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EARTH SYSTEM MONITOR

NOAA's Coastal Change Analysis Program (C-CAP) monitors critical marine habitats

A guide to NOAA's data and information services

INSIDE

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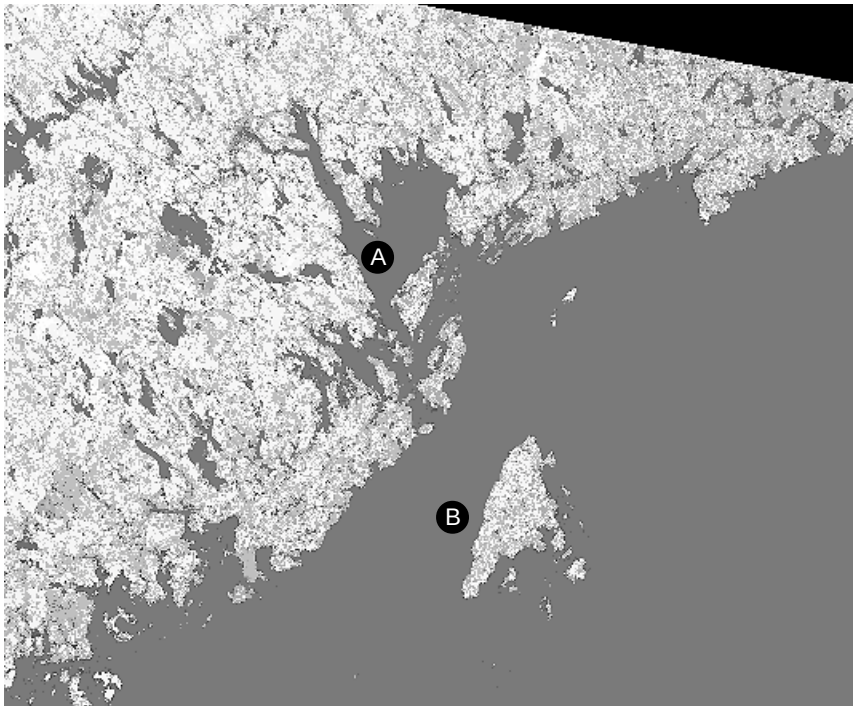

▲ **Figure 1.** C-CAP land cover classification image for the St. Croix River Estuary (A) in the upper Gulf of Maine near Grand Manan Island (B). Land cover images are employed to track habitat alterations resulting from development and forestry, which can affect the productivity of the bay.

Coastal uplands, wetlands, and submersed vegetation play vital roles in nutrient assimilation, geochemical cycling, water storage, and sediment stabilization, and they also support the majority of finfish and shellfish resources in the United States. Human population growth and the resultant development and use of rural lands, however, are placing a severe burden upon the United States' coastal regions. Adverse effects of increasing development, freshwater flow alteration, and forestry and agricultural practices include changes in water salinity, destruction of habitat, increased sedimentation and turbidity, nonpoint source pollution, loss of fisheries, and decreasing biodiversity.

The Coastal Change Analysis Program (C-CAP), a component of NOAA's Coastal Ocean Program, has begun coordinated studies to monitor the alterations of coastal areas of the United States (Figure 1). In this effort, C-CAP is working cooperatively with EPA's Environmental Monitoring and Assessment Program, the Fish and Wildlife Service's National Wetlands Inventory, the U.S. Geological Survey, the National Biological Service, and other federal and state agencies, and universities. Currently, C-CAP is conducting three activities:

- protocol enhancement,
- regional change analysis using remotely sensed data, and
- establishment of a data management infrastructure.

C-CAP protocol

A standard, national protocol for mapping submersed rooted vegetation (SRV), emergent coastal wetlands, and adjacent uplands has been established by C-CAP. Development of the regional guidelines was based primarily on information generated by five regional workshops, topical meetings, and two prototype studies in the Chesapeake Bay and coastal North Carolina. Researchers from universities, state and regional organizations, the Oak Ridge National Laboratory (ORNL), and NOAA have participated in the

– continued on page 2

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C-CAP, *from page 1*

guidelines development.

The C-CAP regional guidelines document is being published as *NOAA Technical Report NMFS 123* and contains sources and procedures for data acquisition, processing, and presentation. The protocol's land cover classification scheme is dynamic and will be improved upon in future editions as it becomes refined through research and input from regional projects. Nationwide acceptance of the protocol will allow comparable analyses to be conducted and land cover products to be generated, regardless of which organization funds or performs the study.

Regional Analysis

Coastal regions are identified as candidates for periodic monitoring based upon the frequency of environmental changes. An agreement is normally made between C-CAP, local researchers, and coastal managers, to perform the analyses in accordance with the regional guidelines document, and to provide the results to C-CAP. In some instances the analyses are performed by ORNL with cooperation from local experts for field verification.

To monitor functional status and change in these critical habitats, C-CAP employs satellite images and aerial photography to cover large coastal areas of interest. When feasible, Landsat satellite Thematic Mapper sensor scenes for a region, observed during clear atmospheric and dry ground conditions, are purchased from the Earth Observation Satellite Company (EOSAT) for approximately the same time of year for two different years. Sensor scenes are then analyzed to determine land cover and classified according to the C-CAP protocol. A third result of the analyses, land cover change, is the difference data set between the different years. Land cover data sets derived from Thematic Mapper data are binary raster. Each suite has a unique size because of the number of Landsat scenes used, and because the amount of truncation done during analysis varies by region.

Vertical aerial color photographs of metric quality are taken during acceptable weather conditions from fixed wing aircraft to determine location and areal extent of submersed rooted vegetation (SRV). These are photointerpreted, classified, and digitized into vector data sets. In many cases, the goal is a suite of three data sets, two time periods, and a change detection (Ferguson, *et al.*, 1993).

Fourteen land cover analyses and/or habitat monitoring projects (Figure 2), jointly sponsored by C-CAP and other federal, state, local, or academic institu-

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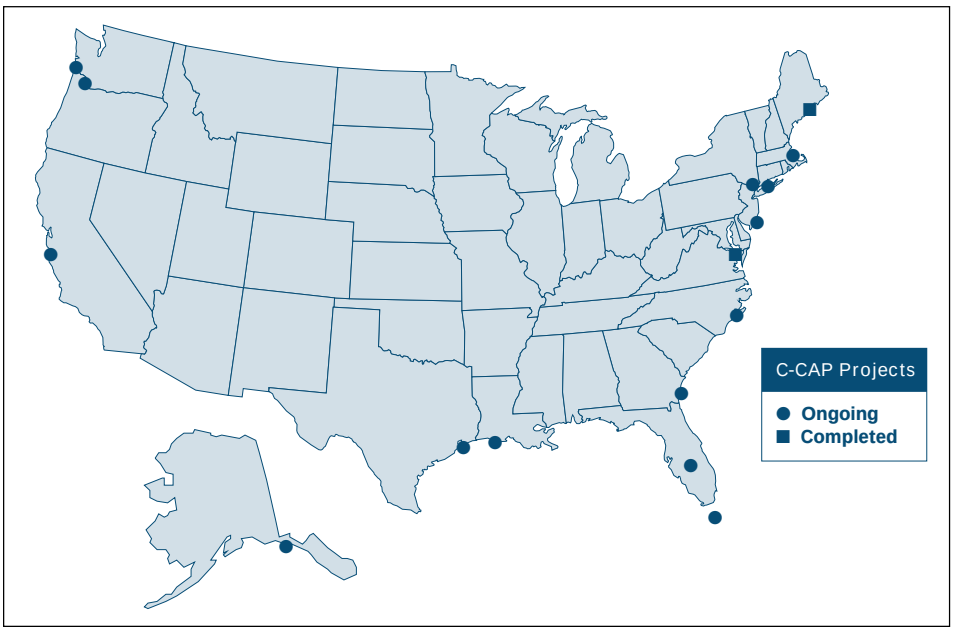

▲ **Figure 2**. Locations of current land cover analyses and habitat monitoring projects, which are being jointly sponsored by C-CAP and other Federal, state, local, and academic institutions.

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News briefs

Workshop produces plan to use paleoenvironmental research in climate variability studies

Dr. Jonathan Overpeck, head of NGDC's Paleoclimatology Group, co-convened a joint International Geosphere Biosphere Programme - World Climate Research Programme (IGBP-WCRP) sponsored workshop entitled "A Paleoclimatic Perspective on Climate Variability and Predictability". The workshop, held in Venice, Italy, on November 16-20, 1994, brought together the world's leading paleoclimatologists and climate physicists to generate an explicit interdisciplinary workplan for using paleoenvironmental research to develop a complete understanding of interannual to century-scale climate variability. Simulation of climate variability with predictive models was also examined.

This understanding is not possible using the short satellite and instrumental record alone. The workshop served as a basis for focussing the international IGBP-WCRP research community on meeting climate prediction goals that are central to NOAA.

Dr. Overpeck also participated in an Executive Committee meeting of the International Geosphere Biosphere Programme/Past Global Change Core (IGBP/PAGES) Project. Dr. Overpeck, elected to this committee earlier this year, helped guide the implementation of the large international IGBP/PAGES research program. In particular, he aided in the coordination of paleoenvironmental data management efforts around the world. The World Data Center-A for Paleoclimatology at NGDC is the data management coordination center for IGBP/PAGES.

NCDC Supports Florida Coastal Science Center

The National Climatic Data Center provided several CD-ROM products to support the Florida Oceanographic Society Coastal Science Center. The mission of the society is to increase the knowledge and understanding of Florida's marine resources through education, public awareness, and the support of scientific research. The Coastal Science Center is being developed on Hutchinson Island along Florida's east coast.

The center will include a library, auditorium, conference center, aquariums, and research facilities. The center will also operate and maintain two coastal weather stations with "real time" weather and sea state conditions available.

NCDC provided copies of the U.S. Navy Marine Climatic Atlas of the World Volume 1.0, the International Station Meteorological Climate Summary Version 2.0, and several additional CD-ROMs as part of a climatology package which will be on display at the center.

NGDC receives new data from the international community

Professor Meiqing Gao, from the Institute of Geophysics, Academia Sinica, Beijing, China, delivered 56 years of geomagnetic hourly data from the Sheshan Magnetic Observatory to NGDC. The data will be placed on a one-off CD-ROM which will be handcarried back to China by Professor Gao. The data will be included on a planned CD-ROM of geomagnetic hourly values to be produced in 1995.

NGDC has also received annual mean values from four geomagnetic observatories in Vietnam. These data are the first received from Vietnam at NGDC (for Solid Earth Geophysics) in many years. The data were sent in response to the Solid Earth Report-52, *A Report on Geomagnetic Observatories and Observations, 1994*, and represent the fulfillment of several months of work in establishing contacts with the Institute of Geophysics in Vietnam.

In addition, a data exchange agreement has been established between NGDC and the Instituto de Astronomia y Geodesia, Universidad Complutense de Madrid, Spain. The Institute forwarded gravity data from the Mediterranean Sea in response to a letter from NGDC that opened discussions in August. They also have offered to forward additional gravimetric data from Spain and Portugal.

38th conference on Great Lakes research scheduled

The International Association for Great Lakes Research (IAGLR) announces the 38th Annual Conference on Great Lakes Research, to be held at the Kellogg Center on the campus of Michigan State University from May 28 through June 1, 1995. The purpose of the conference is to exchange information applicable to the understanding of large lakes of the world, and to the human societies surrounding them.

To date, at least 25 special symposia are scheduled. Topics include such issues as physical dynamics, causality and risk assessment, atmospheric processes, global change records in lakes, food chain transfers, remedial action plans, combined sewer overflow, groundwater and lake interactions, wetlands research, large lakes of the world, contaminated sediments, toxicology, and exotic species. Preliminary program details will be published in the IAGLR *Lakes Letter* newsletter released in April.

Registration for the conference will begin on Sunday, May 28, 1995; preregistration is encouraged. Registration will be followed by four days of technical sessions, poster presentations, and exhibits. For additional information on this conference, please contact:

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Communications hub for ARCSS

The National Snow and Ice Data Center (NSIDC) is developing a bulletin board for the Arctic System Science (ARCSS) community at the ARCSS Data Coordination Center. A Home Page will be accessible using Mosaic or similar software. This site will also function as a listserver, allowing access by electronic mail as well. Using Mosaic, users will be able to browse text, post and read messages, view the ARCSS Data Catalogue, and link to other information sources at NSIDC.

Users without access to Mosaic can e-mail to the listserver, receive a list of message headers, and send e-mail back to receive text of interest.

For more information, please contact Matt Cross at 303–392-5532 or through the Internet at: *cross@kryos.colorado.edu*.

NODC archives shipboard ADCP data

Acoustic Doppler Current Profiler data provides information on structure of the upper ocean

Patrick Caldwell
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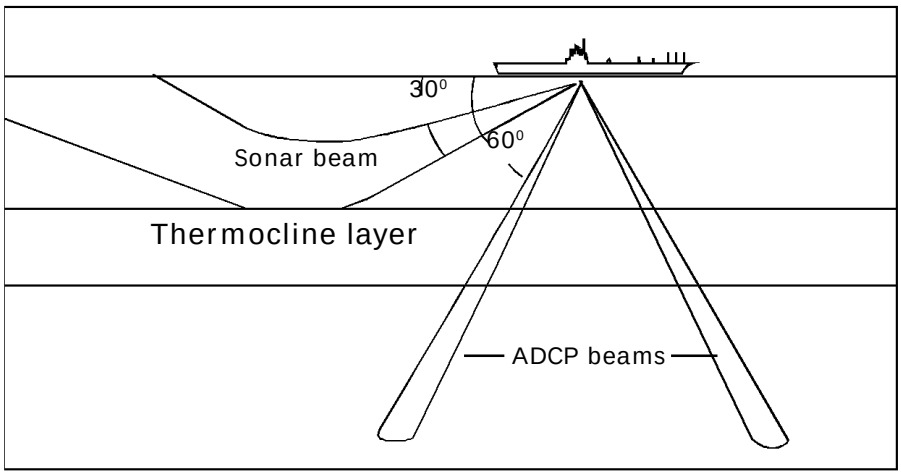
For the past decade, acoustic Doppler current profilers (ADCPs) have become steadily more common aboard the University National Oceanographic Laboratory System (UNOLS), NOAA, and U.S. Navy fleets. During the late 1980s, the data quality was limited by lack of continuous Global Positioning System (GPS) coverage and uncertainties in the ship's heading information. For the past several years, however, the quality has improved significantly due to the 24-hour GPS coverage, differential gps techniques, and the advent of GPS heading sensors. With reliable heading and navigation data, absolute currents in the upper ocean are determined. The data provide fine resolution in time (~5 minutes), depth (~10 m), and horizontal distance (~2 km) throughout the duration of a cruise. The accumulating database allows a fresh view of upper ocean velocity structure on a variety of temporal and spatial scales.

The National Oceanographic Data Center (NODC) has been working for several years on a management scheme for this important new data set and is now ready to share the plan with the scientific community and solicit contributions to the shipboard ADCP archive.

Methodology of data acquisition

The hull-mounted ADCP estimates horizontal and vertical velocity as a function of depth by using the Doppler effect to measure the radial relative velocity between the instrument and scatterers in the ocean (Figure 1). Three acoustic beams in different directions are the minimal requirement for measuring the three velocity components. A fourth beam adds redundancy and an error estimate.



▲ **Figure 1.** Diagram of hull-mounted acoustic Doppler current profiler and acoustic beams utilized in developing current profiles. Three acoustic beams sent in different directions are the minimal requirement for measuring current velocity components.

The ADCP transmits a ping from each transducer element roughly once per second. The echo arrives back at the instrument over an extended period, with echoes from shallow depths arriving sooner than ones from greater ranges. Profiles are produced by range-gating the echo signal, which means the echo is broken into successive segments called depth bins which correspond to successively deeper depth ranges. The operator configures the length of each depth bin and the transmit pulse, which determines the degree of averaging in the vertical, depending on whether one is interested more in vertical resolution or profile penetration.

The noisy velocity estimates from each ping are vector-averaged into 1- to 10-minute ensembles. The relative velocities are rotated from the transducer's to the earth's reference frame using the ship's gyrocompass. Finally, relative velocities and various ancillary parameters are stored on the ship using a data acquisition system (DAS) which also optionally records navigation information, such as provided by the GPS. Specifics of the instrument capabilities and configuration options are well documented (RDI, 1989).

Routine processing, quality control, and calibration are performed at the host institution. Standard checks include detecting and correcting time errors, applying transducer-level temperatures and salinities to obtain a better estimate of the sound speed for the velocity calculation, editing out bad bins or profiles that have been contaminated by interference with the bottom or some other physical object such as a hydro wire, and verifying the quality of the gyrocompass and the navigation data. The final gyrocompass estimates of ship heading and the navigation information are the primary sources for calibrating the ADCP's relative current velocities.

Typically, one is correcting for a "angle" error due to misalignment of the transducer relative to the ship's hull and an "amplitude" component related mostly to minor imperfections of the transducer geometry. Relative current velocity errors caused by these components are orthogonal; the angle errors lead to uncertainties of the athwartships velocity component while the amplitude error introduces uncertainties along the ship track.

The navigation calculation is performed once calibration is complete. Absolute currents over a fixed depth range (reference layer) are obtained by subtracting the average of the ship ve-

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locity relative to a reference layer (i.e., ADCP velocities) from the absolute ship velocity over the ground (from navigation, i.e., GPS). The raw absolute current velocities relative to the reference layer are smoothed to reduce the effects of noise in the position fixes and combined with the navigation data to obtain the best estimates of ship positions and velocities, which are stored in the data base. Thus, absolute currents at any depth can be determined from the final ship navigation data and the relative ADCP measurements.

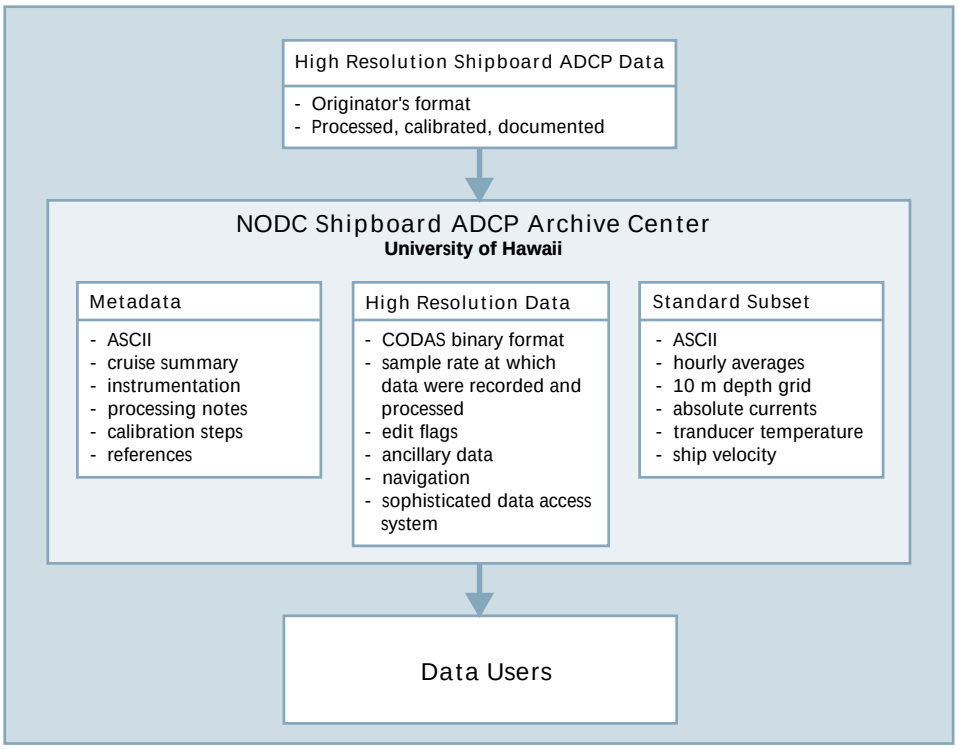
NODC's archive plan

A group of data producers and users of shipboard ADCP met with data management experts at NODC in May 1992 to discuss the tasks at hand (Firing, 1992). The meeting was convened by Dr. Eric Firing, a professor of oceanography at the University of Hawaii (UH) who is a long standing expert in shipboard ADCP collection, processing, and analysis. By this point in time, many of the difficulties in calibrating and obtaining absolute currents had been overcome and the number of scientific publications using this data was steadily rising. With the sharp increase in installation and attention to the shipboard ADCP in the early 1990s, it became clear that a data management plan was required for centralizing the data set into a well-documented, quality-assured archive and for allowing easy access to the scientific community.

Shortly thereafter, the NODC liaison assigned to the TOGA Sea Level Center at UH began collaborating on a part-time basis with Dr. Firing, the NODC data managers, and other ADCP experts in the development of an archive strategy. The primary logistical problem was how to effectively handle the high-density data set consisting of currents and ancillary parameters at the sampling interval with which the data were recorded and processed. It is not merely the volume of data collected on a typical month-long cruise (about 10 Mbytes) that makes this data set complex, but rather the cruise-to-cruise variability (as well as the intra-cruise variability) of the sampling rates and types of ancillary parameters. These parameters include the date-time-group, transducer temperature (and salinity), a variety of diagnostic values, heading information, and navigational data. Moreover, a method of flagging bad values and denoting the depth penetration of reliable data was needed. It was obvious that the traditional flat ASCII file approach was inadequate and the use of a sophisticated processing and data management system was required to facilitate fast, efficient access to the data.

A software package called the Common Oceanographic Data Analysis System (CODAS), designed, documented, and maintained by Dr. Eric Firing and associates at UH, became the focus of attention. The system has been used at UH since 1988 and has been distributed to over 30 agencies in 12 countries. In addition to the processing tools, this readily available public domain software provides easy access to the data with a variety of options for averaging, regridding, and selecting only data that meet specified quality criteria. CODAS stores arrays of flags corresponding to the velocity arrays; thus, the original data are not altered by editing. CODAS is a hierarchal data base which uses a "directory file" to keep track of binary "block files." The system was written in standard C language and the package is primarily used on workstations and IBM-compatible PCs. For the binary block files, the software provides translation between machines with different binary numbering conventions and offers a complete ASCII dump.

Because of its flexibility, the NODC decided to adopt the CODAS system for the archival of the high-resolution data set. This move advances NODC's goal to be not only an archive center, but to maximize ease of access for the scientific community using the most up-to-date technology. The NODC now archives the high-density shipboard ADCP data as CODAS files and a standard subset of each cruise at hourly and 10 m depth intervals as ASCII files (Figure 2). The CODAS files include current velocities and all ancillary data while the subset includes only the absolute current velocities, transducer temperature, and ship velocity. For analysis purposes, the standard subset is best suited for synoptic and climatological research and the high-density set is valuable for fine-scale studies.



▲ **Figure 2.** Flow diagram of data processing, archival, and distribution procedures for shipboard ADCP data sets received at the Shipboard ADCP Center (SAC).

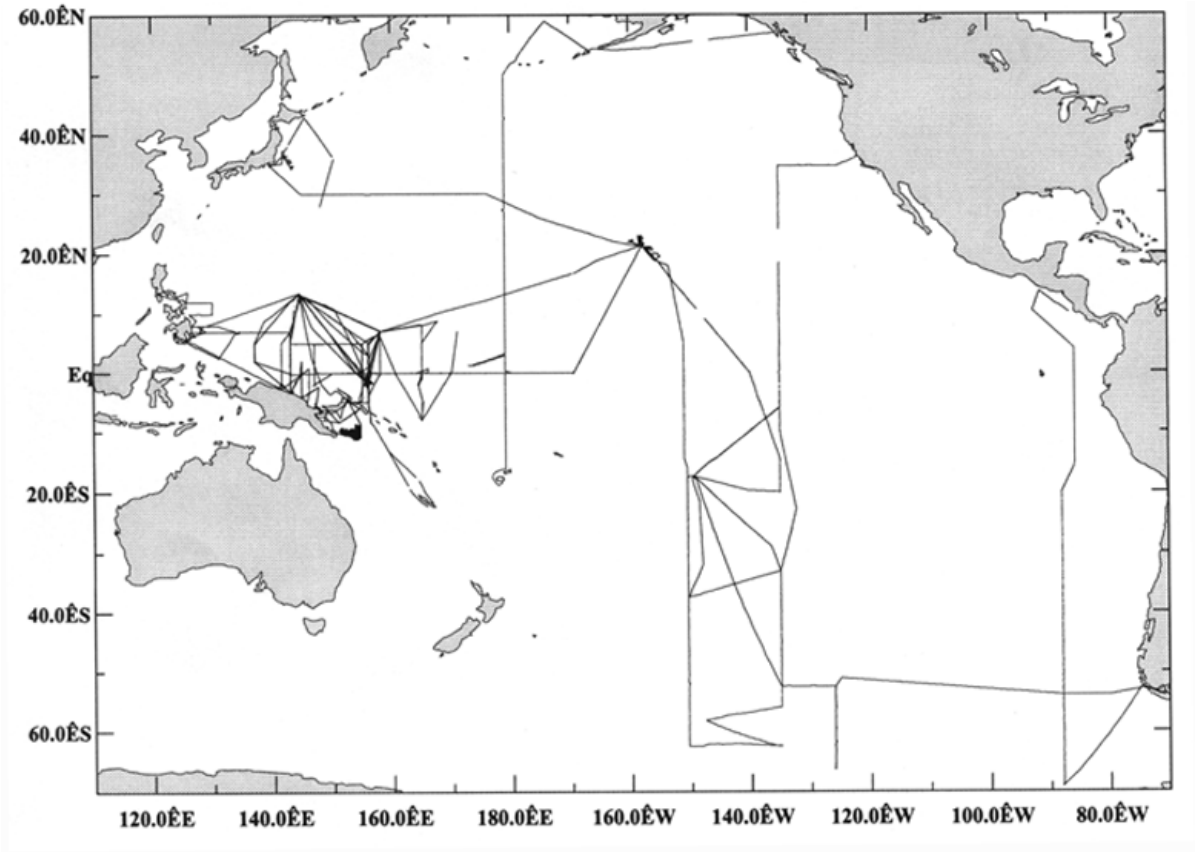
The Shipboard ADCP Center

The NODC has established the Shipboard ADCP Center (SAC) at UH for the acquisition, review, documentation, archival, and distribution of shipboard

– continued on page 6

ADCP, *from page 5*

ADCP data sets (Figure 2). The activities are overseen by the NODC liaison and the locality takes advantage of close proximity to the ADCP and CODAS experts (Dr. Firing and associates). A network of Sun workstations maintain the archive online and facilitate the archiving steps. Data producers are encouraged to contribute the high-density data sets that have passed the quality control, calibration, and navigation stages. Metadata (information about the data) are vital for the archive. The SAC can provide guidelines for the type of metadata desired. The incoming data sets are placed in the CODAS format if necessary, reviewed, reduced to a standard subset, documented, and backed up. The data producers will be contacted if suspect features are identified or if additional metadata are required. The data sets will be periodically passed on to the NODC headquarters which will act as the final repository, assist in advertising data availability and in the encouraging submissions from producers, and prepare CD-ROMs for easy distribution of large volumes of the high- density data sets.



▲ **Figure 3.** Cruise tracks representative of the current data base available from the Shipboard ADCP Center. The growing archive now contains ADCP data from over 70 cruises, including data collected during the HOTS, TOGA/COARE, and WEPOCS projects.

The growing archive now contains 77 cruises including a majority of the Tropical Ocean Global Atmosphere/ Coupled Ocean-Atmosphere Response Experiment (TOGA/COARE) legs, several World Ocean Circulation Experiment (WOCE) lines, all of the Western Pacific Ocean Climate Studies (WEPOCS) sets, and about 75% of the Hawaiian Ocean Time series (HOTS) cruises. Cruise tracks of the present data base are shown in Figure 3. The archive is being filled first primarily with readily available data sets at UH and other institutes that have passed scientific scrutiny, are well documented, and are already in the CODAS format. The database will expand rapidly over the coming years. RD Instruments of San Diego, the dominant source for instruments, has sold about 125 vessel-mounted units to date. If a third of those are active for 10 months a year, that represents ~400 cruise-months per year of potential data.

A browse, inventory, and retrieval system (BIRS) has been developed by the SAC for facilitating access to the global database. Presently, the system is operated solely by the SAC staff, but could easily be placed in a public domain location for anonymous users to query the database and make requests over the Internet. In the interim, please send data requests directly to the SAC.

The high-density data set, the CODAS block files (and software if necessary) the standard subset (~500 Kbytes per cruise), metadata, inventories, cruise tracks, or general information are available through the mail or by Internet (anonymous ftp). Questions, comments, data submissions, data requests, and CODAS software and manual requests should be directed to:

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References

Firing, E., 1992. Notes from the *Acoustic Doppler Profiler Workshop*, NOAA/National Oceanographic Data Center, May 14-15, 1992. Unpublished manuscript. Copies available from P. Caldwell.

RD Instruments, 1989. *Acoustic Doppler Current Profilers Principles of Operation: A Practical Primer*. Available from RD Instruments, 9855 Businesspark Ave., San Diego, CA 92131. ■

C-CAP, *from page 2*

tions are underway around the United States coast. Examples of these projects include:

- The change detection of uplands and wetlands in coastal New Jersey is a joint effort with Rutgers' University. The study will investigate change along a gradient of human influence/disturbance from heavily impacted Barnegat Bay in the north to the relatively pristine Great Bay in the south.
- Change detection of uplands and wetlands in the Mermantau River basin in Louisiana is a cooperative project with the National Biological Service's Southern Science Center. This will be the first C-CAP change detection effort in Louisiana, where some of the largest wetland losses in the nation are occurring.
- The mapping of submersed vegetation in coastal Massachusetts is a cooperative project with the Massachusetts Department of Environmental Protection. The state of Massachusetts will be using these data as a component of a water quality monitoring program.
- The mapping of submersed vegetation in Willapa Bay, Washington is a joint effort with the Columbia River Estuary Study Task Force. This will be the first attempt to map submersed vegetation in the estuary, which is the largest producer of oysters in the United States.
- C-CAP is monitoring the Hubbard Glacier in Alaska, which is advancing rapidly and within the next ten years is threatening to close off the Russell Fjord. The extremely important commercial and recreational fishery of the Situk River may be affected. The analysis of one Landsat scene has been completed for 1992, although snow cover hampered field verification.

C-CAP has also cooperated with other groups within NOAA on regional projects. For example, NOAA's Chesapeake Bay Office provided funding for the Chesapeake Bay change detection prototype. C-CAP is also establishing an operational facility at NOAA's new Center for Coastal Ecosystem Health at Charleston, South Carolina. The operational facility will perform change detection analyses, and manage and coordinate ongoing regional analyses being performed by cooperating investigators throughout the nation's coastal regions (Mason, *et al.*, 1994).

Data Management

C-CAP requested that the National Oceanographic Data Center (NODC) provide data management support to the program. The involvement of the NODC with C-CAP has been continuous over five years. At the program level, NODC assisted in the drafting of the C-CAP protocol document, participated in a protocol workshop and C-CAP Annual Meetings, and provided data management guidance. At the data management level, NODC personnel are archiving and distributing products; planning to implement Federal geospatial standards and a national digital database; procuring hardware, software, and training; and developing the necessary internal procedures and infrastructure to support the full scope of C-CAP data management.

Currently, the C-CAP Archive at NODC contains only digital raster data sets. The archive and distribution process for satellite derived land cover raster products begins when they are received from C-CAP's validation group, Geographic Information Systems and Computer Modeling, located at Oak Ridge National Laboratory. Each data set is displayed by using iAXE, GeoVu, or other Geographic Information System (GIS) package to assist identification, and verified by passing it through an algorithm (which counts the individual pixel values in the scene for comparison with a supplied list to insure the data have not been corrupted). The metadata are reviewed and completed, and internal data management information is extracted for use in a future online catalog. Each suite of regional products and their metadata are copied to their own directory on a WORM optical disk contained in a 300 GB jukebox for local access, and to CD-ROM for archival offsite. Similar procedures will be followed for vector products.

A C-CAP goal is to have a national digital data base containing products and documentation for the contiguous U.S. coasts, including the Great Lakes, as well as Alaska, Hawaii, and all the U.S. possessions. NODC has procured a GIS to help manage both the raster and vector products and their metadata, and to aid in the implementation of federal geospatial standards. The C-CAP Archive will be acquiring SRV vector data, which are usually in a proprietary GIS format. The new GIS should help incorporate these data and metadata into the digital database, and, for example, convert a vector product adjacent to raster product, to raster, for subsequent merging of two into a single raster data set.

The Content Standards for Digital Geospatial Metadata and Spatial Data Transfer Standards (SDTS) are federally mandated standards that have become effective for these digital data. NODC has obtained copies of the current versions of the metadata standards and is coordinating with C-CAP representatives to prepare digital geospatial metadata templates for the raster and vector land cover data sets. In the future, these templates will enable investigators and analysts to compile the metadata as the products are created. This will result in more accurate and useful metadata.

Data distribution

To advertise the availability of C-CAP products, a descriptive flyer is published and distributed after the data and metadata have been reviewed. Data sets can be distributed on Digital Audio Tapes (DAT); 1/2", 9-track cartridge tape; via FTP and on CD-ROM. CD-ROM has been the best medium for distribution of the large volume data sets, especially for users with PCs. FTP through the Internet should also prove to be popular since it avoids computer operating system incompatibilities.

As a joint NODC and National Geophysical Data Center (NGDC) effort, a Chesapeake Bay CD-ROM product was created and distributed to over 50 interested persons as a stand-alone product which uses NGDC's data access and display software, GeoVu. NGDC has provided over 300 of the C-CAP Chesapeake Bay CD-ROMs to Global Change researchers, as one of a set of four in a sample Global View CD-ROM product suite.

Currently, two regional products are available for one complete monitoring cycle from the C-CAP archive at the NODC. The first is a product suite of the Chesapeake Bay. In order to develop a standard, nationally accepted protocol for mapping emergent coastal wetlands and adjacent uplands, a prototype

– continued on page 8

C-CAP, *from page 7*

change analysis for land cover in the Chesapeake Bay region was sponsored by C-CAP. This study was conducted by researchers at Oak Ridge National Laboratory (ORNL), who compared Landsat Thematic Mapper (TM) imagery for 1984 and 1988/89 to detect land cover change. The Chesapeake Bay data set constitutes one of the largest change detection efforts ever attempted, covering an area of approximately 30,000 square miles. Its greatest value is in its synoptic coverage and consistent classification over such a large area.

The second regional product available from the C-CAP archive is from the St. Croix River region in northern coastal Maine. The St. Croix River has historically provided valuable habitat for salmon. Land use changes from the large forest industry in both Maine and Canada have impacted this habitat. The logging increases sediment runoff, which impacts the river's clarity and depth. Also damaging the quality of the St. Croix estuary and the Passamaquoddy Bay (within the Gulf of Maine) is human development that contributes other nonpoint source pollutants from septic tanks, roads, etc.

In addition, a single 1986 C-CAP raster land cover scene is presently available from NODC for the Hubbard Glacier, Russell Fjord, and Yakutat Forelands, Alaska region. The remainder of the Alaska set and other products are expected in the near future.

Information about some of C-CAP's regional products is available through the Internet from the C-CAP Home Page on the World Wide Web:

http://hpcc1.hpcc.noaa.gov/cop/ccap.html

Information on C-CAP products ready for distribution will be made available through the NODC's Home Page:

http://www.nodc.noaa.gov

C-CAP has embarked upon an ambitious task of monitoring man's impacts upon the coastal areas of the United States. The C-CAP approach adheres to a standard protocol, provides funding support, and uses the expertise of local individuals who analyze remotely sensed data to generate land cover classification products in an effective and efficient manner. The results of these analyses, which are being collected in a digital database for preservation and distribution, will provide local and national decision makers with a valuable resource towards achieving the goal of sustainable environments.

NOAA Coastal Change Analysis Program (C-CAP) principals

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Long-term climate monitoring of the Global Climate Observing System (GCOS)

International meeting promotes improvements in global climate observations

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An international meeting of experts was held January 9-11, 1995 in Asheville, N.C., to help establish a list of recommendations for implementation by the Global Climate Observing System (GCOS), a joint program of the World Meteorological Organization (WMO), the United Nations Educational, Scientific, and Cultural Organization (UNESCO), the United Nations Environment Program (UNEP), and the International Council of Scientific Unions (ICSU). The most feasible and practical goals currently achievable were enumerated by nearly 100 scientists attending this workshop. About half the participants were from non-government institutions and the other half were affiliated with national governments. Nine participants also represented world organizations. Scientists from ten countries participated, including North America (Canada and the USA), Europe (Czech Republic, UK, France, Finland, Germany, and the Netherlands), Australia, and Japan.

The documentation of long-term climate variation and change is essential for understanding climatic impacts on managed and unmanaged social and biophysical systems. The early detection of anthropogenically-induced climate change rests upon an observing system capable of delivering adequate long-term data. Several questions have been posed to the scientific community regarding the present and past states of the climate. Unfortunately, our existing observing systems and data management practices have failed to deliver the quality of data required to deduce unequivocal information about the rates and often even the sign of multi-decadal changes and variations.

Answers to specific questions posed to the Intergovernmental Panel on Climate Change (IPCC) are thwarted due to an inadequate or nonexistent climate observing system. Among these questions: Is the climate warming? Is the hydrologic cycle changing? Is the atmospheric/oceanic circulation changing? Is the climate becoming more variable or extreme? Each of these questions is quite complex because each involves many variables at many spatial and temporal sampling scales. Obviously, without adequate answers to such basic questions, understanding climate change and its predictability is not possible. The development of GCOS provides scientists the opportunity to do something about existing observing deficiencies in light of the importance of documenting long-term climate change.

This workshop was an important step toward improving the present inadequacies and defining the long-term monitoring requirements minimally needed to address the four IPCC questions posed above. Special emphasis was placed on detecting anthropogenic climate change. The workshop focussed on three broad areas related to long-term climate monitoring: (A) the scientific bases of the long-term climate products (including their accuracy, resolution, and homogeneity) required from our observing systems as related to the detection issue and the four questions posed by the IPCC; (B) the status of long-term climate products and the observing systems from which these data are derived; and (C) implementation strategies.

In his opening remarks, John Townshend, speaking on behalf of Sir John Houghton, Chairman of the Joint Scientific and Technical Committee, reviewed the overall tasks of GCOS and the challenges ahead. Thomas Spence, Director of the GCOS Joint Planning Office, provided a status report. Greg Withee (speaking on behalf of the U.S.'s focal point for GCOS, Robert Winokur, who is also Co-Chair of the GCOS Joint Scientific and Technical Committee) challenged the participants to address four items of particular concern: What is the science behind monitoring? How can different measurement systems be used together? How can we prioritize our most important global monitoring concerns? How can we best use the measurements we have?

In addition, a number of principles of long-term climate monitoring were introduced by the meeting's organizer, Tom Karl. Karl stressed that data management, analysis, and diagnostics are key parts of a long-term climate monitoring system. Prior to implementing changes to existing systems, or introducing new observing systems, assessment of the effects on climate

– continued on page 10

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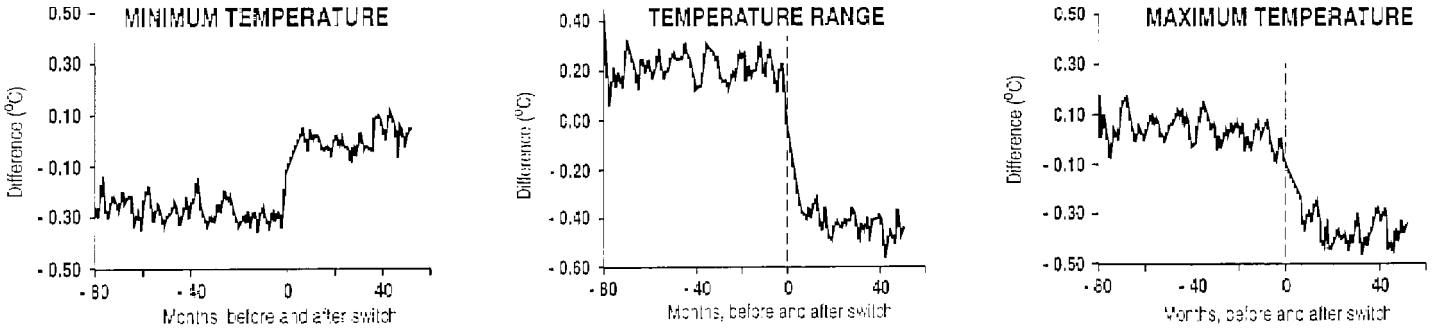


▲ **Figure 1.** Average differences of temperature between stations prior and subsequent to the switch from liquid-in-glass maximum-minimum thermometers in a wooden Cotton Region Shelter to a thermistor in a plastic "Beehive" shelter (from Quayle *et al*., 1991).

GCOS, *from page 9*

monitoring should be standard practice. In addition, routine assessments of the long-term monitoring capability of existing systems should also be consistently performed.

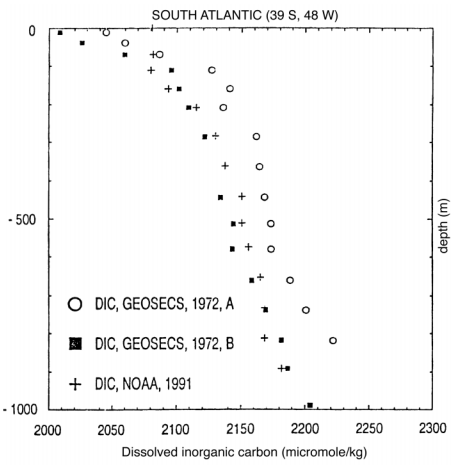
Metadata should include a precise chronology of processing algorithms; instruments; observing practices; station location, elevation, and exposure; and other pertinent documentation of each platform's history. Such information is essential and should be treated with as much care as the data itself. *In situ* and other observations with a long uninterrupted record should be given special consideration. Instrument calibration, validation, and maintenance are critical to long-term climate monitoring. Observing systems should be complete, possibly including both "low technology" and "high technology" components and ground truth validation. The transition from research measurements to operational measurements for long-term climate monitoring must be planned in an orderly and systematic manner. Data management systems must facilitate full and open exchange of data, easy data access at low cost, and data analysis.

Following introductory lectures, a series of technical papers were presented and discussed. These papers are in peer-review for the journal *Climatic Change*. They were used as the basis for developing recommendations in three breakout groups: 1) Climate Forcings and Feedbacks; 2) Climate Responses and Feedbacks; and 3) Climate Impacts. The task of each break-out group was to develop a set of recommendations that could be used to help ensure an adequate global long-term climate monitoring capability. It was not possible to set priorities with respect to the set of specific recommendations as related to the many needs within each of three break-out group topics. Instead, the recommendations should be viewed opportunistically as related to each characteristic of the climate system.

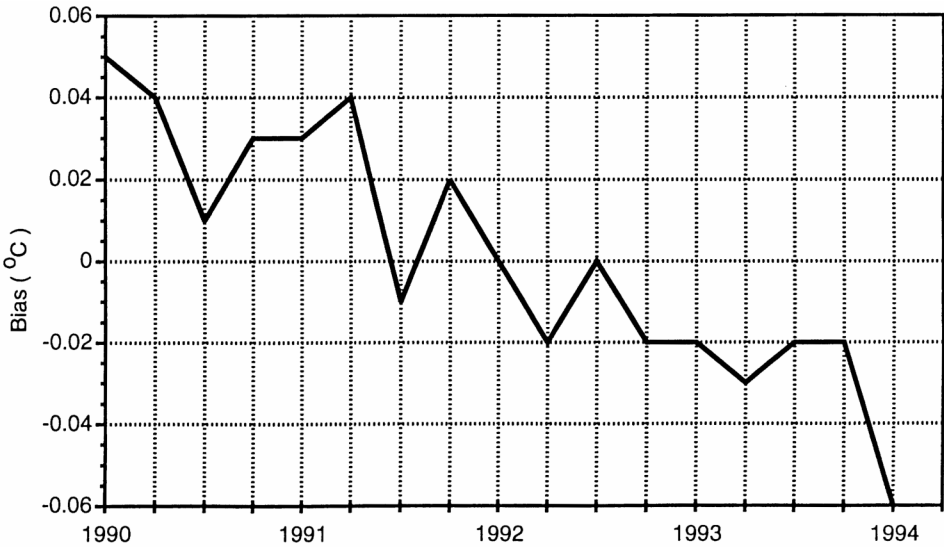
The GCOS focus on decade to centennial climate monitoring must not be polarized into operational versus academic interests. Instead, a partnership must be forged among observing system operators, analysts, and modelers. Experience indicates that operations and research can indeed work as an effective team. This takes time, leadership, and organization. GCOS interests on decade-to-centennial time scales will have to ensure that such a partnership is forged.

The General Recommendations included:

- guidance on changes to existing observing systems in order to quantify or minimize inhomogeneities (e.g., note the differences in temperature



▲ **Figure 2.** Dissolved inorganic carbon measured in 1972 using gas chromatography (circles) and potentiometric titration (squares), and in 1991.



▲ **Figure 3.** MSU2R tropospheric temperature bias (plotted by year) attributed to diurnal sampling changes due to orbital satellite drift (Christy, *et al.*, 1995)

measurement shown in Figure 1, for which overlapping measurements are clearly needed),

• quality control, product development, examination and improvement of the ocean climate data base (e.g., note the differences in measurement of dissolved inorganic carbon shown in Figure 2; the 1972B measurements are improvements, as shown in comparison more recent with 1991 values ... the apparent 1972A to 1991 "trend" is spurious),

• on-board calibration of operational satellite sensors,

• control of polar orbiting satellites (so diurnal sampling is not biased, as shown in Figure 3),

• alternative means for calibrating stratospheric measurements from satellites,

• full and open international exchange of data, and

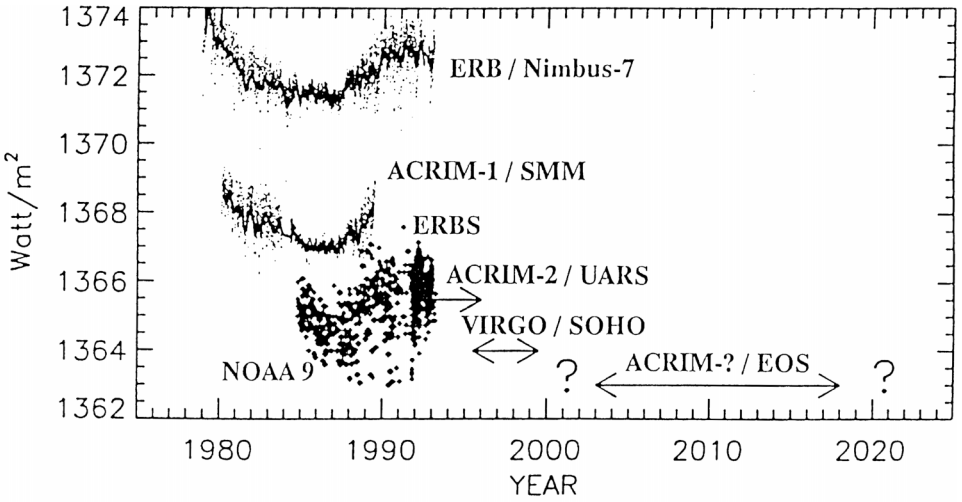
• development of metadata information systems.

Climate Forcings and Feedbacks Recommendations involved monitoring of greenhouse gases, aerosols, solar energy and the Earth's radiation budget (e.g., note the inter-satellite differences in measurement of solar irradiances and concomitant need for overlapping measurements shown in Figure 4); integrating satellite and *in situ* cloud data; and measuring water vapor.

Climate Responses and Feedbacks Recommendations included performing model reanalyses; improving WMO CLIMAT TEMP data (which has been deteriorating, as shown in Figure 5); determining greenhouse-sensitive variables to monitor for climate change detection; establishing reference stations; continuing satellite tropospheric and stratospheric temperature measurement; improving surface marine monitoring, sea level measurement, and subsurface ocean data; and assuring homogeneous cryospheric and precipitation monitoring.

Climate Impacts could best be measured by climate indices using long-term global *in situ* and satellite data, including weekly snow cover, spring onset of greenness, a weekly drought index, and land cover change.

Clearly there are many opportunities for GCOS to improve our long-term climate monitoring capabilities. And clearly, monitoring requires the synthesis of observations, analyses, and modelling. One recommendation stands out among all others that simply must be addressed: adequate long-term climate monitoring will continue to be critically dependent on developing a partnership among network operators, data managers, analysts, and modelers. Such a partnership exists for weather prediction and must now be supported for long-term climate prediction. All must be stakeholders in long-term climate monitoring.



▲ **Figure 4.** Changes in total solar irradiance as measured from different satellites and instruments (adapted from NRC, 1994).

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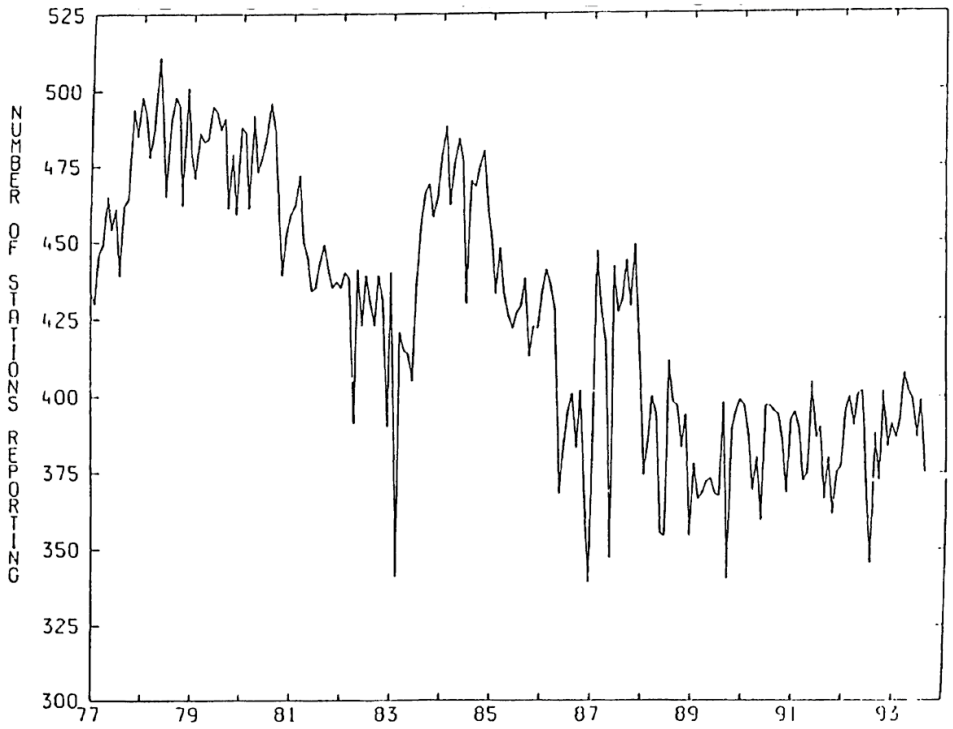

▲ **Figure 5.** Number of monthly "CLIMAT TEMP" messages (containing monthly upper air temperature summaries) by year received at the UK Meteorological Office through the Global Telecommunications System.

A new home for the National Climatic Data Center

NCDC facility provides a state-of-the-art meteorological archive and servicing center

National Climatic Data Center
NOAA/NESDIS

The world's largest active archive of weather data, NOAA's National Climatic Data Center (NCDC), has moved into a new facility in Asheville, North Carolina. The new building, located in downtown Asheville, has over 170,000 square feet of occupiable space, with the NCDC requiring 130,000 square feet of this amount. In addition to the NCDC, thirteen other Federal agencies, including offices of one of the US Senators from North Carolina, are collocated in the building.

Groundbreaking for the data center's new facility took place on June 29, 1992, two years after funding for the project was approved by Congress (Figure 1). An official ribbon cutting ceremony will be held in April 1995 with various Federal and local government dignitaries invited to participate. In addition to the official ceremony, the NCDC plans an open house for Commerce and NOAA officials, employees and their families. "We're all very proud of our beautiful new facility and want to share it with the entire community" stated Ken Davidson, the Center's Deputy Director.

NCDC's new facility finally provides the state-of-the-art security and environmental controls required for the nation's meteorological archive and data services Center. The facility was developed to meet the specifications and requirements as stated by the National Archives and Records Administration (NARA) for a National Records Center. The initial phase of construction was the requirements definition. This was completed for all occupants by NCDC as the major tenant for the building. The design and construction phases were led by the General Services Administration (GSA) with input and monitoring by the tenant agencies.

The NCDC collects information from the National Weather Service, Federal Aviation Administration, Coast Guard, and the Department of Defense. Volunteer cooperative weather observers also contribute to the massive database the Center manages for NOAA. "The center is contacted over 100,000 times annually by national and international users for information stored at the facility," said NCDC Deputy Director Kenneth Hadeen. "We have more than 100 years of data on hand, with 55 gigabytes of new information added each day—that's equivalent to 18 million pages of data a day."

Ensuring that the architectural design and construction met the Center's and other tenants' requirements has been on-going for the past two years. This effort was overseen by NCDC Deputy Director, Ken Davidson. "It was a cooperative effort by many NCDC employees to ensure the computer, LAN, archive, furniture and office space met our requirements" stated Davidson. "Many employees were involved from the beginning through the move-in phase. They have done a tremendous job in limiting down-time and making this move virtually transparent to our customers.

We intentionally established 24 different committees with 4-5 employees serving on each to coordinate and plan this move. This permitted all levels of employees to be part of (have ownership in) the moving process."

Today, the move is nearly complete. NCDC's nearly 200 employees and 120 contractors are working in the new facility (Figure 2). The massive archive will continue to be moved through March.

The centerpiece of the facility is an

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▲ **Figure 1.** Groundbreaking: Turning over the first shovels of dirt for the Center. Left to right: Director Kenneth D. Hadeen, GSA Regional Administrator Gary Cason, Deputy Assistant Administrator for Environmental Information Services Gregory Withee, and the Center's Deputy Director Kenneth Davidson.

▲ **Figure 2.** The new modern home of the National Climatic Data Center, located at 151 Patton Avenue, Asheville, NC 28801-5001.

entire floor devoted to computer operations and digital data media storage. The Center manages over 200,000 magnetic cartridges of climate data and information. For the first time in history, these data are now housed under properly maintained environmental conditions, with room for continued growth.

The Center's computer move was a complicated effort in that it involved mainframes, workstations, and over 300 personal computers. To eliminate downtime during the two-month phased move process, the NCDC systems staff designed a new Local Area Network (LAN) system for the new facility, and had it connected to the old facility with a fiber optic cable. This connection permitted employees in both locations to continue full operations during the entire move process, including use of all systems and file servers.

The physical computer move was accomplished during evening hours for all personal computers, and over a weekend for the workstations, mail file servers, and mainframes. The majority of Center employees went home after their normal duty day from the old building and returned the next duty day to the new building, with their PC working at the new site. This, of course, enabled the Center to maintain normal operations, but required constant coordination and technical support from a small group of employees. This group, one of 22 "move" committees formed by the Center, worked many weekends and nights to make this a "transparent" move.

The new NCDC computer facility occupies an entire floor of the building and is environmentally controlled to Department of Commerce and U. S. Air Force requirements. The facility has a dry sprinkler system for fire prevention, a full emergency electrical system, and a central Uninterruptible Power Supply (UPS) system. The computer facility also provides ample space for expansion of computers and digital media storage.

In addition, the Center's new hard-copy archive area is operating at the NARA standards. The Center took advantage of the move to develop a computer-based inventory system covering the entire hard-copy archive, which is now available to its customer servicing personnel as well as the data management personnel. Mr. Davidson stated that "This new inventory system permits both experienced and new employees and contractors easy and rapid access to the weather archives of the nation." The new facilities and systems installed for the Center will enable the NCDC to improve its role as the world's leader in data management for climate information. ■

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The NOAA Home Page on the World Wide Web: Gateway to NOAA Internet resources

The NOAA Home Page, available on the World Wide Web over the Internet, was designed to give users a thematic view—as well as a more traditional line office view—of the various NOAA components. Since line offices and geographic locations of NOAA offices mean little to the general public, the subject-oriented view is likely to be more useful to most people. In fact, educating the public on the broad scope of NOAA's scientific research and data collection activities is a prime function of the NOAA Home Page. A collage of images depicting the parts of the 1995 NOAA strategic plan was selected to show the cross-cutting nature of NOAA's areas of responsibility (Figure 1). By selecting a subject of interest, users can read highlights from the strategic plan.

Though "hot button" links to home pages of individual NOAA elements and offices, the NOAA Home Page serves as a gateway to all the NOAA resources available on the Internet. Starting at the NOAA Home Page, users can browse through the data and information files installed by elements within all five of the major NOAA line offices:

- National Weather Service;
- National Marine Fisheries Service;
- National Ocean Service;
- National Environmental Satellite, Data, and Information Service; and
- Office of Oceanic and Atmospheric Research.

Many NOAA groups are continuing the process of building and expanding their Internet resources. Some are experimenting with using Internet tools to provide access to NOAA data and data inventories and catalogs. As this article goes to press, there are over 50 NOAA groups that have installed home pages that are part of the interlinked resources available through the NOAA Home Page.

A portion of the NOAA Home Page is reserved for new items about NOAA. Many items have already been highlighted in "NOAA in the News," including schedules for television broadcasts featuring NOAA, press releases and pictures from the new GOES-8 satellite, and announcements of awards received by NOAA offices and personnel.

Following "NOAA in the News," the NOAA line offices and cross-cutting programs are listed on the NOAA Home Page. Users can read about the various offices and programs as well as link to the home pages of other NOAA components. The NOAA mission and a photo of NOAA Administrator Dr. D. James Baker follow. Finally, a list of Frequently Asked Questions (FAQ) about NOAA points users directly to information of general interest. This FAQ includes a pointer to the NOAA online phone directory and vacancy announcements.

The NOAA Home Page (at address: *http://www.noaa.gov/)* was registered with the World Wide Web Directory of Servers early in 1994. Since then many helpful comments have been received. Several government agencies have expressed interest in following NOAA's lead by depicting their agencies in a subject-oriented manner also. Future plans for the NOAA Home Page include completing the text for all NOAA offices, adding links from the text of the strategic plan to the appropriate home pages throughout NOAA, and adding to the Frequently Asked Questions.

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▲ **Figure 1.** Beginning of the NOAA Home Page on the World Wide Web.

ARCSS/LAII Data Series Volume 1 CD-ROM

The first Arctic System Science (ARCSS) CD-ROM is now complete. This volume, titled *ARCSS/LAII Data Series Volume1: Alaska North Slope Data Sampler* contains climate, soils, permafrost, and vegetation data from the north slope of Alaska (some data sets cover the entire state of Alaska) that were identified at the January 1993 Flux Study PI meeting The data sets provided on the CD-ROM and the contributors are listed below:

- Climate database for the Imnavait Creek Watershed—Douglas Kane, University of Alaska, Fairbanks.
- ETOPO5 gridded elevation data set for all areas above 50°N—National Geophysical Data Center, Boulder, Colorado.
- Long Term Ecological Research site data (climate, temperature, plant biomass, soils, and nutrient data)—David Jones and John Hobbie, Ecosystems Center, Marine Biological Laboratory, Woods Hole, Massachusetts.
- Global Historical Climatology Network (GHCN) monthly temperature and precipitation data for Alaska—Jon Eischeid, University of Colorado, Boulder, Colorado, and NOAA/NCDC, Asheville, North Carolina.
- Permafrost data from Barrow, Alaska (soil temperature, soil moisture, thaw depth, snow depth)—Frederick Nelson, Department of Geography, Rutgers University (now at SUNY-Albany, NY).
- River runoff data from Arctic Canada and Arctic Russia—Esther Munoz, University of Washington, Seattle, Washington.
- Soil Conservation Service soil survey from Barrow, Alaska—John Kimble, Soil Conservation Service, Lincoln, Nebraska.
- Global FAO soil unit data compiled by Leonard Zobler—Elaine Matthews, Goddard Institute for Space Studies, New York, NY.
- GIS and Permanent Plot data for the Toolik Lake area, North Slope of Alaska—Donald Walker, INSTAAR, University of Colorado, Boulder, Colorado.
- Matthews vegetation data set—Elaine Matthews, Goddard Institute for Space Studies, New York, NY.

The CD-ROM is available to ARCSS-funded researchers on request. Those not funded by the ARCSS Program may obtain copies for $50.00 including shipping and handling. For more information or to place an order, contact the National Snow and Ice Data Center (NSIDC) User Services Branch by mail at: NSIDC, Cooperative Institute for Research in Environmental Sciences (CIRES), Campus Box 449, University of Colorado, Boulder, CO 80309-0449; by phone at: 303-492-6199; by FAX at 303-492-2468; or by E-mail at: *nsidc@kryo.colorado.edu*;
Contact: NSIDC

Data products and services

New data collections from the National Geophysical Data Center

The NGDC announces the availability of a new collection of digital elevation data on CD-ROM. The collection, called Terrainbase, includes improved 5-minute digital terrain data of land and ocean values for the entire world. Also included on the CD-ROM are 26 regional grids that provide land elevation and ocean depth values for various areas throughout the world.

The data are stored on the CD-ROM in binary format. Included on the CD-ROM is GeoVu, a browse, visualization, and access application, which operates in the Microsoft Windows environment. GeoVu also provides:

- Help files that identify the source of the data, the size and structure of the file, and describe the development history;
- Histograms of digital elevations for each data set.

The data can also be accessed using UNIX and Macintosh systems, but the user will not have the advantage of GeoVu.

In addition to the TerrainBase CD-ROM product, NGDC can provide these data in a variety of media formats, including floppy diskettes and magnetic tapes. Electronic delivery of data via Internet is also possible.

NGDC also has several recently released groups of Geologic Hazard Slide Sets available, including slide sets of the January 17, 1994 Northridge, CA earthquake, and slide sets depicting damage from two major tsunamis occurring in Nicaragua and Indonesia in 1992, and from one of the largest tsunamis in Japan's history in 1993. Please contact the Center for pricing and information.
Contact: NGDC

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E-mail: sdsdreq@ncdc.noaa.gov

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E-mail: info@ngdc.noaa.gov

National Oceanographic Data Center (NODC)
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Fax: 202-606-4586
E-mail: services@nodc.noaa.gov

NOAA Environmental Services Data Directory
202-606-5012
(Gerry Barton)
Fax: 202-606-5012
E-mail: barton@esdim.noaa.gov

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

Historical Soviet Daily Snow Depth CD-ROM

The NSIDC announces the release of the Historical Daily Snow Depth CD-ROM. Production of this CD-ROM was funded by the NOAA Earth Science Data and Information (ESDIM) Initiative through the NGDC.

Historical Soviet Daily Snow Depth is based on observations at a series of 284 World Meteorological Organization (WMO) stations throughout the former Soviet Union. The earliest operational stations began recording snow depth in 1881, and the data continues until 1985. Geographic distribution of stations is primarily in the mid-latitudes of Eurasia, and correspond to inhabited areas. Stations range from 35° to 75°N and from 20° to 180°W. Stations range in altitude from -15 meters to 2100 meters.

Daily data, as well as NSIDC-generated monthly means, are available on a single CD-ROM containing ASCII data files, extraction software, and data documentation. The source of the data used is the State Hydrometeorological Service in Obninsk, Russia. Data were provided to NSIDC via the Bilateral US-USSR WG-8 Exchange. For further information, please contact NSIDC User Services.
Contact: NSIDC

The NODC Bulletin Board Service

The National Oceanographic Data Center (NODC) announces the creation of an Ocean Bulletin Board Service (BBS) to promote communication among the oceanographic community. This new bulletin board was implemented using tools and resources of the Internet. Every effort will be made to keep it simple to use. Users of the NODC Ocean BBS will be able to post and read oceanographic messages of their choice. They will also have the option to browse the posted messages or subscribe to the BBS and have all the messages automatically sent to them through e-mail.

Currently, NODC plans to have three different types of access to its Ocean BBS. The easiest way to browse and read messages will be to use Internet tools such as Mosaic or Gopher. The NODC Home Page and Gopher Server will also have future utilities for posting user messages.

Those who do not have Mosaic or Gopher servers at their disposal can use e-mail to post, read, and subscribe to the BBS. New messages can be found in the main area of the BBS. Old messages will be combined and archived under a different heading on the BBS. The initial NODC Ocean BBS has already been implemented, and improvements will be made when necessary.

In order to post messages to the bulletin board, the user simply sends the message via e-mail to:

ocean_post@ocean.nodc.noaa.gov

Please use a subject heading, so that other users know the content of the message before they read it, as shown in the following example:

To: *ocean_post@ocean.nodc.noaa.gov*
From: *<your e-mail address>*
Subject: name of message, or your name
Body of message:

Tools are being developed that will allow a user to post messages using Gopher or Mosaic. When they are complete, it will be announced on the Ocean Bulletin Board.

In order to read messages on the NODC bulletin board, users have three options:

1) Via Gopher (must have gopher client software), gopher to:

gopher.nodc.noaa.gov

and then select NODC's Ocean Bulletin Board and browse.
2) Via the World Wide Web (must have Mosaic, or some other WWW client software), open URL:

http://www.nodc.noaa.gov/

and then select the NODC Ocean Bulletin Board direct link or NODC's Gopher Server on the Home Page.
3) Via E-mail: Send a message to:

ocean_read@ocean.nodc.noaa.gov

with no subject or message. You will receive via return mail a list of all NODC Gopher offerings. Reply to the message and put an X in front of the line: NODC's Ocean Bulletin Board. Then send.

You will receive via return mail a list of all items on the bulletin board. Again, reply and insert an X in front of the items that you want to receive and send it. (Note: no Xs will get you everything in the list). Keep doing this until you have seen everything that interests you.

Users may also subscribe to the Ocean Bulletin Board. Using this option, any messages posted to the Ocean Bulletin Board will automatically be sent to you through e-mail. The bulletin board works in concert with a list processor. To subscribe, send an e-mail message to:

listproc@gopher.nodc.noaa.gov
with the line: *subscribe ocean_list <your name>* in the body of the message. No subject is needed on the subject line, as in the following example:

To: *listproc@gopher.nodc.noaa.gov*
From: *jsmith@nodc.noaa.gov*
Subject: *subscribe ocean_list John Smith*
To be removed from the list send the line: *unsubscribe ocean_list <your name>*.

— Andrew Allegra
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