new dimension. No longer limited by the comparatively small sampling of ground-based measurements used to construct analyses of the state of the atmosphere, meteorologists adapted data from weather satellites to see between the cracks in the conventional observing network, and to take frequent looks at threatening storms.

Limitations in scanning on the original series of GOES in the 1970's and 1980's required observing the entire Earth from limb-to-limb, and in only two or three wavelengths of light. Furthermore, a typical forecast office was only capable of receiving two GOES pictures per hour. Small cloud features, within which lay clues to the onset and evolution of severe weather, went unnoticed in many cases. NOAA teams assembled to define requirements for new satellites in 1983 insisted on more frequent, higher-resolution views from

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U.S. DEPARTMENT OF COMMERCE
Ronald H. Brown, Secretary

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

Collaborative effort to produce new U.S. snow climatology booklet

Nolan Doesken, Assistant State Climatologist from Colorado, completed his visit to the National Climatic Data Center (NCDC) under the State Climatologist exchange program. His work included assembling sections of a snow climatology booklet containing information on snow properties, snow structure, measurement difficulties, measurement inconsistencies, proper procedures for consistent measurements, record snowstorms, and a bibliography. Mr. Doesken collaborated with NCDC personnel in gathering information and photographs for the booklet. The 1961-1990 climatic normals produced by NCDC for approximately 2000 U.S. locations will be used in the preparation of tables and graphs of comparative snowfall statistics, seasonal snowfall distribution, average snowfall, probability distribution, long-term variations and daily snow frequency.

This *U.S. Snow Climatology Booklet* will likely become a popular resource for basic snow information. It will help educate weather observers and assist them in recording more accurate and consistent snow observations. This should lead to higher quality and more homogeneous climate records in the United States. The booklet is expected to be available by the end of 1995.

NGDC completes participation in joint project with Japan

The Solar-Terrestrial Physics Division of the National Geophysical Data Center (NGDC) has completed its participation in the joint U.S.-Japan project to formalize the exchange of global scientific data sets known as the Global Observation Information Network (GOIN). This participation involved developing an interactive data search and browse capability through the World Wide Web for three Space Weather-related data sets selected as key by our Japanese counterparts: ionospheric sounding, magnetic observations, and Defense Meteorological Satellite Program imagery. Japanese counterparts included Nagoya University, Kyoto University, and the Communications Research Laboratory, all of which have developed similar capabilities for complementary data sets.

On June 6, 1995, a demonstration was held to illustrate how data are being shared across the Pacific. The VIP demonstration featured dignitaries in Washington

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and Tokyo exchanging statements and information via a network teleconference. Attendees at the Washington site included Mr. Takakazu Kuriyama, Japanese Ambassador to the United States; Dr. John H. Gibbons, Assistant to the President for Science and Technology Policy; Mr. Timothy Wirth, Under Secretary of State for Global Affairs; Dr. D. James Baker, Under Secretary of Commerce for Oceans and Atmosphere; and Dan Goldin, NASA Administrator. The event took place at the Old Executive Office Building, White House Briefing Room.

NODC scientists visit Russia to promote data exchange

The National Oceanographic Data Center's (NODC) Daphne Johnson and Godfrey Trammell visited the P.P. Shirshov Institute of Oceanography in Moscow and the Russian NODC and World Data Center-B (WDC-B) in Obninsk from August 14-25, 1995. The purpose of the trip was to conduct joint management activities with the WDC-B and work on the exchange of oceanographic data through the Intergovernmental Oceanographic Commission/International Oceanographic Data Exchange Global Oceanographic Data Archeology and Rescue (IOC/IODE GODAR) project.

The scientists reviewed oceanographic data sets currently held in Russian archives which have not yet been submitted for exchange under the auspices of the GODAR project. Data management procedures and formats were also examined for compatibility with NODC standards. The trip resulted in a significant increase in the number of unique data sets available to the world oceanographic community.

NGDC honored for innovative work on the Internet

In recognition of its innovative work in providing environmental data online via the Internet, the National Geophysical Data Center (NGDC) received the first annual award for the best World Wide Web home page in NOAA.

The NGDC home page was also selected as the best home page in NESDIS. Both awards were presented at the NOAA/World Wide Web Workshop held in Silver

Spring, MD on June 13, 1995. Ted Habermann accepted the awards on behalf of the NGDC.

NCDC hosts annual meeting of the AASC in Asheville, NC

The annual meeting of the American Association of State Climatologists (AASC) was held at the National Climatic Data Center (NCDC) in Asheville, NC, with 33 of 49 state climatologists represented. Nearly 80 people attended the two-day meeting, including retired state climatologists Arnold Court (CA), Paul Waite (IA), John Purvis (SC), Wayne Decker (MO), and Gayther Plummer (GA). Many NCDC employees involved in work with the state climatologists also attended.

After introductory remarks from AASC president David Smith, NCDC Projects Coordinator and organizer of this year's meeting, John Hughes, briefed on local arrangements and activities such as tours of the facility and demonstrations of NCDC's OASIS online system. NCDC Director Ken Hadeen gave an update on NCDC activities and emphasized the importance of participating in the state climatologist exchange program offered yearly at NCDC. There were reports from most of the states attending.

Other agency representatives attending were David Phillips, Anna Deptuch-Stapf, and James Ross (Atmospheric Environment Program, Canada), Bob Bermowitz (NWS Climate Predictions Center), Phil Pasteris (U.S. Department of Agriculture-Climate Data Access Facility), Roger Tucker (U.S. Forest Service), Tom Lockhart (Meteorological Standards Institute), Bob Lefler and Tom Blackburn (NWS Cooperative Program Office), Bob Manning (NWS Southern Region Cooperative Program Manager), and Ray Motha (U.S. Dept. of Agriculture-Agricultural Weather Facility).

Activities held during the meeting included an address by Dr. D. James Baker, Undersecretary of Commerce for Oceans and Atmosphere and Administrator of NOAA, to the attendees at the annual banquet held at Grove Park Inn Country Club. David Smith (SC), Past President, turned over duties to Myron Molnau (ID), President. Pamela Naber-Knox (WI) was elected President-Elect and Keith Eggleston (NY) was elected to a second term as Secretary-Treasurer. Laramie, Wyoming was voted as the site for the 1996 AASC meeting.

GOES, from page 2

space from future GOES.

GOES-8 and its followers will answer the demand, yielding up to 8 views per hour across all five spectral channels for forecasters in modernized weather offices. In doing so, the GOES system will serve up a bounty of data for future atmospheric research.

Yet, even more frequent views are possible. NOAA scientists have been thrilled by scenes of severe thunderstorms and tropical storms taken every minute during special research events. When viewed in animation at this time scale, the atmosphere becomes a bubbling cauldron of thermal interaction. Insights into atmospheric physical processes afforded by the new spacecraft are unprecedented.

Meteorologists will use imagery to differentiate between ice and super-cooled water clouds to aid aviation forecasts. They will detect the return of moisture from the Gulf of Mexico following the passage of winter storms and analyze intense, localized snow squalls developing in the lee of the Great Lakes before radar makes them visible.

The GOES Sounder

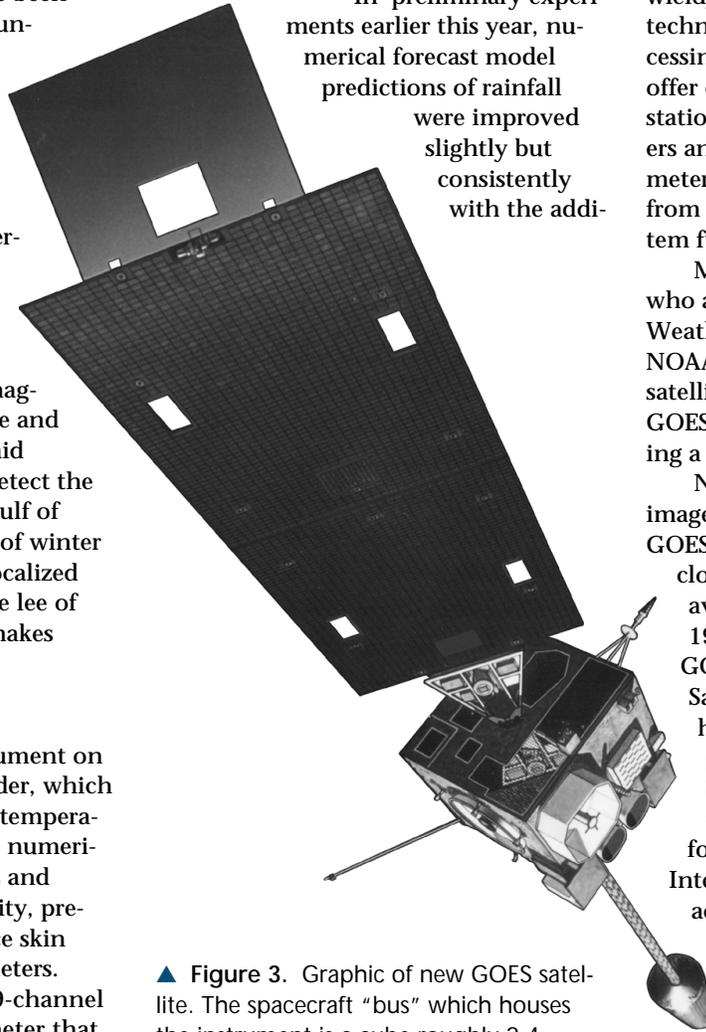
The second primary instrument on GOES is an atmospheric sounder, which yields profiles of atmospheric temperature and moisture for input to numerical weather prediction models and analyses of atmospheric stability, precipitable water content, surface skin temperature, and other parameters.

The GOES sounder is a 19-channel (1 visible, 18 infrared) radiometer that operates in a fashion similar to the imager. However, while the imager can scan an area the size of the U.S. in around four minutes, the sounder takes nearly 45 minutes, scanning longer to acquire a higher signal from each radiometric band.

Different vertical regions of the atmosphere absorb and emit outgoing infrared radiation differently as a function of wavelength and moisture content of the observed region. Assembling the radiance measurements recorded by the GOES sounder allows temperature

and humidity profiles to be constructed that resemble soundings made by the conventional radiosondes. GOES soundings are produced hourly over North America, but when a two-GOES operation is established, the instrument will be used to scan ocean areas around storms to provide glimpses into atmospheric structure where no radiosondes or other ground-base temperature observations exist.

In preliminary experiments earlier this year, numerical forecast model predictions of rainfall were improved slightly but consistently with the addi-



▲ **Figure 3.** Graphic of new GOES satellite. The spacecraft "bus" which houses the instrument is a cube roughly 2.4 meters (8 feet) long on each side.

tion of GOES-8 soundings. The National Weather Service is planning a more complete battery of tests when both new GOES are in operational positions.

Sounding information should prove especially useful in determining the state of the atmosphere around developing tropical storms and hurricanes over ocean areas where data for forecast models is sparse or infrequent. Continuously staring at a storm, the GOES sounder will provide the Olympian view

needed to fill in the missing pieces of the tropical atmospheric jigsaw puzzle. Better input to models of hurricane prediction will mean better forecasts of storm track and intensity.

Where does the data go?

Until the last five years, installing and operating a ground receiving and data processing system for full-resolution GOES data was an expensive, unwieldy proposition. Thanks to technological advances in signal processing, several private companies now offer complete image-processing ground stations based on off-the-shelf computers and antennas as small as three-meters in diameter. Price tags range from \$18K to \$80K, depending on system functionality.

Most occasional users of GOES data who are outside the realm of National Weather Service operations or other NOAA research will find the traditional satellite data archive or online access to GOES images more feasible than installing a ground station.

NOAA's satellite data archive holds images from GOES and other derived GOES products (winds, moisture and cloud fields, soundings, etc.) that are available in various formats. By early 1996, a new NOAA service will offer GOES data access online. The GOES Satellite Active Archive (GSAA) will house a sample of near-real time products, including remapped images similar to those to be used at modernized Weather Service forecast offices, to clients over the Internet. The GSAA will feature Web access, a browse capability, and inventory and ordering options.

Around the corner

Other avenues of access to GOES data are sure to open as the utility of the data from the GOES imager and sounder is demonstrated. Many Internet sites now maintain reduced-resolution GOES image picture files for general purpose browsing and downloading such as the image in Figure 5. Commercially available image analysis packages and fourth-generation computer programming languages will allow rapid development of new applications of the data for all Earth system fields, especially in ocean sciences. As newer applications are unveiled, and as

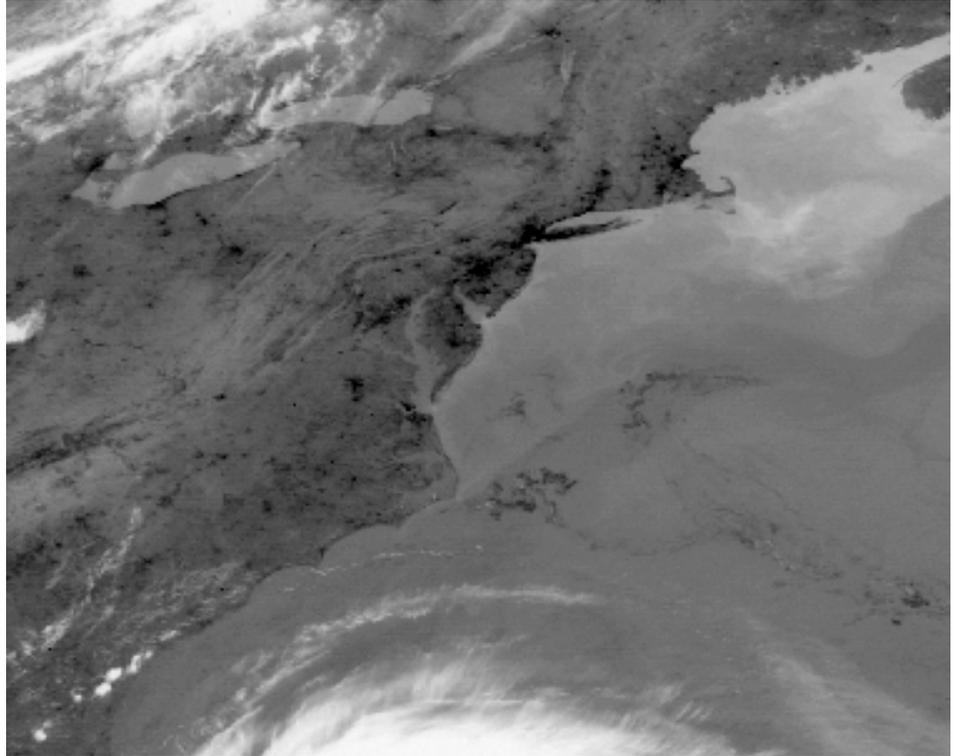
the community of meteorologists who demand most from the new GOES system grows with the continued implementation of modernized weather service offices, a feedback loop into requirements-setting for the next generation of GOES will grow.

Conclusion

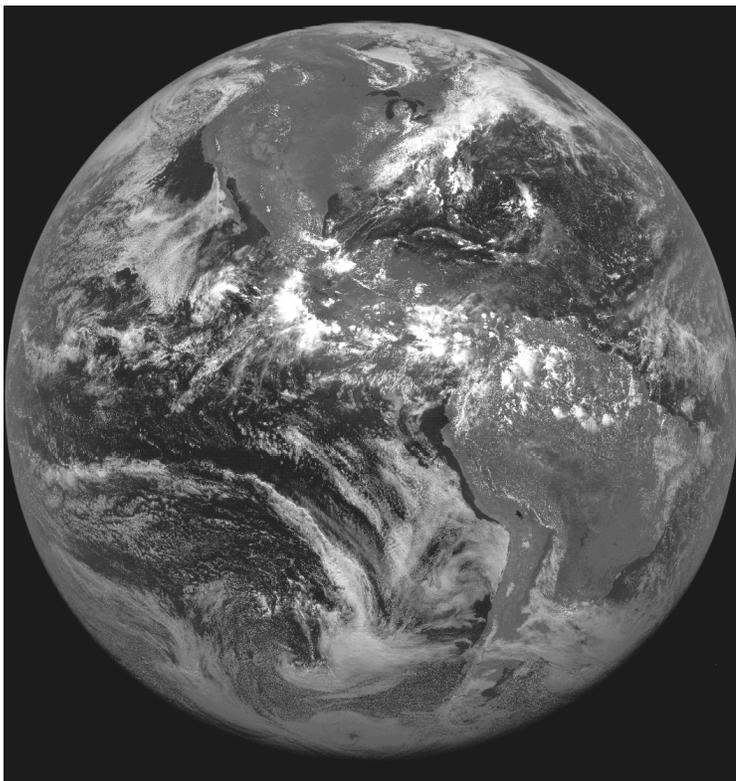
NOAA's newly-deployed GOES spacecraft carry the best civilian instruments ever built for meteorology. Early studies with the data have demonstrated they yield far more detailed cloud and moisture field analyses for operational forecasting and atmospheric science research than ever before possible. The potential for the development of new, unanticipated derived products is high, and the availability of data to people not historically GOES users is increasingly easy and inexpensive. A future GOES active archive service will further improve access to the new data in 1996.

Acknowledgements

Special thanks to Sharon Souther of NOAA/NESDIS for her preparation of the graphics for this article. ■



▲ **Figure 4.** While Hurricane Erin was marching on Florida, northeastern U.S. cities were also enduring a heatwave, as observed by GOES-8 at 8:00 AM on August 2, 1995. This thermal infrared image shows the urban heat-island effect (dark hot-spots are major cities), as well as the cooler waters of the Great Lakes and the Gulf of Maine (lighter gray). Note the sprawling megalopolis between New York and Washington, D.C.



▲ **Figure 5.** The first image taken by the new GOES-9 satellite, a visible-light view from 36,800 kilometers up, taken June 12, 1995. Such sample images are routinely available on many Internet sites.

Information about GOES

The following NOAA/NESDIS contact addresses are provided for individuals who would like more information concerning the GOES program and associated data and products, or technical help in downloading GOES information via the WWW:

For information on GOES products:

Jamison Hawkins
GOES Product Manager
Phone: 301-457-5125
E-mail: jhawkins@nesdis.noaa.gov

For information on the GOES spacecraft:

Gerald Dittberner
GOES Program Manager
Phone: 301-457-5277
E-mail: gdittberner@nesdis.noaa.gov

For archived GOES data:

National Climatic Data Center
Phone: 704-271-4800
E-mail: satorder@ncdc.noaa.gov

For online WWW access to information on GOES and other NOAA programs via the NOAA Home Page:
<http://www.noaa.gov/>

The Global Climate Perspectives System

GCPS provides access to high-quality global climate change data and information

Michael Crowe and
C. Bruce Baker
National Climatic
Data Center
NOAA/NESDIS

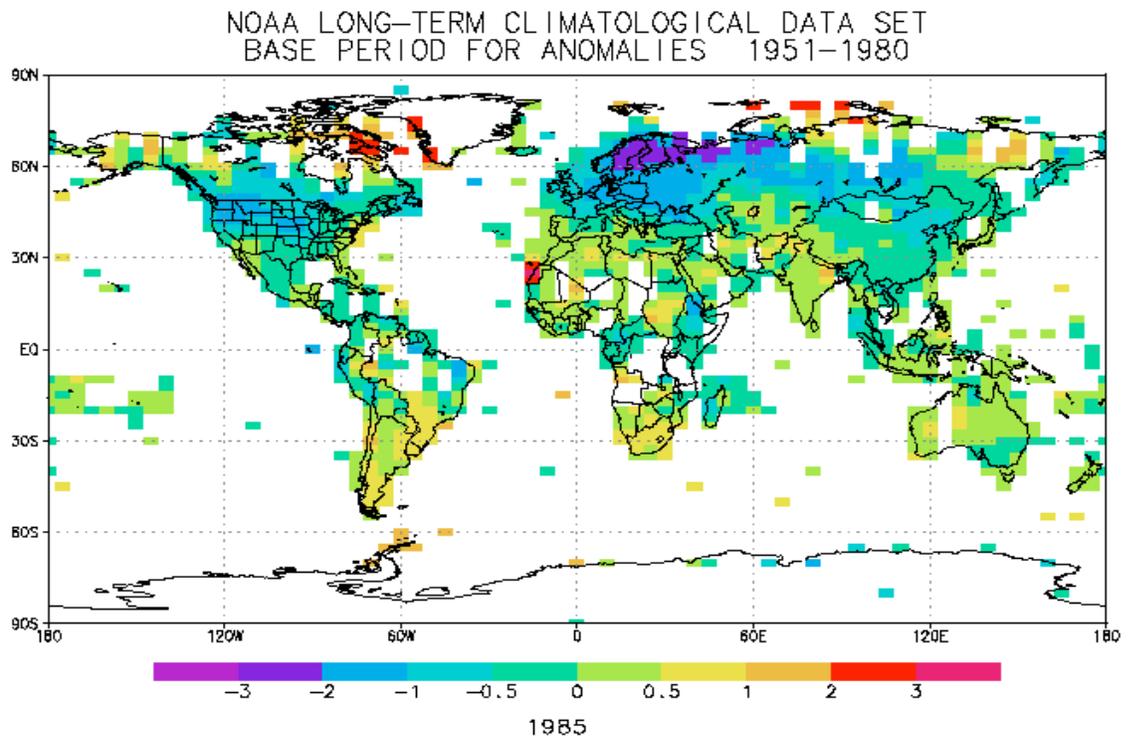
The Global Climate Perspectives System (GCPS) is a project within NOAA's Climate and Global Change Program founded on the principle that good data management requires not only data, delivered by computerized management systems, but also supporting metadata and, importantly, scientific analyses of both. The data sets and products within GCPS are considered research quality and are not accepted unless they have undergone a rigorous, peer-reviewed process of collection, building and quality control.

GCPS is a joint research project between two laboratories of NOAA: The Global Climate Laboratory of the National Climatic Data Center (NCDC) in Asheville, North Carolina, and the Climate Diagnostics Center (CDC) of the Environmental Research Laboratories in Boulder, Colorado. The goals of GCPS are to:

- Study the existence and magnitude of climate changes on a global scale;
- Create high quality global climate reference datasets and products and to provide access to this information to the research community;
- Create a set of computer tools to aid climate research.

A significant component of GCPS is the gridded climatological anomaly

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▲ Figure 1. A gray scale rendering of a color image depicting an example of a selected gridded display of global, annual temperature anomalies for the year 1985.

products feature which encompasses several data sets selectable over various time scales and spatial domains. With the advent of Mosaic/World Wide Web on the Internet, users have the opportunity to easily access these climatological products and browse and download them along with accompanying data and metadata.

The interactive online gridded climatological products are produced using The Grid Analysis and Display System (GRADS) developed at the Center for Ocean-Land-Atmosphere Interactions, University of Maryland.

Global land temperature and precipitation anomalies

The monthly station precipitation and temperature data for which anomalies were produced is from the Global Historical Climatology Network (version 1) data set which was produced by NCDC and the Department of Energy in 1992 (Vose, *et al.*, 1992). Using GCPS, the version 1 data were updated using global monthly CLIMAT reports

gathered through the Global Telecommunications System (GTS) of the World Meteorological Organization.

These data have been updated through 1994 and run through a rigorous quality control scheme developed under the auspices of GCPS. The quality control techniques are described in (Baker, Eischeid, *et al.*, 1994). The objective estimation of missing data is performed prior to the quality control. The development of the QC procedures that are in the process of being implemented required extensive experimentation and analyses of numerous spatial interpolation methods.

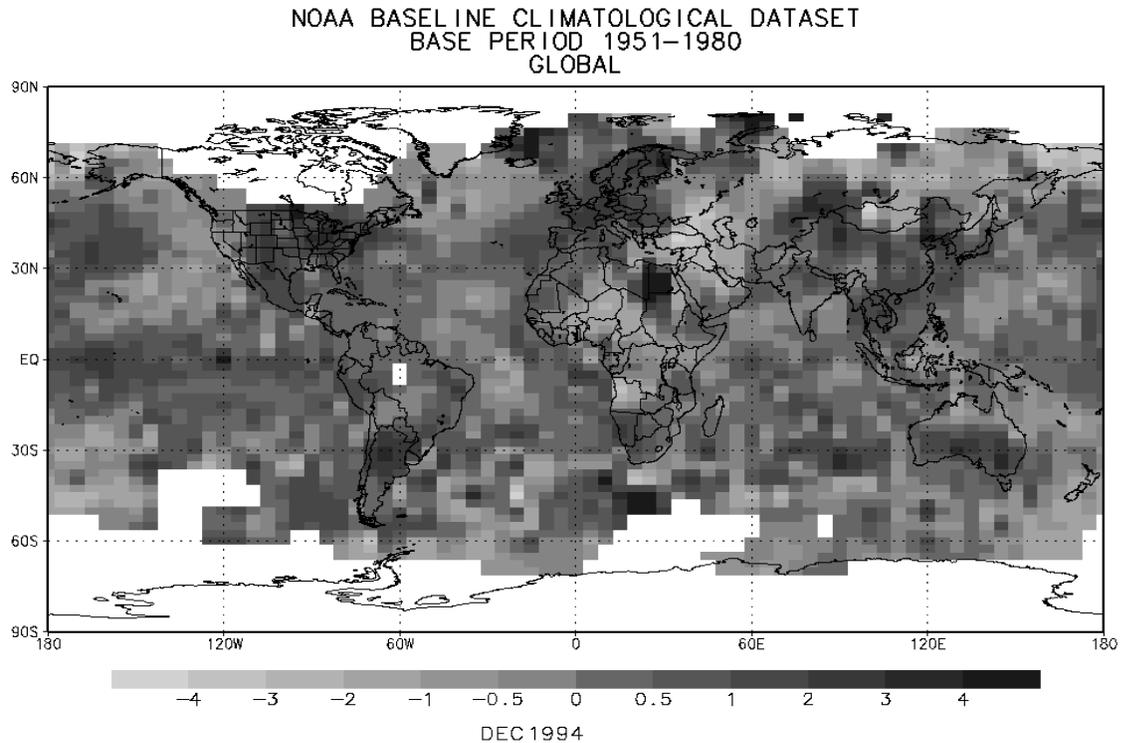
Along with the data, summary statistics and flags are provided. The data are then gridded at 5 degree by 5 degree square resolution. This updated, value-added subset of GHCN is termed the NOAA Baseline Climatological Dataset. Figure 1 shows an example of a selected gridded display of global, annual land temperature anomalies for the year 1985. There is limited data over the oceans and a number of data-sparse

areas, particularly in Africa and the Amazon region of South America.

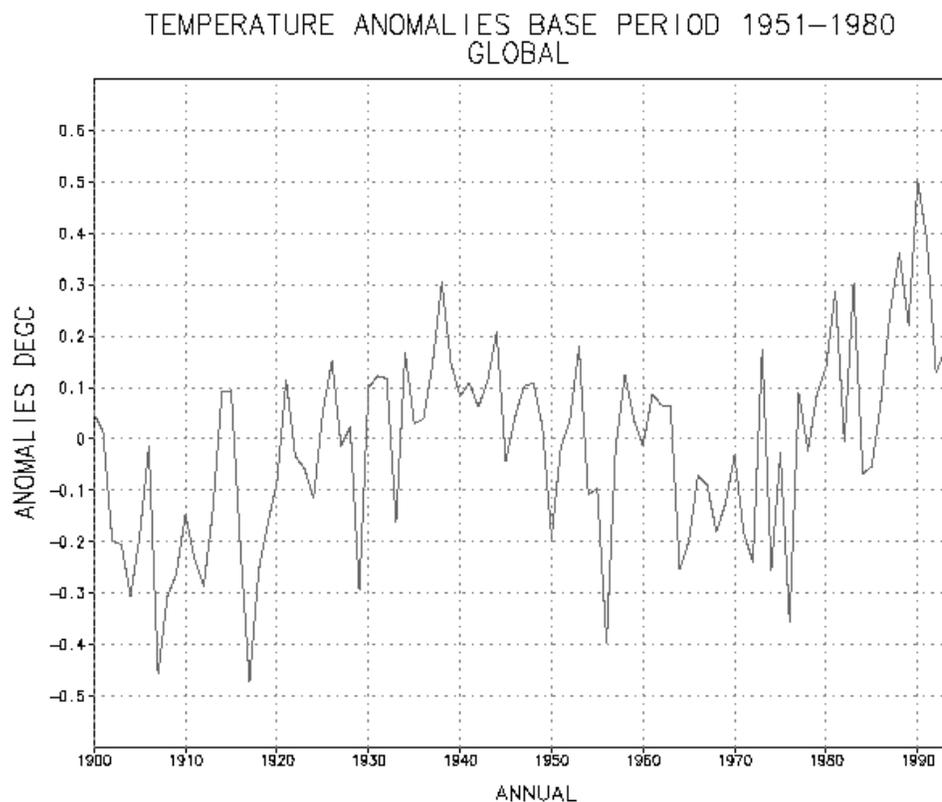
Version 2 of GHCN is set for release in 1995 and will contain much more data along with a homogeneity adjusted version, in which most of the effects of changes in instrumentation and station locations have been removed (Peterson and Easterling, 1994).

Merged land/ocean dataset

In June 1995, the NOAA Baseline Climatological Dataset was augmented with a gridded ocean anomaly data set of sea surface temperatures to give a truly global anomaly product. The ocean data set is a compilation of data from the United Kingdom Meteorological Office and the



▲ **Figure 2.** In June 1995, the NOAA Baseline Climatological Dataset was merged with a gridded ocean anomaly dataset of sea surface temperatures. The image depicts this merged land/ocean gridded anomaly product.



▲ **Figure 3.** The GCPS can produce time series products of temperature and precipitation for stations or aggregates of stations. This plot shows annual global temperature anomalies from 1900 through 1993, based on land stations.

Comprehensive Oceanic and Atmospheric Data Set (COADS). Monthly updates are performed by ERL using GTS ship reports. Figure 2 depicts this merged land/ocean, gridded anomaly product.

User interface to gridded products

The user interface was developed using the fill-out forms feature of the Hypertext Mark-up Language (HTML) within Mosaic. This allows the user to create a contour map or a time series plot of temperature anomalies. The color scale represents anomalies in degrees Celsius.

The user is queried as to the type of graph to be generated:

1. Contour Plot
2. Time Series Plot

The geographic coverage for the plot is then selectable as follows:

1. Global
2. Northern Hemisphere
3. Southern Hemisphere
4. North America
5. Africa
6. Australia
7. South America
8. Asia
9. User defined area

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GCPS, from page 7

If number 9 is selected the user may input maximum and minimum latitude and longitude to define an area. For a contour anomaly plot the user must select the year and month desired. The ending year and month are only used if a time-series plot is selected. Output format (GIF or Postscript) and background color are also selectable.

GCPS can produce time series products of temperature and precipitation for stations or aggregates of stations based on selected geographical area. Figure 3 shows annual, global temperature anomalies from 1900 through 1993, based on land stations. The base period for anomaly calculation is 1951-1980 and the anomalies are shown in tenths of a degree C.

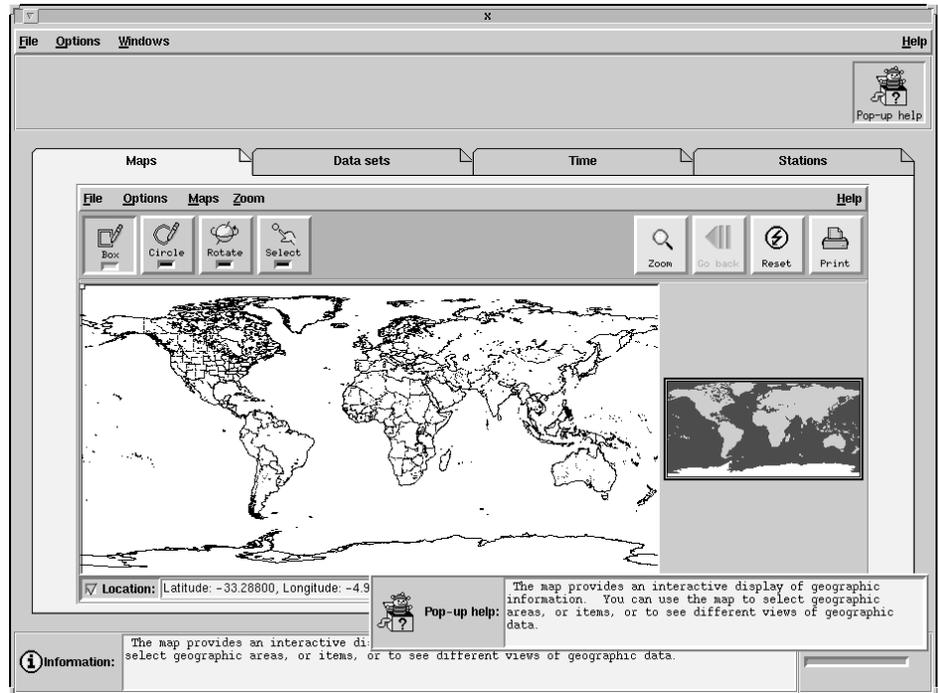
Station data extraction/client server prototype

In the last few months, work has progressed on a prototype client-server GCPS interface which will allow full GCPS functionality to be available to a much wider user community. The data browsing and extraction subsystem, named Xtract, is a graphical tool which uses the Xerox WWW/Mosaic map server to generate geographic map images, and is being written in the Tcl/Tk interpreted language. An interesting part of this development is the online hypermedia help feature which aids users in navigating through the Xtract tool in an efficient manner.

Figure 4 depicts the main Xtract window. The user has the capability to select data via a map interface as shown in the figure, and also through selecting data sets and by station. The user may select data by drawing a circle or box around a geographical area on the map interface. The map rotate and zoom features aid the user in data extraction.

Metadata

The backbone of GCPS is a newly designed, developed and documented database which is also being used by a wide variety of other NCDC applications. The database has a rules-based design and is intended to be self-descriptive with the structure of the database (its schema) and the items it describes being contained within the database itself. The scope of the data-



▲ Figure 4. Prototype client-server GCPS interface. The data browsing and extraction subsystem, named Xtract, is a graphical tool which utilizes the Xerox WWW/Mosaic map server to generate geographic map images. Through this main window, users may select data via a map interface as shown or by specifying particular data sets or stations.

base includes not only the geophysical parameters but also all supporting metadata including station history information.

Products available from the GCPS

The suite of gridded climatological anomaly products available from GCPS includes:

- **NOAA Baseline Climatological Dataset**
 - Seasonal and annual temperature data;
 - Monthly temperature data;
 - Seasonal and annual precipitation data; and,
 - Monthly precipitation data
- **Microwave Sounding Unit (MSU) Lower Tropospheric Data (surface-500 mb)**
 - Seasonal and annual temperature data; and
 - Monthly temperature data.

Further information on the GCPS and its associated products can be obtained from NCDC by contacting: National Climatic Data Center
NOAA/NESDIS

151 Patton Avenue
Asheville, NC 28801-5001
Phone: 704-271-4800
Fax: 704-271-4876
E-mail: orders@ncdc.noaa.gov

or through the NCDC Home Page on the World Wide Web at URL:
<http://www.ncdc.noaa.gov>.

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New and recently updated online datasets available from NCDC

Unique climatological datasets made accessible to users through FTP and the WWW

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NOAA/NESDIS

The following is a short review of new and just recently updated online datasets available from NCDC via the Internet. Some of these are accessible via direct File Transfer Protocol (FTP) and some via the World Wide Web (WWW) with a user interface such as Mosaic (Figure 1). The following are instructions for accessing the data: For FTP -

Address is *ftp.ncdc.noaa.gov*
Login is 'ftp' or 'anonymous'
Password is your e-mail address

For WWW -

URL is *http://www.ncdc.noaa.gov*
No login or password needed
Use mouse to click menu items

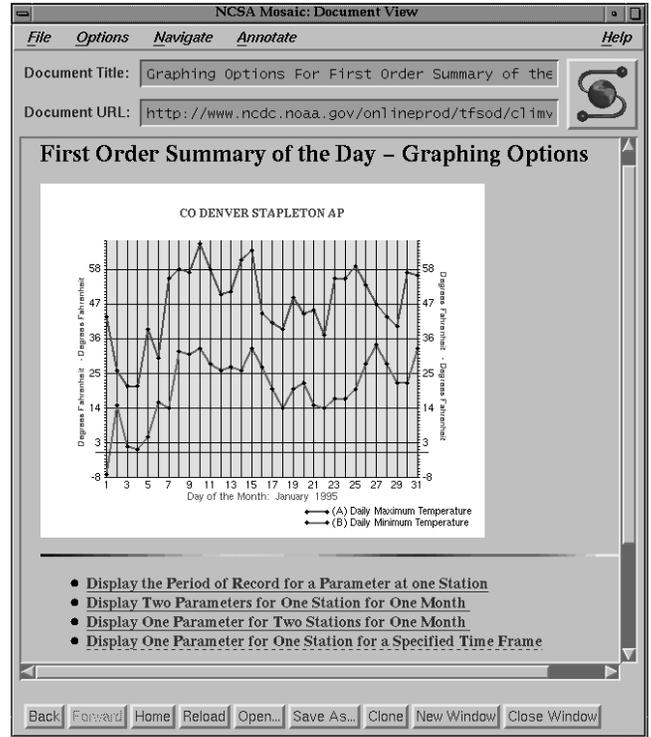
National Climatic Data Center
151 Patton Avenue
Asheville, NC 28801-5001
Phone: 704-271-4800
Fax: 704-271-4876
E-mail: *orders@ncdc.noaa.gov*

A new dataset now available online is the National Weather Service (NWS) Summary of Day Data. The set generally covers the period of 1948-1995 for all NWS sites, including over 1000 historical stations and over 400 currently active stations. It includes all observed elements, such as max/min temperature, mean wind speed, precipitation, snow depth, mean dew point, and percentage of possible sunshine.

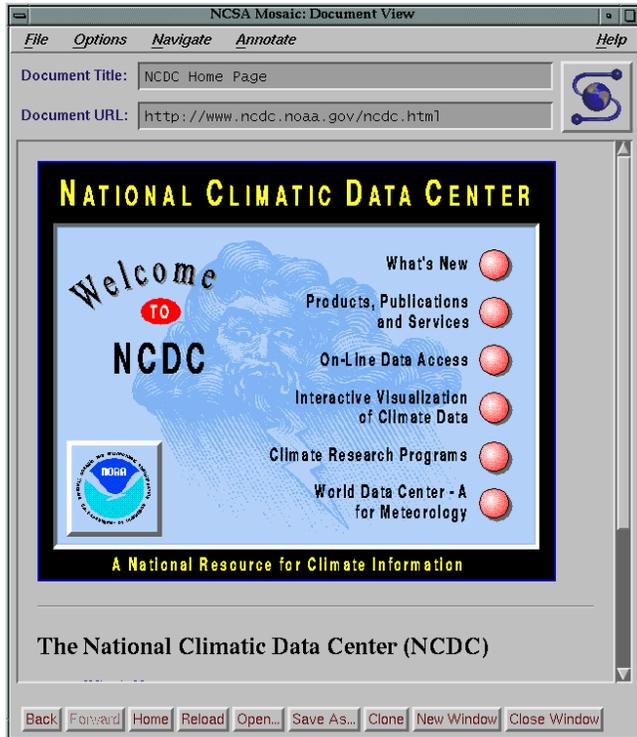
The file, 'fsod.READ-ME', describes the data in detail. These data are available through the WWW or by FTP in the directory: */pub/data/fsod*. The WWW interface includes graphical

display tools for plotting the data (Figure 2). The Global Summary of Day Data has been newly updated and incorporates several new features, including availability in a compressed form for quicker

downloads, as well as a set of complete ASCII text files. Additional quality control has also been incorporated into the system. This dataset has good worldwide coverage of over 8,000 global stations, both land- and ocean-based. The period currently covered is from January 1994 through July 1995; normally the latest month's data is placed online about one month after the end of the data month. The latest month is now available in both English and metric units. The Global Summary of Day Data includes 18 elements, such as mean temperature, max/min temperature, mean dew point, mean wind speed, max wind speed, mean pressure, mean visibility, precipitation, and snow depth. A 'readme.txt' file with a complete explanation of the dataset along with a GIF format image of station locations is provided for users (Figure 3).



▲ Figure 2 Through NCDC's Climate Visualization (CLIMVIS) System, users can produce and download visual displays of the NWS Summary of Day Data dataset.



▲ Figure 1. The NCDC Home Page on the World Wide Web, which is accessible to users with a graphical interface such as Mosaic. Through the NCDC Home Page, users can easily obtain a wide variety of data products and information offered by the NCDC, including the datasets reviewed in this article.

- continued on page 14

New bathymetry of the Great Lakes being compiled as part of NOAA's Great Lakes data rescue effort

Lake Michigan bathymetry completed in joint effort between NGDC and the Great Lakes ERL

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David Reid²
Great Lakes Environmental
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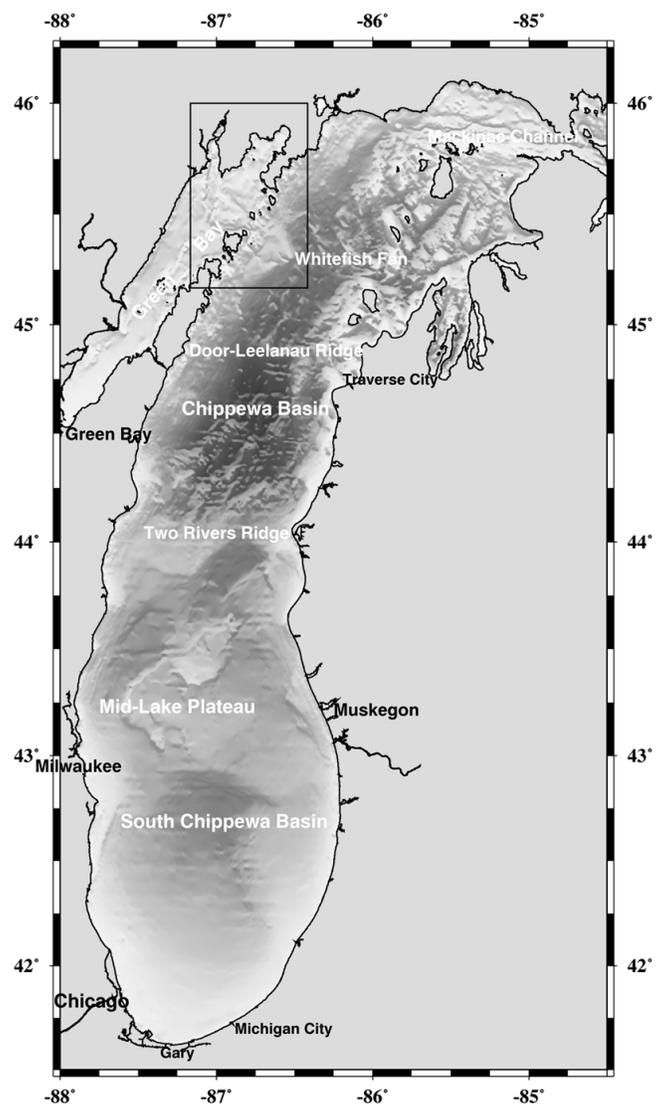
New bathymetry of Lake Michigan has been compiled as a component of a NOAA project to rescue and make more accessible Great Lakes lakefloor geological and geophysical data. This bathymetry was compiled at a scale of 1:250000, with a contour interval of 5 meters. This project is a cooperative effort between investigators at the NOAA National Geophysical Data Center and the NOAA Great Lakes Environmental Research Laboratory.

The bathymetry and accompanying explanation of the geomorphology were presented at the recent 1995 Annual Meeting of the International Association for Great Lakes Research, held at Michigan State University in East Lansing, Michigan. Bathymetric data has been collected from the Great Lakes in support of nautical charting for at least 150 years by the U.S. Army Corps of Engineers (prior to 1970), the NOAA

National Ocean Service (since 1970), and the Canadian Hydrographic Service. Whereas in several previous exercises generalized bathymetry of Lake Michigan was compiled, the entire array of 540,000 accumulated historic soundings were never, until now, used to systematically map lakefloor topography in the greatest detail possible. Compilations of this type, never a small task, are now made more manageable by a confluence of technology.

A high-quality bathymetric chart is of great value as a base map for geological and limnological sciences as well as for decision-making. Modeling of lake circulation and sediment transport, and predicting the effects of climate change and toxic waste remediation on the lakeshore, are only a few of the things that can be done better and more accurately with the availability of a good base map (Figure 1). In addition, bathymetry is of interest for curiosity's sake and certainly makes an attractive wall display. Sport fishermen and recreational sailors also find value in having a good bathymetric map on hand.

Spacing of data control tracklines is generally about 2000m for the open lake and ranges from 200m to 600m for nearshore areas. In preparation for bathymetric contouring, digital soundings were converted to metric units and plotted in color; and separate colors



▲ Figure 1. Shaded relief image of Lake Michigan bathymetry. The box corresponds to the area shown in Figure 2.

were assigned to the various depth ranges. From the paper sheets, contours in metric units were generated directly on overlays; these contours were then reduced to the compilation scale of 1:250,000 and patched in. Compilation sheets were scanned and vectorized; and the resulting digital vector bathymetric contour data base in geographic coordinates constitutes the primary product.

Maps and color posters at most any

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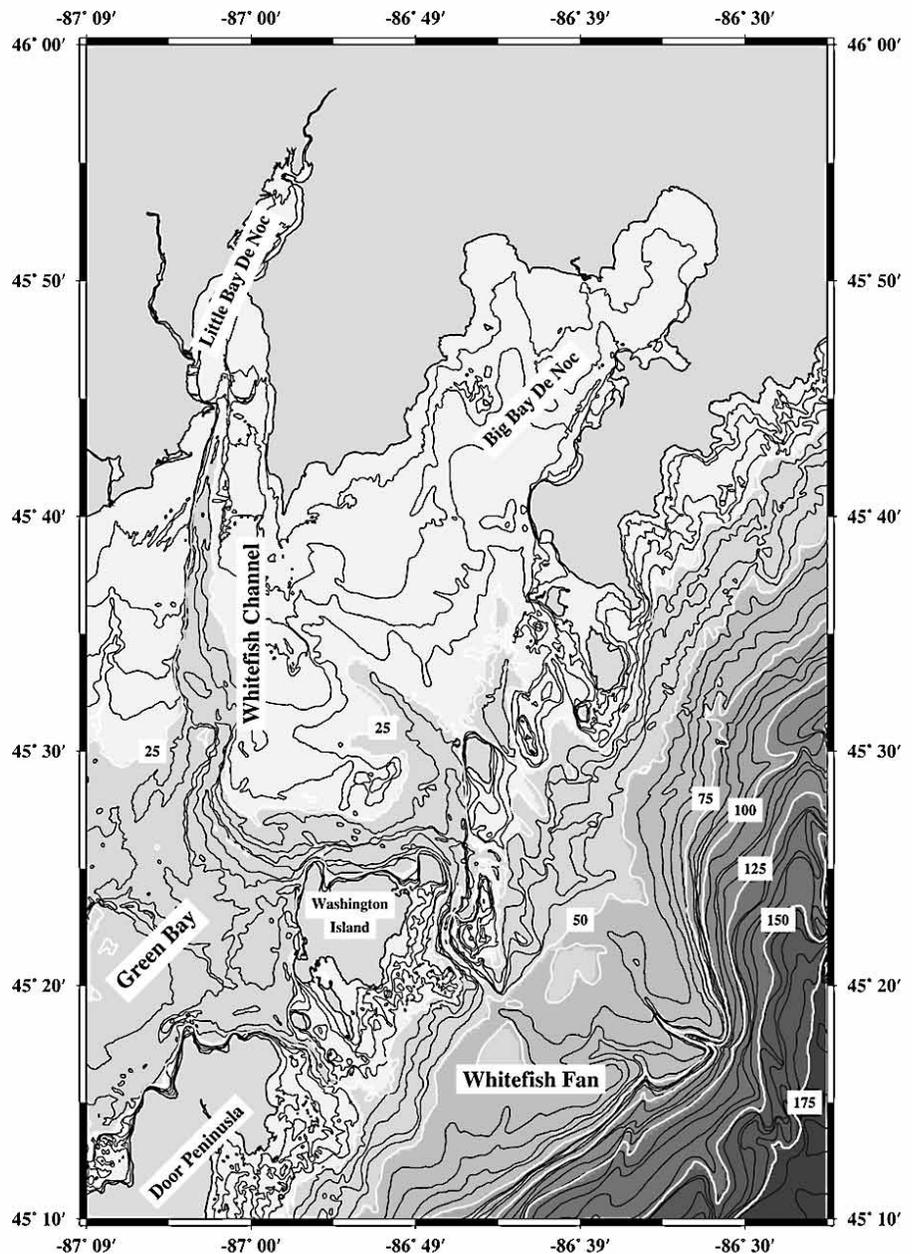
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scale and projection for all or any portion of the lake can be generated from the digital data base. The digital contour data can be loaded into geographic information systems as a base layer and in this way be used for all kinds of graphic presentations. Known lake floor physiographic features are revealed more accurately, and several features are revealed for the first time. For example, Figure 2 depicts a drowned fan lying at depths of 50 to 60m which dominates the lake floor east of Washington Island, at the end of the Door Peninsula, and a large drowned river channel leads upstream from this fan, across the floor of Green Bay.

This fan and channel have probably resulted from catastrophic overflow of Lake Superior into Lake Michigan across the Michigan Upper Peninsula during the Lake Chippewa low stand. Geologists have been speculating for over a century about the history of the large valley extending northward from Little Bay de Noc across the peninsula of northern Michigan to Au Train Bay on Lake Superior. These earlier interpretations presented difficulties because only higher, not lower, late glacial and postglacial lake levels were assumed.

Once the likelihood of a postglacial lowstand in Lake Michigan was established, University of Illinois Professor Hough (1955) recognized that the Au Train - Whitefish Valley, together with the submerged channel extending across Green Bay, was probably the site of the main outlet of Lake Duluth into Lake Michigan at a time when Lake Michigan level was low.

About 1968, University of Northern Michigan Professor John Hughes obtained the Lake Survey sounding sheets from the immediate area of the Whitefish Channel and described the bottom morphology. He discovered the existence of the large fan, here named the Whitefish Fan, which lies at the downslope end of the Whitefish Channel and has a top depth in the range of 50 to 55m. Hughes (1989) attributed formation of the Whitefish Channel and Fan to short-term, possibly catastrophic drainage of Lake Superior, when western Lake Superior was open water but eastern Lake Superior was filled with ice of the Marquette readvance and the St. Mary's River out-



▲ Figure 2. New bathymetry of the Whitefish Fan and Channel, Lake Michigan. Contour interval is five meters.

let was blocked. Hughes recognized that the level of the top of the fan constitutes a record of the level of Lake Chippewa at this location.

This new bathymetry gives an integrated view of the Channel and Fan and the topography of the surrounding lake floor, which is more detailed than that published by Hughes (1989). It demonstrates that there are no other submerged fans or channels in northern Lake Michigan of anywhere near comparable size. The twenty-meter difference between Lake Chippewa level here and Lake Chippewa level at

its outlet is accounted for by the difference in subsequent isostatic rebound which has occurred between the two localities.

References

- Hough, J.L., 1955. Lake Chippewa, a low stage of Lake Michigan indicated by bottom sediments. *Geol. Soc. Amer. Bull.*, v.66, p. 957-968.
- Hughes, J. L., 1989. When Green Bay was a valley: the Au Train-Whitefish-Green Bay spillway. In Palmquist, J.C., ed., *Wisconsin's Door Peninsula*, Perin Press, Appleton, WI, p. 49-65. ■

U.S. Joint Global Ocean Flux Study data online

NODC participates in bringing U.S. JGOFS data to the World Wide Web

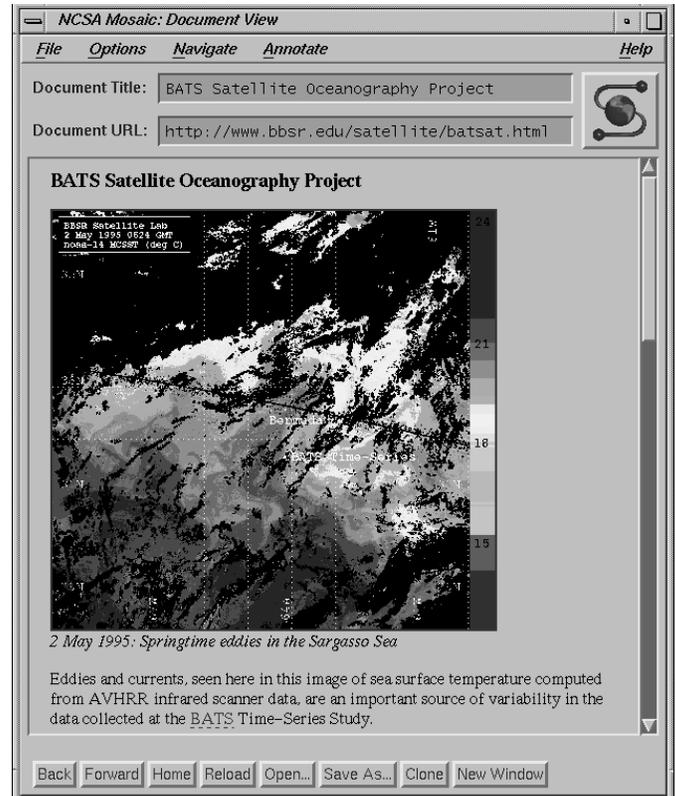
George Heimerdinger
National Oceanographic Data Center
NOAA/NESDIS

For the past 6 years, the National Oceanographic Data Center (NODC), through the efforts of its Northeast Liaison Office at the Woods Hole Oceanographic Institution (WHOI), has been actively providing project data management services to the U.S. component of the Joint Global Ocean Flux Study (JGOFS) program. JGOFS is an internationally coordinated program studying the global fluxes of carbon and associated biogenic elements in the ocean. The multidisciplinary nature of the JGOFS data set prompted NODC to contribute support to the data management

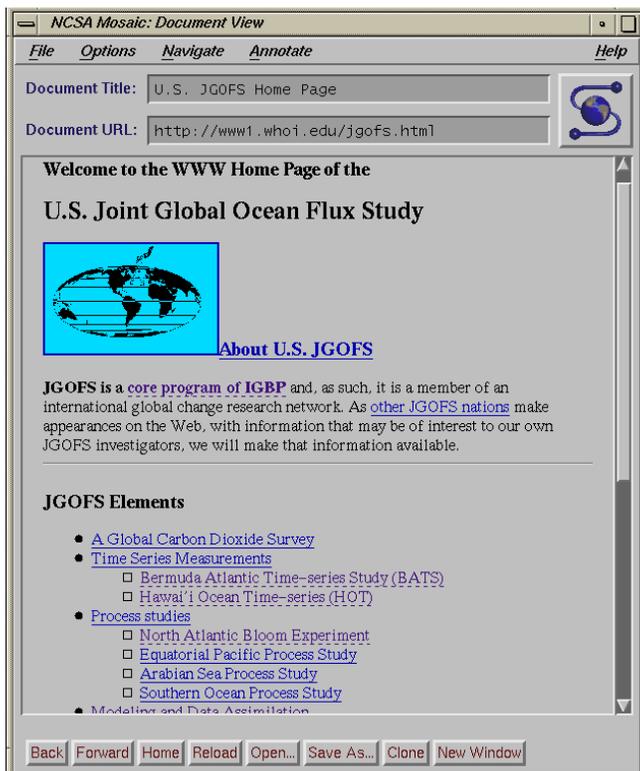
National Oceanographic Data Center
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task as it exposed NODC to data sets it seldom archived.

Initially, the U.S. JGOFS Data Management Office was staffed solely by NODC with the data management services focusing on inventory, accession, quality control, documentation, and distribution at the file level. These tasks were considered interim steps in support of the then being developed Distributed Data Management System (DDMS) adopted by the U.S. JGOFS Program. The systems development team coupled the



▲ **Figure 2.** An image of sea surface temperature computed from AVHRR data in connection with the Bermuda Atlantic Time-Series Study (BATS). The image was produced by the Satellite Laboratory of the Bermuda Biological Station for Research, Bermuda.



▲ **Figure 1.** The U.S. JGOFS Home Page, which is administered by Christine Hammond at the U.S. JGOFS Data Management Office, Woods Hole Oceanographic Institute.

evolving DDMS to the emerging technologies of the World Wide Web (WWW).

Today, access to the U.S. JGOFS data is via a Web-hosted home page (Figure 1). The present U.S. JGOFS data management office (DMO) has been expanded to a three member task team, one of which is supported by NODC. In addition to the initial data management activities, the role of the DMO has been expanded to address DDMS maintenance and Web Server issues.

The U.S. JGOFS Home Page supports the standard array of program descriptive materials, and over 1000 biogeochemical data files and their supporting metadata from two field programs (North Atlantic Bloom Experiment and Equatorial Pacific). The Home Page also points to data being served by the two U.S. JGOFS time-series stations in Bermuda (the Bermuda Atlantic Time-Series Study (BATS)) and Hawaii (the Hawaii Ocean Time-Series study (HOTS)).

In addition, the Home Page points to JGOFS related data collected by NOAA's Pacific Marine Environmental Laboratory (PMEL) and the Atlantic Oceanographic and Meteorological Laboratory (AOML). In the very near future, data from the Arabian Sea field program will appear on the system, with the field program for the Southern

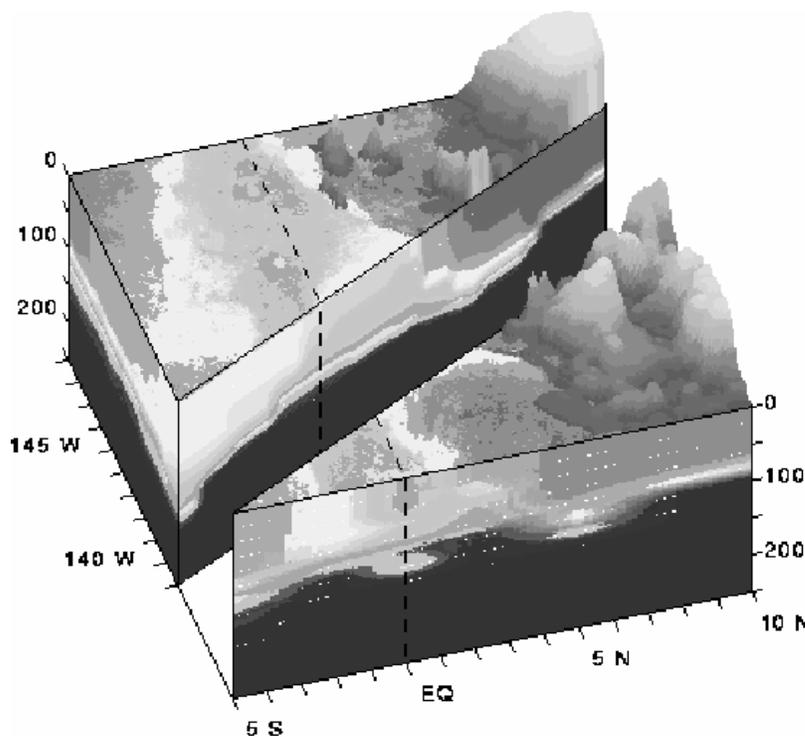
Ocean to begin within a year.

With the DDMS overlaying the Web, the user community has an array of tools for plotting, selecting, merging, and calculating prior to downloading a data set. Through hypertext capabilities, users can view JGOFS and JGOFS-related data plotted by investigators in graphical format (such as the plots shown in figures 2 and 3). The system is currently being interrogated at the rate of approximately 300 requests a day. The successful installation of this system can be attributed to the foresight of the U.S. JGOFS Steering Committee's insistence that a data management element be included in the overall design of the U.S. JGOFS program. Another measurement of the success of this system is evidenced by the adoption of this data management model by other programs.

The address to the JGOFS Home page on the World Wide Web is:

<http://www1.whoi.edu/>

Comments on the U.S. JGOFS Web Server are encouraged, and a form is included on the home page for users' remarks. ■



▲ Figure 3. View of the three-dimensional equatorial temperature field in August 1992, looking towards the northwest. The equator is represented by a dashed line. This data plot was produced from JGOFS cruise data by Michael Sawyer, June Firing and Pierre Flament of the Satellite Ocean Laboratory, University of Hawaii. The color version of the plot can be accessed through the WWW at: <http://satftp.soest.hawaii.edu/jgofs.html>.

Surface current and subsurface float data on CD-ROM

The National Oceanographic Data Center (NODC) is pleased to announce a new CD-ROM set containing the Surface Current (Ship Drift) Data Archive obtained from the Naval Oceanographic Office and the World Ocean Circulation Experiment (WOCE) Subsurface Float data released by the WOCE Subsurface Float Data Assembly Center (located at the Woods Hole Oceanographic Institution). The two-volume set also contains format descriptions and citation files for specific experiments.

The surface current (Ship Drift) file contains over 4 million surface current observations, almost all of which were obtained by the ship drift method. Date, data source, position, and current direction and speed are recorded for each observation. With the exception of about 5,100 observations taken using the Geomagnetic Electrokinetograph (GEK), these are not instrument-measured current data. Rather, they are indirect determinations of ocean surface currents based on the ship drift method.

In the ship drift method, the difference between a ship's dead-reckoned

position (determined from its previous position, speed, and heading) and actual position determined from a navigational fix is ascribed solely to the effect of surface currents. These data are contained in disc 1 of the set.

In addition to the data files, disc 2 of this set provides surface current data summaries in the NODC Long Summary format. These data are summarized by Modified Canadian 10° square, 1° square, and month for all years. A Postscript file showing the modified Canadian 10° square numbers is also included.

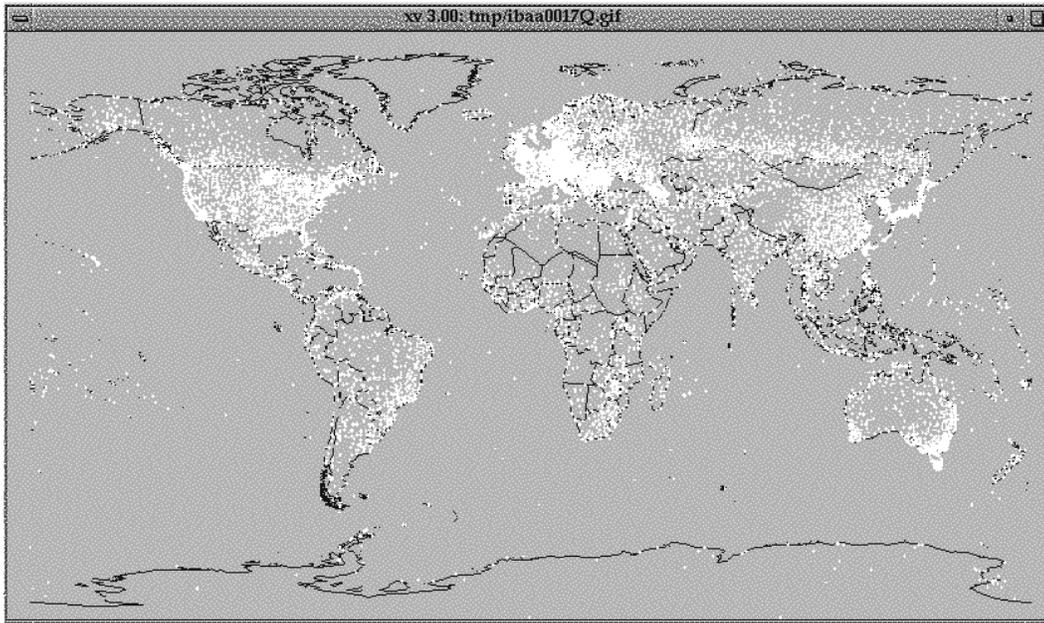
The subsurface float data set on disc 1 consists primarily of SOFAR (Sound Fixing and Ranging) and RAFOS (SOFAR spelled backwards) float trajectories. These floats are ballasted for a target depth and acoustically tracked. Some recently released ALACE (Autonomous Lagrangian Circulation Explorer) float trajectories are included in this float data set. ALACE is a subsurface float that cycles vertically from a depth where it is neutrally buoyant to the surface where it is located by, and relays to, System Argos satellites.

The subsurface float data has approximately 475 float trajectories and 432 float-years of data. Float depths range from a few hundred meters to several thousand, with most observations falling in the 700 m to 2000 m depth range. Most of the trajectories are located in the North Atlantic and were obtained as part of a variety of experiments during 1972-1992. Some recent observations reflect work being performed in the Pacific and South Atlantic.

For more information or purchases of this CD-ROM set, contact:

National Oceanographic Data Center
User Services Branch
NOAA/NESDIS E/OC21
1825 Connecticut Ave., NW
Washington, DC 20235
Phone: 202-606-4549
Fax: 202-606-4586
E-mail: services@nodc.noaa.gov

—Andrew Allegra and Gary Keull
National Oceanographic Data Center
NOAA/NESDIS ■



▲ **Figure 3.** A gray scale rendering of a GIF format image which depicts station locations from the Global Summary of Day Data. Station locations are marked in white. Global Summary of Data is one of the many datasets available by FTP or through the WWW.

NCDC online data, from page 9

The Global Summary of Day Data can be accessed through the WWW or by FTP in the directory: `/pub/data/globalsod`.

Monthly Precipitation Data for the U.S. Cooperative and National Weather Service Sites has also been updated. The period covered is from 1948-1994, with some data acquired as far back as 1900. Over 8000 stations recorded are currently active; historical data covers thousands more inactive stations. Monthly and annual precipitation amounts for all years are available.

Each U.S. state is available as an individual ASCII text file; a complete dataset for all states can be downloaded as a 17 MB compressed file. A 'readme.txt' file provides users with detailed information on the data. Monthly Precipitation Data is available through the WWW (Figure 4) or by FTP in the directory: `/pub/data/coop-precip`.

Other datasets and items available from NCDC via the WWW include:

- Various data inventories (also in FTP directory: `/pub/data/inventories`.)
- World War II era Summary of Day Data (also in FTP directory: `/pub/data/ww-ii-data`.)
- A subset of the Comprehensive Ocean-Atmosphere Dataset (ocean-based data.)

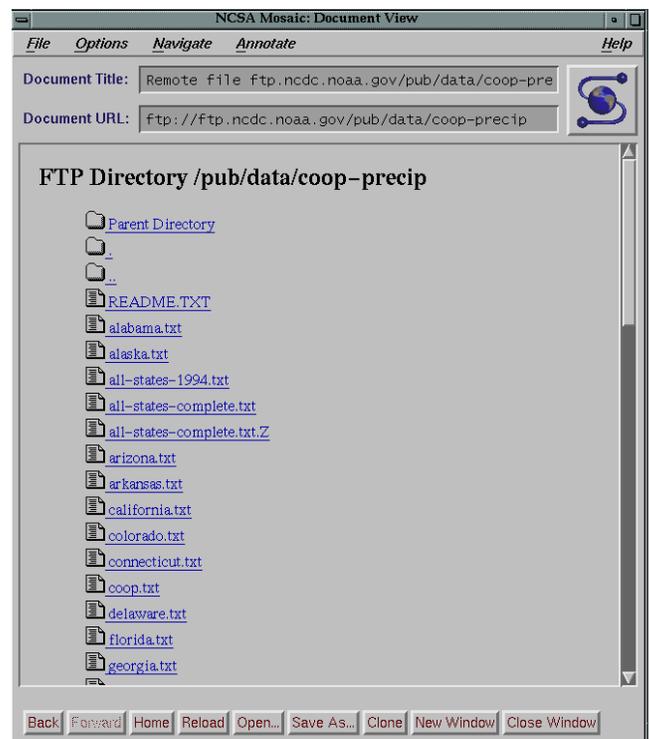
- The Global Climate Perspectives System (graphical display of long-term data; see article on the GCPS on page 6 of the *Earth System Monitor*, Vol. 6/1.)
- The Global Historical Climatology Network dataset (long-term monthly data.)
- The U.S. Historical Climatology Network dataset (long-term monthly data.)
- The Satellite Active Archive (browse/inventory system for satellite data.)
- Publications such as: *NCDC Products and Services Guide*, the *Climate Variations Bulletin*, and *Technical Reports* on weather events (e.g., 1993 Midwest flooding.)

Data and publications can be ordered off-line by contacting the National Climatic Data Center at:

Climate Services Branch

NOAA/NESDIS/NCDC
151 Patton Avenue
Asheville, NC 28801-5001
Phone: 704-271-4800
Fax: 704-271-4876
Internet: orders@ncdc.noaa.gov

NCDC sometimes 'reboots' its online systems at about 4:00 AM Eastern Standard Time, resulting in temporary difficulties in downloading. Technical questions concerning the data and other problems may be directed to Mr. Neal Lott (E-mail: nlott@ncdc.noaa.gov) or Mr. Tom Ross (E-mail: tross@ncdc.noaa.gov) at NCDC. They may be contacted by phone at: 704-271-4995 or 704-271-4994 and by Fax at 704-271-4876. ■



▲ **Figure 4.** The NCDC has updated its dataset of Monthly Precipitation Data for the U.S. Cooperative and National Weather Service (NWS) Sites. As shown in this screen image of the WWW user interface, each U.S. state is available as an individual file or the entire dataset may be downloaded as a 17 MB compressed file.

NCDC announces International Station Meteorological Climate Summary Version 3 CD-ROM

The National Climatic Data Center (NCDC) announces the availability of the International Station Meteorological Climate Summary (ISMCS) Version 3 CD-ROM. This CD-ROM is the third in a series produced at the Federal Climate Complex in Asheville, NC, as a joint product of NCDC, the U.S. Navy, and the U.S. Air Force. It contains detailed climatological summaries for about 2200 international locations along with brief summaries for about 5000 other locations.

The software is IBM-compatible and allows the user to view, print, export, and even graph (histograms of selected tables, wind roses, etc.) the data. The user can select the station or region in a number of ways, such as by World Meteorological Organization (WMO) station number, individual country, alphabetical sort, latitude/longitude area, or mouse-click on a user-defined map. This upgrade from Version 2 includes 1100 additional non-U.S. locations with detailed summaries, several additional tables and narratives, and new graphical plots of selected tables.

The package includes 38 different climatic tables/summaries, such as:

- A one-page climate summary for the station with monthly averages and extremes of temperature, precipitation (amount and/or frequency), cloudiness, humidity, winds, and occurrence of various weather phenomena (e.g., fog, thunderstorms).
- Frequency distribution of daily max/min temperatures by month.
- Bivariate distribution of dry vs. wet bulb temperatures.
- Frequency distribution of wind direction vs. wind speed by month-hour.

Contact: NCDC

Ocean drilling program article available online

The National Geophysical Data Center (NGDC) has posted an online version of the text, graphics, and data of "Revised chronology of neogene DSDP holes from the world ocean" (Lazarus, *et al.*, 1995) from the *Ocean Drilling Program Technical Note No. 24*. An electronic copy of the publication and associated data were sent to NGDC by the senior author for distribution as an alternative to the 301-page printed volume. Data available for down-

Data products and services

loading include stratigraphic data files and age depth plots for Deep Sea Drilling Program holes, as well as the program that generates the age depth plots. This posting is part of the NGDC/World Data A for Marine Geology and Geophysics' cooperation with the Ocean Drilling Program (ODP) to offer digital ODP data.

Contact: NGDC

NCDC merges satellite data services operations in Asheville, NC

Approximately one year ago the NCDC initiated a study to determine how satellite data services could be improved to better meet the needs of its customers. One of the recommendations resulting from this study was to merge the satellite customer service operation in Camp Springs, MD with the customer service operation at NCDC's Asheville, NC location. The study showed that merging the two operations in Asheville would provide a higher quality and more timely service

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NOAA Central Library
Reference Services:
301-713-2600
Fax: 301-713-4599
E-mail: noaalib@libmail.lib.noaa.gov

for NCDC customers, and would also result in a significant savings cost for NCDC and ultimately the taxpayer.

Effective July 10, 1995, the NCDC began servicing both satellite and *in situ* data requests from its Asheville center. Satellite data requests can be forwarded to NCDC by mail, fax, or e-mail at the contact address listed.

Contact: NCDC

Volume 5 of the World Ocean Atlas 1994 issued

The National Oceanographic Data Center's (NODC) Ocean Climate Laboratory has released the fifth volume in its *World Ocean Atlas 1994* series, subtitled *Inter-annual Variability of Upper Ocean Thermal Structure*. The new atlas extends an earlier work entitled *Climatological Atlas of the World Ocean* (Levitus, 1982).

This volume contains maps of yearly *in situ* upper ocean temperature anomaly fields at selected standard levels of the world ocean, computed on a one-degree latitude-longitude grid, for the 1960-1990 period. The fields used to generate the maps were computed by an objective analyses of all historical temperature data available from the NODC, plus data gathered as a result of two data management projects: the NODC Oceanographic Data Archeology and Rescue (NODAR) project and the Intergovernmental Oceanographic Commission (IOC) Global Oceanographic Data Archeology and Rescue (GODAR) project.

Figures showing the results of multivariate analyses of the fields, linear temperature trends occurring in the upper ocean, and difference fields between selected years are also presented in this new atlas.

Contact: NODC

NGDC issues prototype CD-ROM set in support of GLOBE project

In support of the international Global Land One-km Base Elevation (GLOBE) project, the NGDC has released a new, two-volume prototype CD-ROM set. Highlighted on these CDs are 30-minute digital elevation models developed from the U.S. Department of Defense's Digital Terrain Elevation Data 3-second data.

Coverage includes most of the northern hemisphere, and contains average, maximum, and minimum elevation grids.

Contact: NGDC

NODC and NGDC directors retire

NOAA's National Environmental Satellite, Data, and Information Service (NESDIS) regretfully announces the retirement of directors of two of the NOAA/NESDIS national data centers, Dr. Michael A. Chinnery of the National Geophysical Data Center (NGDC) and Bruce C. Douglas of the National Oceanographic Data Center (NODC). Both men were instrumental in spearheading long overdue technological advances which have since propelled NESDIS data centers into the 21st century. Using their technical knowledge and insightful management, each contributed greatly to the advancement of science and through their long years of service, greatly benefited the world geophysical and marine science communities.

Formerly on the faculty of Brown University and later the Massachusetts Institute of Technology (MIT), Dr. Chinnery holds both a Ph.D. and a Doctorate of Science in seismology. Dr. Chinnery became Director of NGDC in 1982. One highlight of his 13-year tenure as director was the production by NGDC in 1987 of the first CD-ROM issued by the Department of Commerce, a collection of solar-terrestrial data. With other scientists he formed the Paleoclimatology Branch in NGDC and contributed to the Defense Meteorological Satellite Program (DMSP).

Under the management of Dr. Chinnery, the NGDC became a leader in using Internet resources to improve data access and developed an NGDC interface on the World Wide Web. Recently, the NGDC Home Page was acknowledged as both the best of the NOAA home pages and best of the NESDIS home pages.

After completing his duties at the NGDC, Dr. Chinnery plans to research new projects which will benefit from his expertise and management skills. Dr. Chinnery stated that his greatest regret at leaving his current position would be ending his long association with the staff of NGDC.

Bruce Douglas came to the NODC in 1992 from the NOAA National Ocean Service, where he served as Chief of the Geosciences Laboratory. As NODC Director, he was the driving force behind

the recent NODC modernization that saw outmoded computer technology replaced by a client/server network of advanced workstations.

In his 12 years of government service, Douglas received many accolades for his work. He was awarded six Senior Executive Service awards within the last decade. In 1987, he received a Presidential-level Meritorious Executive Award for his leadership to the Geosat effort, and a Department of Commerce Silver Medal. He was elected to Fellowship in the International Association of Geodesy in 1991, and two years later he was made a fellow of the American Geophysical Union for his contributions to the use of artificial satellites in geodesy and geophysics. After leaving NODC, Douglas will continue his researches into global sea level change. He will hold the position of Research Scientist at the University of Maryland in the Department of Geography.

Douglas says he is proudest of his part in the NODC modernization and credits newly available technology including the World Wide Web, CD-ROM and client/server computing with enabling the NODC to increase the volume of data distributed in recent years by over 10-fold, while greatly reducing the cost of data. Before modernization the average cost of a megabyte of NODC data was \$10; today it is about 10 cents.

— Nancy O'Donnell
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 User Services Branch
 NOAA/NESDIS
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