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New Advisory Group to Help Coordinate NOAA Networking

Technological advances and a dramatic growth in the number of "cross cutting" NOAA programs such as the Earth System Data and Information Management (ESDIM) Program have combined over the past few years to increase the importance of telecommunications in NOAA's mission. Virtually all of the major initiatives on the horizon, such as the Weather Service Modernization, the National Marine Fisheries Service's Information Technology-1995, and the Coastal Ocean Program, include as a major component electronic communications such as electronic mail, distributed processing, or remote file transfer.

In recognition of the need for high level coordination of these resources, the Network Advisory and Review Board (NARB) was established last summer to provide a NOAA-wide perspective on issues related to network integration and development. Since that time the Board has begun energetically to address strategic issues related to network management and integration in NOAA, focusing

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

Electronic Notes about Data: The Metadata Project

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Data management is sometimes called "everyone's second priority." If this is true, then data documentation is everyone's third priority. Documentation efforts seldom receive adequate resources, yet there is general agreement that complete, easy-to-use documentation is crucial if environmental data sets are to be understood and properly used by those not familiar with them. And the broad use of multiple data sets by people other than those who assembled the data is becoming increasingly common.

Metalog
A computer notebook for data documentation

The Metadata Project seeks to use advanced computer technology to facilitate data documentation. Our goal is to develop systems and strategies that will make documentation a relatively painless part of data gathering and assembly, allow documentation to be kept up to date, and allow easy access to it.

The vehicle we are developing to accomplish this is a personal computer based "scientist's electronic notebook." In this article, we describe the notebook, discuss how it has been used over the past year to document an important NOAA data set, and briefly discuss its other uses. (For an earlier report on this project, see the January 1991 issue of *Earth System Monitor.*)

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Why use electronic notes?

Scientists have long kept notes about experiments and data analysis in personal paper logbooks. Logbooks are easy to carry and use. Putting notes into a computer, even a small portable computer, is more cumbersome. So why change?

The same question must have been asked by the first people to use word processors. Typed or handwritten documents were indeed more convenient to create, initially. Based on our experiences and those of others over the past few years, we believe the advantages of electronic notes (which accrue primarily to readers) outweigh the decreased convenience to writers for the following reasons:

- Electronic notes are easy to copy and share, and are therefore at less risk of loss. Paper notes can be copied, but only a page at a time. Multiple copies of files containing electronic notes can easily be made, and distributed to multiple locations, for use and archiving. They can be transmitted over electronic networks, or mailed on floppy disks. Our experience in several field experiments indicates this rapid sharing of notes is widely appreciated.
- Electronic notes can easily be incorporated in word processor documents such as technical reports and journal articles. Expensive and error-prone rekeying is not needed.
- Electronic notes can be searched, classified, summarized, and routed using current software technology. Examples of current systems that perform

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Metadata Project, *from page 1*

these tasks include:

CONSTRUE (Hayes and Weinstein, 1990), a system used by Reuters News Service to automatically classify all their news stories into several of 674 categories. CONSTRUE is faster and more accurate than human indexers.

SCISOR (Jacobs and Rau, 1990) automatically identifies and summarizes documents in particular subject areas. SCISOR runs on a workstation and takes about 10 seconds per document to generate classifications and a summary. It is currently being applied to aircraft maintenance records and military intelligence messages.

Hypertext systems (Nielsen, 1990) provide relevant portions of (possibly very large) sets of documents to those who need to see them. Nonadjacent pieces of text can be linked to facilitate cross-referencing. Readers can rapidly follow the links (much faster than by thumbing through a paper document). Context-sensitive help documents provided with many computer operating systems are examples of hypertext.

Thus electronic notes about data, even though voluminous and not initially well-organized, can, by taking advantage of computer technology, be classified, organized, and made available to those who need to use them.

Metalog

The electronic notebook we built is called Metalog, which stands for "a logbook for metadata." A user enters notes into Metalog by typing them directly, by loading from separate files, or by cutting and pasting from other windows on the computer screen. Notes receive an automatic time stamp when they are written, and can be given automatic or manual specific identifiers (author, type, and project). Different notes can be linked. Thus one note can be a comment on another, or several notes can be linked to form a thread that describes a particular subject. Notes can be retrieved by following links, by searching for specific identifiers, and by searching for any word, string, or phrase in the note. When a search is performed, the first lines of all notes containing the searched-for item are displayed, and the desired note or notes can then be read. Notes can also be shared with others.

Because the system runs on personal computers, the notes can be as private as their author desires. However, we have made provision for the sharing of notes between users. Notes can be printed, or sent to a text file that can be read into other Metalogs, or into any word processor document. Finally, notes can be sent to "metadata central." At the moment, this is simply a file on each user's computer that appends all notes that are sent to it. The file can be periodically sent to a central location (via mail or e-mail) where the notes can be shared. Ultimately, we expect "metadata central" to be a direct link to one of several repositories of metadata.

Metalog runs on Macintosh computers or PC-compatible computers running Windows 3.0. (It runs somewhat slowly on PC compatibles less powerful than 386-based machines.) Metalog is supplied with a set of 78 "help" notes on how to use the system.

Use of Metalog in documenting COADS

The Comprehensive Ocean-Atmosphere Data Set (COADS) is a 140-year record of ocean meteorological observations taken by ships-of-opportunity. During the past year we used Metalog to document this data set. This work, partially funded by NOAA's Climate and Global Change Program, has been a joint effort between the Climate Monitoring and Diagnostics Laboratory's (CMDL) Climate Research Division and the Forecast Systems Laboratory's (FSL) Artificial Intelligence Program. Co-principal investigators are Bill Moninger (FSL) and Scott Woodruff (CMDL).

COADS metadata currently consist of the following.

- Notes on specific aspects of COADS, derived from extensive interviews with Ralph Slutz, one of the prime developers of COADS. Dr. Slutz came out of retirement to work with us on this project.
- Notes that consist of text from two

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published articles about COADS (Woodruff et al., 1987, and Slutz et al., 1985).

- More than 50 abstracts of journal articles relevant to COADS.
- More than 200 citations relevant to COADS from a climate researcher's personal database of papers and talks.
- Sample information on ship routes and instrumentation, decoded from World Meteorological Organization data tapes.
- A set of notes that form a tutorial on how to use Metalog to access the COADS metadata.

The COADS metadata are continually being extended. For instance, Metalog was used on a laptop computer to take notes at a recent international workshop on COADS. Abstracts of the 38 talks presented at the workshop, and possibly some of the personal notes taken (suitably edited), will become part of the COADS metadata.

Metalog loaded with COADS metadata has been given to several researchers in CMDL's Climate Research Division. It has also been requested by 20 participants at the international workshop (representing a wide international cross-section). In addition to the Macintosh and Windows 3.0 versions, the COADS metadata were made available as ASCII text, so anyone with a word processor can access and search it.

Scientists requesting Metalog were encouraged to freely annotate the existing metadata with their own notes, add additional notes of their own, and send those notes that they wished to share with the broader COADS community to us. We plan to issue updated sets of COADS metadata from time to time.

Other uses of Metalog

Metalog is also being used by the Paleoclimatology Program of NOAA's National Geophysical Data Center in Boulder, Colorado to document the many data sets they are gathering.

Most other users of Metalog are using earlier versions of the system. These versions use a simple, command-based interface, and lack the more sophisticated search and linkage capability of the new system. Nonetheless, this old software, which runs under VAX/VMS and Sun/Unix, is being used by several groups at NOAA and NCAR (the National Center for Atmospheric Research) to maintain notes in the office, and to keep log comments in the field. (These uses are described more completely in Moninger et al., 1990.)

Plans for future development

As further steps in the development of Metalog, we plan over the next year to:

- Accept new items of COADS metadata, and distribute to users a revised set of COADS metadata, both as Metalog notes and as ASCII text.
- Provide more sophisticated note classification and retrieval by using artificial intelligence and other advanced software technology.
- Develop systems and techniques to make it easier for scientists to share notes, and to add new notes to existing metadata.
- Develop a faster PC version of Metalog.
- Port Metalog to run under the X-windows user interface environment.
- Increase the richness of notes by adding figures, equations, multiple fonts, and possibly audio.

Availability

Metalog and the COADS metadata are available to interested environmental scientists. The Macintosh and Windows 3.0 versions take about 1.5 megabytes of storage for the COADS metadata; empty Metalog (with help notes) takes about 0.4 megabytes. The ASCII only text of COADS metadata is about 1 megabyte. Files are supplied on one or two floppy disks. No runtime license fees are required. Requests should be directed to: William Moninger, NOAA Forecast Systems Laboratory, Mail Code R/E/FS1, 325 Broadway, Boulder, CO 80303; Phone 303-497-6435; Electronic addresses: *W.Moninger* on Omnet and *moninger@fsl.noaa.gov* on Internet.

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NEXT ISSUE

The next issue of the *Earth System Monitor* will feature a report on the **Ocean Climate Data Workshop** hosted by NOAA and NASA at the Goddard Space Flight Center, February 18-21, 1992.

Interactive Environmental Data Analysis, Display, and Management Using Off-the-Shelf Software

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As the lead United States environmental information agency, NOAA has an important need for easy access and manipulation of large, diverse data sets. This is particularly true of many of the data sets being used for studies of climate and global change. One of the largest sets of data being used to assess the state of the global environment comes from NOAA and NASA satellites over the past 10-20 years. The growing complexity and diversity of datasets demands new techniques and concepts for data management.

Data management software should allow users to tailor data storage to the requirements of intended applications. Data should also be easily sharable and transportable. One technique to achieve these goals is to use a Common Data Format (CDF). A CDF lets the data designer combine data in ways that help identify its characteristic variability, isolate anomalies, and establish correlations. With a CDF, data do not have to be forced into a pre-existing format; a new format that better suits the data is merely defined. This new format, however, can immediately be read by all who wish to use the data.

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For climatological studies of satellite data within the Climate Research Division of NOAA's Climate Diagnostics and Monitoring Laboratory (CMDL), Unidata's netCDF software, an implementation of a Common Data Format, was selected (Rew and Davis, 1990). This software is available free of charge by anonymous file transfer propocol (ftp) from Internet node *unidata.ucar.edu*.

For graphical data display and analysis and the user interface, we chose a commercial package called Interactive Data Language (IDL, available from Research Systems, Incorporated). IDL is an interpreted programming language

With a CDF, data do not have to be forced into a pre-exising format; a new format that better suits the data is merely defined.

for processing, displaying, and analyzing scentific data on a wide variety of workstations. The syntax of IDL is similar to FORTRAN or BASIC making it easy for the scientist to learn. Scalars, vectors, matrices, or arrays are expressed and manipulated as single entities. An operation that would take several lines to implement in C or Fortran may take only one line in IDL.

Procedures for contouring, mapping, statistical analysis, and image processing are included with the system as well as extensive user contributed software. IDL also contains a "widget library" that makes the construction and manipulation of simple graphical interfaces straightforward. Small prototypes can be built and tested without investing too much time. Several small demos are included with the distribution. In March 1992, Research Systems, Inc. plans to release a version that includes access to mathematical and statistical functions.

Advantages of common data formats

A Common Data Format is an implementation of an abstract data type. An abstract data type can be thought of as a mathematical model with a set of operations defined on that model. Data in a CDF can be accessed only by the functions or procedures defined for that CDF. This means that a user does not need to know the details of how the data are stored. At a later time the underlying implementation may be changed without affecting any software that depends on that implementation. Storing data in a CDF provides two important benefits: (1) the user interacts with the data through a well-defined interface of procedures or functions, and (2) any changes in the CDF itself will have no effect on the user.

An important feature of a CDF is that it is self-describing. This means that a user can read data that he or she literally knows nothing about by making calls to the appropriate procedures or functions of a CDF. The user is freed from having to know *a priori* the size, type, or shape of the data being accessed.

Advantages of the netCDF

A netCDF file has dimensions, variables, and attributes. These components define the data in the file. Data are partitioned into multi-dimensional arrays called variables. Dimensions specify the size and shape of the variable, and attributes store metadata about the variable. A netCDF file may contain up to 512 different variables and 32 dimensions. Attributes store metadata, or data about data, that may pertain to the entire dataset or to just one variable. Six different data types are supported: byte, character, short integer, long integer, floating point, and double precision.

The netCDF provides several other important benefits for data management. NetCDF files are machine independent because Sun's external data representation software, or XDR, for describing and encoding data is used. This means that files written on a DEC VAX computer may be accessed using a Sun workstation without any pre-processing. The netCDF has been ported to virtually every machine that is in use today in the scientific community. NetCDF files are also network transportable, allowing files to be widely shared within the scientific community.

Data in a netCDF may be randomly accessed eliminating the need to process large amounts of data before selecting the data wanted. To select data the user specifies the volume of data wanted by specifying the origin and lengths of the sides of the volume for the appropriate variable. Single values may be randomly accessed or a record number specified.

The netCDF was not designed to be efficient in terms of storage size. It was intended to simplify the difficult and often frustrating problem of accessability and storage of large datasets. Several scientists working at the Climate Research Division have used the netCDF interface and report that it is easy and straightforward to use. As technological advances in storage media become available, storage efficiency becomes less important while issues of design, adaptability, and ease of use become more important.

Many historical datasets are not as useful as they could be because critical information about the data was not stored with the data. Information such as the conditions under which the data were gathered, the types of sensors used, known flaws in the data, missing values, or the processing the data has undergone all affect the validity of the data itself.

Most of this information may only be stored in people's heads. It is important that data storage systems have the ability to capture this important textual information. In some cases it may be more efficient to store textual data; for regularly gridded data, starting and ending latitudes and longitudes can be stored instead of an entire grid.

The netCDF stores textual information as attributes. Any number of attributes may be defined, and may apply to the entire dataset as a whole or to one variable in particular. Attributes may be appended any number of times allowing the history of a dataset to be recorded consecutively.

Designing and creating netCDF files

NetCDF files may be created using either C or Fortran routines. The netCDF library also supplies a utility called NCGEN that at the user's option will create a netCDF file, or C or Fortran code to generate a netCDF file based upon a template that has been created with a text editor using a small language called Common Data Language. Scientists at the Climate Research Division have been able to create netCDF files of their data in a matter of hours even though they had no previous experience with the netCDF software.

Care needs to be taken to design a netCDF efficiently and completely. We have developed a set of standard attributes that adequately define the geographical boundaries and time duration of our datasets. The regularity of the data, scale-factors, offsets, and names in general need to be known by the display and analysis routines. These metadata need to be well thought out and agreed upon in advance. In practice, accumulating this information has proven to be more time-consuming than coding up the necessary routines.

The IDL/CDF interface

We have written IDL jacket routines that allow netCDF functions to be called

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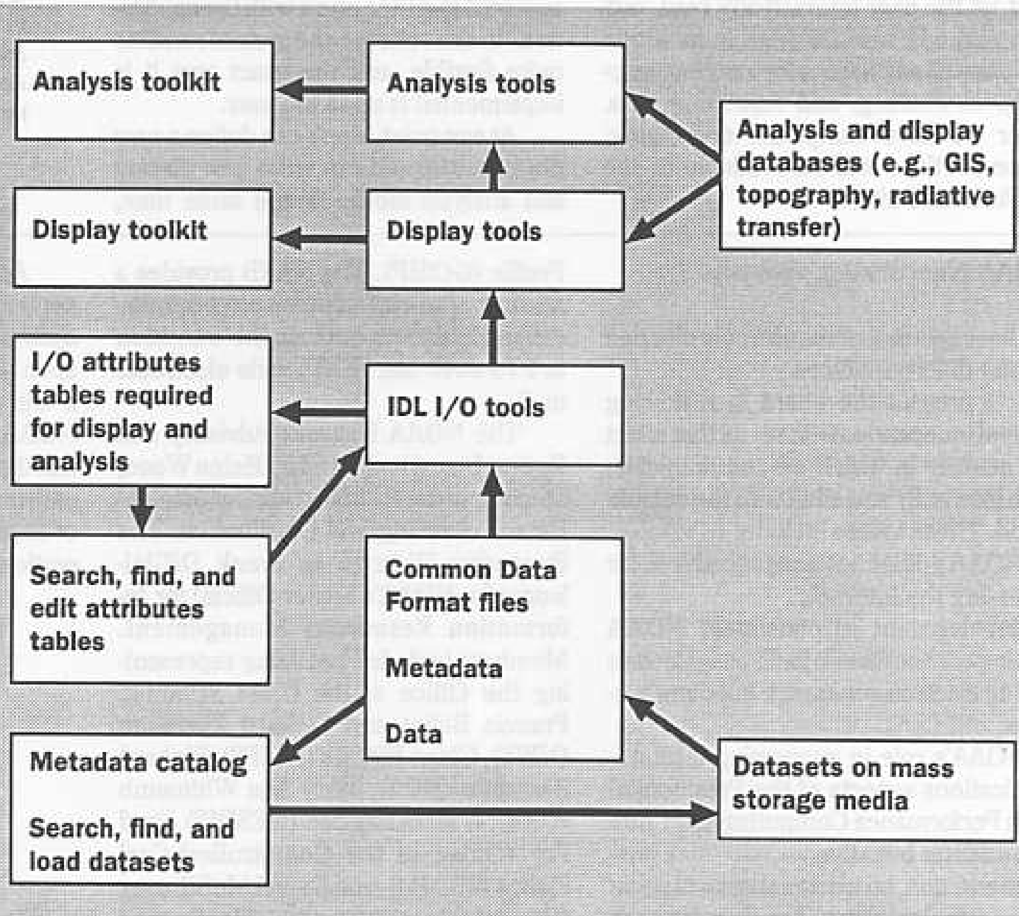

Fig. 1. System Components

Interactive Data Analysis, *from page 5*

from IDL. The CALL_EXTERNAL function enables IDL to load and call routines written in other languages that are contained in a sharable object file. This facility is available only with Sun OS 4.1 or VMS. Our jacket routines run only on Sun Sparc machines but could easily be ported to DEC machines. Because this function is available with IDL, no alterations to the netCDF code or IDL were necessary.

Similar jacket routines for other Common Data Format implementations, such as NASA's CDF/2 or HDF developed by the National Center for Supercomputing Applications at the University of Illinois, could easily be added. The jacket library consists of two parts: IDL functions that call CALL_EXTERNAL, and C language routines that call all the respective netCDF functions in the sharable object file. We have written interface routines that let the user interactively read, output, and edit netCDF files from within IDL, as well as routines for imaging, mapping, contouring, and animating data. After we have completed debugging, these routines will be available to the public in mid-1992.

Proposed integrated system concept

The concept of this system is illustrated in Figure 1. The left column depicts database search and interactive help functions, the center column depicts dataset input/output (I/O), display, and analysis functions, and the right column depicts dataset storage on a mass storage media. All components are not completed at this time, we have been working on the center column items first.

In the diagram users enter at the bottom center column and access a dataset through the IDL I/O tools and perform a display or analysis function. Even though netCDF is very general, it became clear that users would need to specify some basic set of attributes to their dataset in order to use the display and analysis tools. To facilitate the use of these tools, new users will be referred to a table of I/O attributes required for the tool they choose and will interactively be able to enter the few additional attributes required and then go on with the application. In this scheme, the system remains quite flexible, and the exact way it is implemented is up to the user.

At any point, users can define a new file structure and can write new display and analysis tools. At the same time, these new files and tools remain general and other users can use them with only slight modifications to their attributes and no modifications to their datasets.

Conclusion

In summary, the combination of the netCDF and IDL is giving scientists the ability to design their data to fit its intended uses. These applications include an easy to use analysis and visualization system that can access heterogenous data with a graphical interface. In the future we plan to continue developing and extending capabilities for interactively editing, modifying, and creating datasets. We expect to release a public version of the IDL I/O interface in the second quarter of 1992.

Reference

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NOAA Networking, *from page 1*

on those issues that require coordination among different offices.

At present the board is reviewing several independent elements that affect the manner in which we communicate, both internally as well as with the outside world. These issues include:

- NOAA guidelines and procedures for accessing the Internet;
- development of consistent NOAA naming conventions to facilitate gateways among electronic message handling systems; and
- NOAA's role in supporting telecommunications aspects of the Presidential High Performance Computing and Communications Initiative.

In addition, board members will serve as the principal point of contact for each NOAA office in implementing the Government Open Systems Interconnection Profile (GOSIP). The NARB provides a forum to share information on communications initiatives such as the transition to FTS 2000 and NOAA-wide electronic mail .

The NOAA Network Advisory and Review Board is chaired by Helen Wood, Director of the NESDIS Office of Satellite Data Processing and Distribution. The Executive Director is Frank DiGialleonardo, NOAA's Senior Official for Information Resources Management. Members include Fred Long representing the Office of the Chief Scientist, Francis Balint and Richard Zitzmann (NWS), Glenn Flittner (NMFS), Richard Barazotto (NOS), Mary Ann Whitcomb (OAR), William Callicott (NESDIS), Fred Fry (Office of the Comptroller), Carl Fisher (ESDIM), and Darrel McElhaney (Coastal Ocean Program). Meetings of the board are scheduled about every four to five weeks.

Activities of the NARB will be reported on in future issues of the *Earth System Monitor*. The board also expects soon to disseminate throughout NOAA a set of guidlines for Internet usage. NOAA employees are welcome to contact their office representative for further information about specific NARB projects or to propose subjects for future consideration.

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Managing data from the Earth's cryosphere

The National Snow and Ice Data Center

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The National Snow and Ice Data Center (NSIDC) and the collocated World Data Center A (WDC-A) for Glaciology (Snow and Ice) provide data management and data archival services that focus on the cryosphere–the Earth's frozen realm of snow and ice. NSIDC/WDC is operated for NOAA's National Geophysical Data Center (NGDC) under a cooperative agreement between NOAA and the University of Colorado's Cooperative Institute for Research in Environmental Sciences (CIRES).

In November 1976–before NSIDC was established–responsibility for WDC-A for Glaciology was transferred from the U.S. Geological Survey in Tacoma, Washington, to NOAA in Boulder, Colorado. NSIDC was established by NOAA in 1982. Today, funding for the Center's data-related activities comes from NASA, NOAA, the National Science Foundation, and the Office of Naval Research. Within CIRES, NSIDC/WDC is a part of the newly formed Division of Cryospheric and Polar Processes. The Center is housed in research buildings adjacent to elements of NOAA's Environmental Research Laboratories and the NGDC in Boulder.

The role of NSIDC/WDC is to acquire, archive, and disseminate data relating to all forms of snow and ice. This work supports NOAA's mission of providing data and information to users and is conducted in accordance with guidelines of the International Council of Scientific Unions for international data exchange through the World Data Center system.

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Data holdings

Data holdings relate to all forms of snow and ice, as indicated in Figure 1. NSIDC maintains a large collection of visible and infrared analog data from the Defense Meteorological Satellite Program (DMSP), 1973 to the present, and since June 1987, digital passive microwave DMSP data, as well as a collection of historical glacier photographs dating from the 1880s to the 1960s. Other digital data holdings are described below. To support the research activities of the Center's scientific staff, to document the data holdings, and to meet the increasing demands for information on cryosphere/climate studies on a global scale, NSIDC/WDC maintains an active program to acquire published materials on snow, ice, and permafrost research.

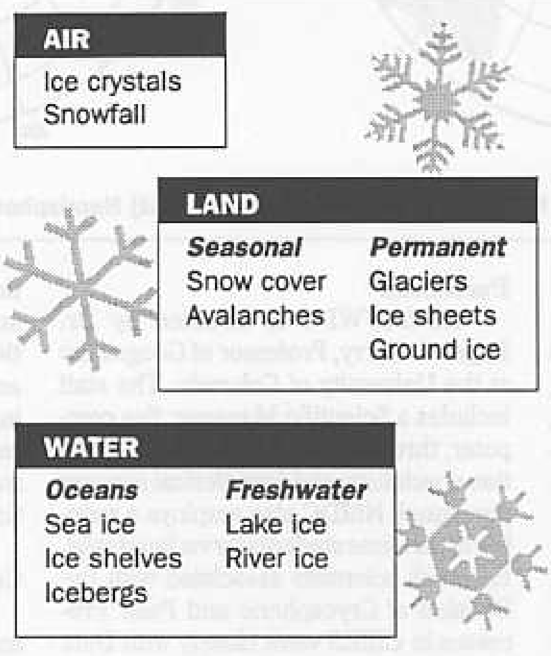

Fig. 1 Global snow and ice forms.

Activities and products

By virtue of its multiagency funding and the strong mix of data and related research projects, NSIDC is involved in not only data archival and distribution, but also in data product generation and in the management of several multidisciplinary field research data sets. In this multi-agency cooperative spirit, NSIDC is undertaking several projects.

A major, new activity involves responsibilities for snow and ice data under the Earth Observing System Data and Information System (EOSDIS) as one of seven Distributed Active Archive Centers (DAAC) supported by NASA. EOS is a long-term, interdisciplinary and multidisciplinary research mission to study global-scale processes that shape and influence the Earth as a system. EOSDIS will provide the distributed ground system for the collection, production, archival, distribution, and analysis of EOS and other related earth science data.

The most significant current activity sponsored by NASA in the EOSDIS DAAC effort is the production and distribution of a series of Special Sensor Microwave/Imager (SSM/I) daily brightness temperature grids for the polar regions on CD-ROM. Figure 2 shows the polar coverage of the grids. To date, 11 CD-ROMs with data from July 1987 to March 1989 have been distributed to over 300 users.

A CD-ROM of oceanographic, ice, bio-physical, bathymetric, and acoustic data for the Coordinated Eastern Arctic Experiment program in the northern North Atlantic, produced for the Office of Naval Research, will also be issued in the near future.

NSIDC also provides data management services for the National Science Foundation's Greenland Ice Sheet Program and the Arctic System Science Ocean-Atmosphere-Ice Interactions program and for NOAA's Great Lakes ice data.

As part of the NOAA-funded core program, two publication series are produced, the quarterly *New Accessions List*

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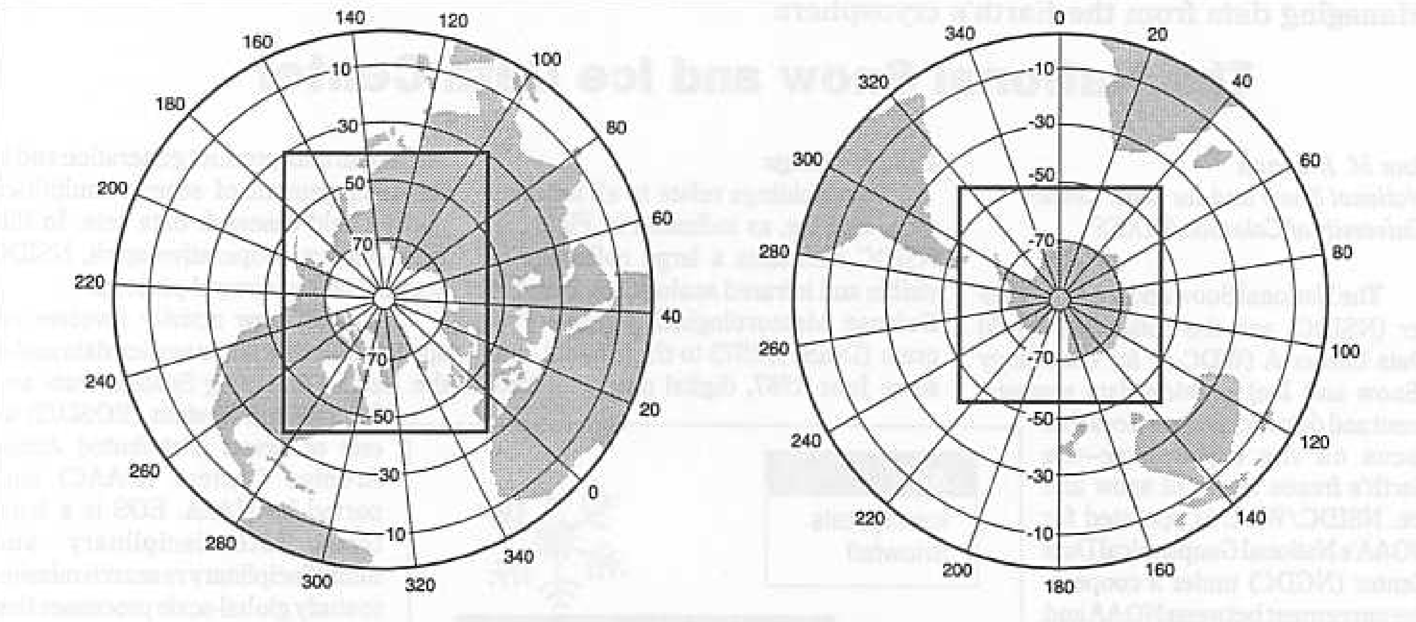

Fig. 2 Geographical areas in the Northern (left) and Southern (right) Hemispheres covered by the SSM/I grids.

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and the *Glaciological Data* report series. The latter provides data inventories (ice cores, snow cover, and sea ice data sets), bibliographies (e.g., avalanches, sea ice, snow cover, permafrost, passive microwave research) and reports of conferences and workshops (e.g., Snow Watch, the Permafrost Data Workshop, the Antarctic Climate Data Workshop and the Northern Libraries Colloquy). Data sets which are part of the NOAA-funded effort include: the CITATION bibliographic data base, Arctic Drifting Data Buoys, Northern Hemisphere snow extent, and the Navy/NOAA Joint Ice Center gridded (and analog) sea ice charts

Personnel

NSIDC/WDC is directed by Dr. Roger G. Barry, Professor of Geography at the University of Colorado. The staff includes a Scientific Manager; five computer, three discipline, and two information specialists; and four clerical support personnel. NSIDC also employs a number of part-time students for various tasks. Research scientists associated with the Division of Cryospheric and Polar Processes in CIRES work closely with Data Center staff.

Research activities relate especially to climate-ice interactions in the Arctic, satellite remote sensing and climate-snow/ice variability. Current investigations include the development of an ice surface temperature algorithm; applications of artificial intelligence techniques and neural networks to the remote sensing of arctic surfaces; and analysis of the relationships between Arctic sea ice, atmospheric circulation, and North Atlantic salinity.

Conclusion

NSIDC's cryospheric data and information holdings, combined with its scientific expertise and role in the EOS Project, ensure it will play an active part in the vitally important area of global change research. ■

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