III. Challenges for the Future

A. User Needs

Environmental scientists and advisors have a critical need for a long environmental record of historical and recent global data. These data are used to assess long-term trends, evaluate current status, and predict future conditions and events. This information is necessary to help answer questions from the public, industry, and policy makers such as the following:

- Is global climate change really occurring?
- Are the oceans getting warmer?
- What is happening to the Nation's ecosystems?
- How do El Niño and La Niña affect the weather?
- How long will the drought last?
- How severe will winter be this year?

To fully support its users, NOAA must 1) listen to their needs, 2) partner with the broader research and operational communities and 3) capitalize on new science and technology that accelerate service improvements our customers expect — all in a responsive and cost-effective manner.

NOAA must solicit users' requirements for environmental data and information products and services and use this information to help improve our services. NOAA must continue to strive to provide the Nation's environmental data to its customers in a secure and easily accessible manner. NOAA must work with its customers to ascertain how they are using the data and information so that the search, browse, and other discovery tools most beneficial to them can be provided.

Universities are important links in the environmental research and information dissemination network for the United States. University researchers develop knowledge about climate and ocean dynamics and other physical processes essential to improving global models. University researchers are also important for bringing output from such models to the regional scale in order to attain better resolution about how global changes will impact regions and relevant sectors. Network-building efforts underway in the form of regional integrated sciences and assessments will eventually include all regions of the United States.

NOAA/private industry partnerships hold tremendous promise for innovative application of environmental information. NOAA seeks to enhance our national competitiveness through optimized use of information. Industries such as weather derivatives, electricity production, agriculture and aquiculture, ranching, and fisheries could all achieve economic benefits through the improved use of environmental information.

For example, the array of climate services providers already in place, such as the Regional Climate Centers and State Climatologists, is essential to the delivery and use of climate information products. These centers provide operational information products used by public and private decision-makers. As models for transforming data into information and educating the public about the utility of climate information, these organizations are invaluable in the broad endeavor of transforming research into operations.

Climate observations and services will draw upon the knowledge generated, and experience gathered, from association with other U.S. agencies. Research sponsored by the National Science Foundation and research satellites flown by NASA are central to developing and improving environmental services. Mission-driven research from the Department of Energy, such as its efforts on atmospheric radiation and carbon, is contributing important advances as well. Climate services to particular sectors such as agriculture, forestry, and water resources would be impossible without the participation of mission agencies like the Department of Agriculture, Department of the Interior, and Environmental Protection Agency.

Global data sets require cooperation and partnerships with other nations. This is particularly true for environmental data sets derived from satellite observations. Geostationary satellites are operated by the United States, Japan, India, and the European Community, as well as polar orbiting satellites operated by some of those nations. Geostationary satellites also are planned for China. As in the United States, some of the satellite programs are experimental and some are operational; however, both provide important observations necessary for environmental studies.

International partnerships are also critical to land and ocean observing programs. The United States has been a central participant in the GCOS. For the newly deployed Argo ocean profiling system, international partners supply two-thirds of the instruments.

It is clear that use of NOAA's environmental data and information can contribute significantly to our Nation's economic well being. Several examples of how use of these data may contribute are described below:

Disaster Preparedness: Better preparation, response, and mitigation could reduce the average cost (approximately $500 million per event) of storm-related disasters by 10 percent (approximately $50 million per event). A 10 percent reduction in the cost of storm-related disasters means $700 million savings per year.[25]

Agriculture: Authors of a 1997 NOAA report[7] estimated that economic benefits to U.S. agriculture from improved El Niño forecasts by altering planting decisions could be $265 – 300 million annually, throughout El Niño, normal, and La Niña years. Similarly, benefits to Mexican agriculture range from $10 million to $25 million annually. United States corn storage savings could approach $200 million annually.

Tourism: What's the weather like in Western Europe in May? Is there generally more snow in Colorado in November or February? Increasingly, companies reach consumers directly through the Internet, which can provide specialized seasonal weather information for sports and recreation enthusiasts and vacationers. A 2001 NOAA report[26] states that "travel and tourism is the Nation's second largest contributor to the Gross Domestic Product, generating over $700 billion annually."

Construction: According to NOAA[8], Air-Freezing Index research has allowed "the construction industry to build shallower frost-protected foundations that save $330 million annually."

Weather Derivatives: There is an increasing amount of emphasis on weather throughout many commercial endeavors, leading to the use of increased financial weather derivatives to protect commercial efforts affected by weather. The growth in the use of weather-related "volumetric risk" hedging instruments has been tremendous during the past few years. NOAA's degree-day information is one of a number of inputs to the weather derivatives industry, which began in late 1996 and has issued over $7 billion in contracts in the four year period of 1997-2000.[27]

Weather risk is the uncertainty in cash flow and earnings caused by weather volatility. Colder than normal summers reduce electric power sales for residential and commercial space cooling. These cooler temperatures idle capacity, raise the average cost of power production, and reduce demand for natural gas and coal energy stocks. Above average winter temperatures reduce natural gas and electric power sales for space heating, while lower than normal precipitation upstream of hydropower facilities reduces power production. This reduces revenues to the facility and diverts buyers of hydropower to higher cost power alternatives.

Both the development and settlement of these financial instruments are based upon access to accurate, objective, and very timely national and international data from a source that is considered to be accurate and unbiased. NOAA operates the networks that collect these data, and NOAA archives these data; therefore, NOAA is the only source for the data that are the basis for this new industry.

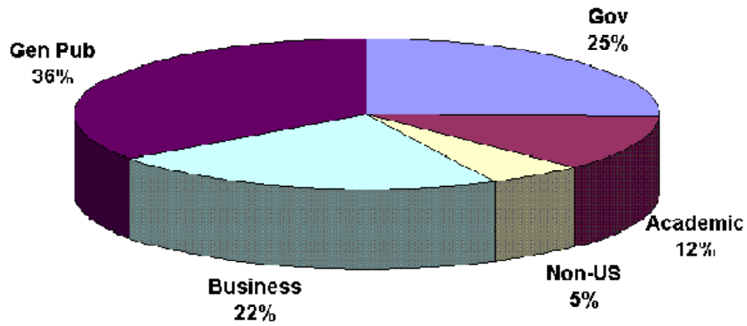
Evaluation of long-range historical environmental data is the basis for the terms of these financial instruments that are traded on the financial markets. The evaluation of the actual environmental conditions during the agreement's period of performance is the basis for the settlement. This requires accurate and complete environmental data currently provided by NOAA for any specified geographic area on Earth, for the dates specified – all within days of the actual environmental observations being recorded. This is placing a very high demand upon NOAA to deliver quality data, with almost immediate turnaround, and on a continual basis.

Increasing Numbers of Requests

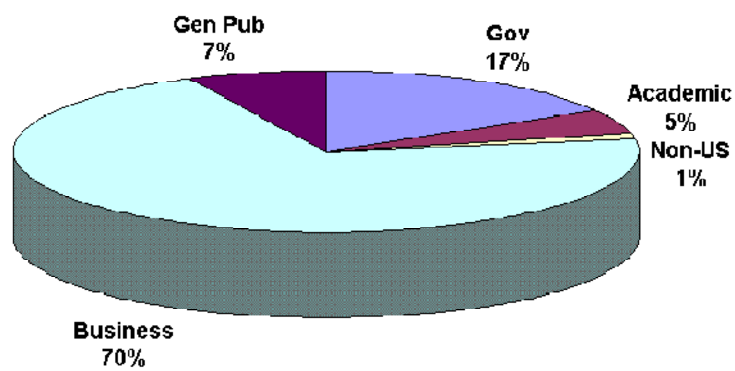
Over the past 20 years, there has been a tremendous increase in the number of business users who request data and information from NOAA. The initiation of an on-line store service for ordering data products and the acceptance of credit cards as a payment option have also contributed to the changing user profile by simplifying the process of obtaining data and information from NOAA. A small sample of the business uses of NOAA environmental data include the following:

- Attorneys and consulting meteorologists: Evidence and expert testimony in court cases.
- Insurance industry: rate determination and claims settlement.
- Engineering, marine, architectural, and construction industries: Design and construction guidelines, site selection, environmental impacts, construction deadline penalties and extensions.
- Utilities: Projections of demand, computation of rate adjustments, air pollution studies.
- Agribusiness: Determine optimal geographic locations by crop type, plan the application of herbicides and pesticides, study effects of climate variation on crop yield.
- Navigation: Nautical charts, the coast pilot, and other marine products are used by commercial and recreational users of the Nation's waterways.
- Fishing industry: Locating prime locations for fishing (through ocean temperature data).
- Financial services: Use temperature, precipitation, drought, and flood data to reduce risk and minimize losses.

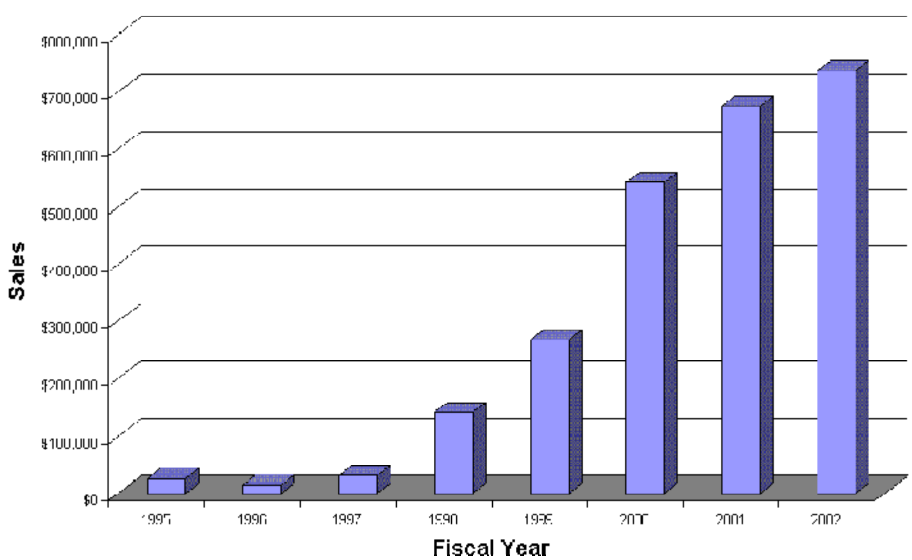
Off-Line Requests in 1982



Off-Line Requests in 2002



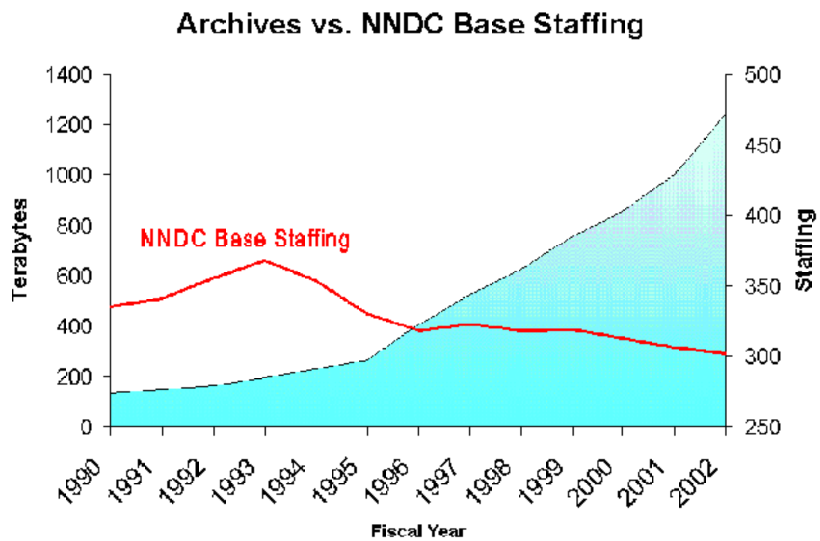
NNDC On-Line Store-Data Sales



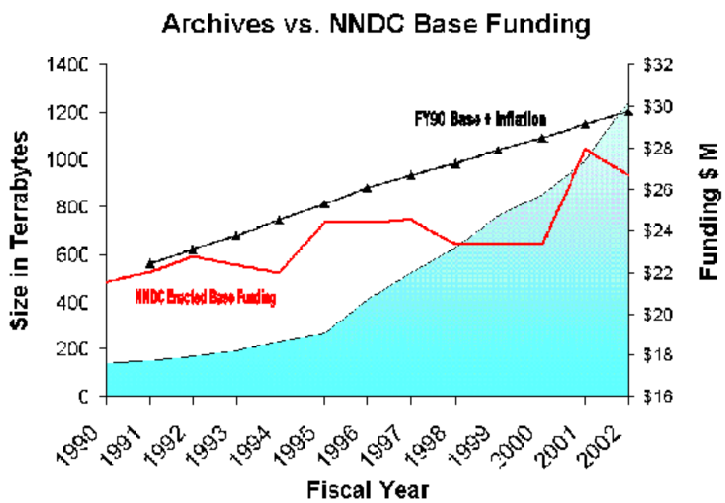
On-Line Ordering and Data Delivery

Historically, NOAA received requests for data via telephone, fax, or mail. The requested data were usually supplied to the user on paper (printouts, copies, maps, publications, etc.). In the case of digital data, magnetic tapes were supplied. Over the past few years, compact discs have been used to provide many data sets to users.

With the growth of the Internet, users are expecting on-line ordering and on-line search and browse capabilities, with electronic file transfers for data delivery. Users are no longer content to wait days or weeks for their data or information requests to arrive at NOAA, be subsequently processed, and mailed back to the user.



In response to user demand, NOAA has made a number of its most requested data sets available to users through the Internet to improve customer service and to reduce the costs for servicing user requests. By the end of 2001, many customers were both using new NOAA on-line ordering systems and receiving environmental data from on-line NOAA sources.

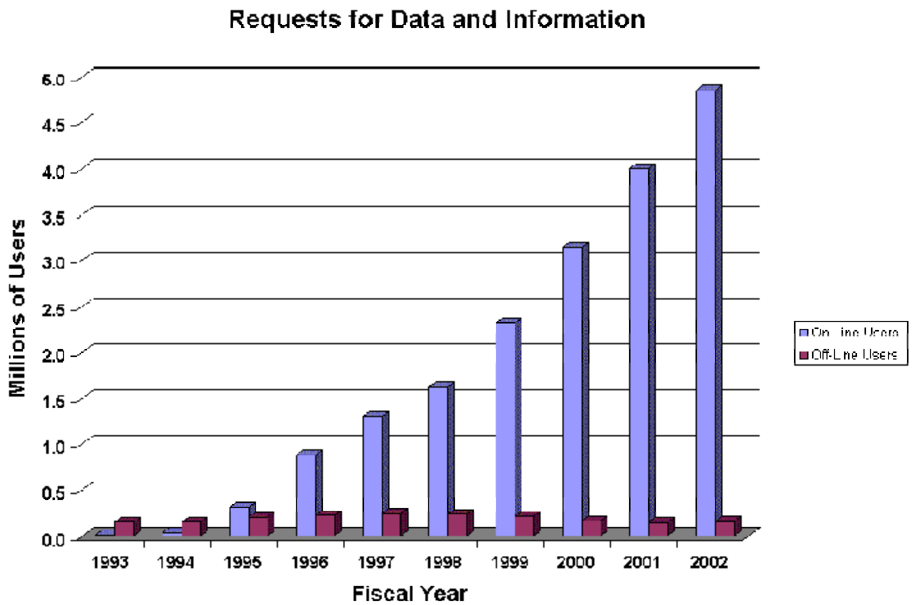


An additional challenge to data accessibility is to allow users ready access to NOAA data – regardless of its actual geographic or organizational location. For example, a user investigating the relationship among weather, oceanography, and the abundance of fish stocks should be able to locate and download the necessary data without being concerned that the various data sources may actually reside in several different locations.

On-line data delivery typically provides benefits to both the user and NOAA by providing easier and faster turnaround for the user, while requiring less NOAA staff time to service the more common, high-frequency requests. On-line data delivery also eliminates media and shipping costs. Benefits increase when large numbers of these requests can be filled without direct staff intervention, by providing the user with on-line browse and search capabilities via the Internet.

Increasing Requests for Information

As on-line access to NOAA's data expands, the user's average level of technical sophistication and scientific expertise is changing. On-line users are searching for information and answers to specific questions rather than access to data.



B. Technology Changes

NOAA has been an early adopter of emerging advanced computing and communications technologies to improve data management and data availability on the Internet and next generation Internet/Internet2.

The Internet

In the early 1990s, NOAA discovered the utility of the Internet and began developing a handful of organizational home pages. While first begun as a way to introduce the public to the agency mission, NOAA soon found that the network held great potential as a radically new way to deliver data products to its constituents. What was first perceived as a "fad" in those early years, the Internet would, over the next decade, prove to be one of the most important communication technologies ever adopted by the agency. The Internet has had a substantial impact on the day-to-day business operation of NOAA and has enabled it to become a scientific and world leader in the dissemination of environmental information.

Over the years, as NOAA's Internet popularity grew, the number of NOAA Internet sites and their visitors continued to rise at a dramatic rate. Some sites, such as NOAA's weather page and the NOAA home page, have seen their community of users grow from the thousands to millions per day. Likewise, NOAA internal use of the Internet has escalated as NOAA developers began incorporating the "web" as a key element in data management operations for acquiring, processing, transmitting, and sharing data and information.

Early on, it became apparent that the lack of adequate Internet connectivity would be a major limiting factor in NOAA's ability to continue its delivery of data and information products to the public and others. Stretched network resources would dictate which new technologies would be incorporated into NOAA's operational systems and which would not.

In order that NOAA could continue to meet the expectations of the ever-growing user community and to support its in-house network application requirements, a plan for improving management of NOAA's information technology resources was developed in October 2001, and specific objectives were identified[29]. These included:

- Developing a robust, common network environment with adequate bandwidth;

- Adopting technologies to improve customer service;
- Providing improved information technology (IT) security;
- Improving management of IT resources, including maintaining a baseline of NOAA web servers; and,
- Using high performance computing resources to run high-end, environmental system modeling applications with the rapidly increasing amounts of newly available data.

Next Generation Internet/Internet2

NOAA has been an active participant in the Next Generation Internet (NGI) planning and the Joint Engineering Team for implementation of the NGI from its inception. Building on that foundation, NOAA began establishing links to the NGI through Internet2 (Abilene) at strategic NOAA locations. Today, NOAA's major research and data center campuses located in Boulder, Colorado; Norman, Oklahoma; Seattle, Washington; Silver Spring, Maryland; and Miami, Florida, are all connected to high-performance networks.

Operating at speeds about 1,000 times faster than the typical dial-up connection or 100 times faster than the typical home digital subscriber line, NOAA's second generation network connections support the development of advanced applications that cannot be implemented using the current Internet. An example of this would be the challenge of transferring massive amounts of data in real-time.

The transition to direct electronic delivery of digital data to the data centers and to the customer has proven to be extremely effective and crucial in meeting timeliness demands of customers. One example of a NOAA Internet2 application is currently under development by the NOAA National Severe Storms Laboratory (NSSL). In collaboration with other NOAA, university, and private-industry partners, NSSL's experimental Collaborative Radar Acquisition Field Test (CRAFT) project provides real-time compression and real-time delivery of NEXRAD data from multiple radars to users including NOAA's NCDC. This has dramatically increased the ability for NOAA to successfully archive as much as 30 percent more NEXRAD data than was previously possible (60 percent to 95 percent). NOAA's NWS has decided to adopt a CRAFT-like approach for all the radars in the continental United States. NSSL is helping to transfer this technology to NWS.

Another prototyping effort to use large scale networking within NOAA has been undertaken by NOAA's NGDC. In partnership with NASA, NGDC has been testing and prototyping the operations involved in transferring and ingesting hundreds of gigabytes of satellite data per day.

C. Increasing Complexities and Volumes of Data

NOAA's vast data observations and measurements are collected and stored in many different distributed facilities across the country, some of which are responsible for the perpetual stewardship, archiving, and dissemination of environmental data.

NOAA must ensure and maintain a healthy infrastructure that is capable of the ingest, archive, curation, access, and dissemination of its data sets. Under NOAA's archive and access architecture, its data management strategy is to accomplish two goals: (1) replace the assortment of aging and inefficient systems it currently operates, and (2) incorporate all of the data management functions shown in the accompanying "Status of NOAA Environmental Data Management" table. (See Appendix C for definitions of data sets.)

The NNDCs have the unique responsibility for the long-term management and stewardship of the bulk of NOAA's data – in addition to environmental data collected by other federal agencies, countries, and research programs – for use in resolving today's and tomorrow's environmental issues. Also, there are numerous distributed Centers of Data with data collections located throughout NOAA's line offices, and programs that are responsible for the management of data sets developed in the process of fulfilling their particular environmental missions and operational responsibilities.

Over the next 15 years, current and planned remote sensing observing systems will produce volumes of environmental data on a scale that has not been seen before. Data from these systems will be preserved and made available by NOAA to support a myriad of users. By the year 2017, plans for the current NEXRAD, GOES, POES for NOAA, including the DMSP, and EOS/MODIS campaigns, future European Meteorological Operational Satellite (METOP), NPOESS, and NPOESS Preparatory Project (NPP) campaigns and numerous *in-situ* observation programs will increase the total data volume (primary and backup copies) to more than 140 PB.

NOAA's CLASS Project is designed to enhance NOAA's capability to predict and assess decadal to centennial climatological changes. It will provide various environmental data and information archive and access services to the Nation through the effective application of modern, proven techniques and technology.

A large portion of the Nation's current archive of environmental data is stored and maintained by NOAA's NCDC, NODC, NGDC, and Satellite Active Archive (SAA). To prepare for the large increases in data volumes over the next 15 years, NOAA must increase the data-handling capacity and capabilities of its Data Centers. The CLASS project will afford efficient management of high volumes (petabytes) of data critical to the United States Global Change Research Program and scientific community. It includes the development and implementation of standardized archive methods, which will be integrated with a robust, large-volume, rapid-access storage and retrieval system that is capable of receiving a user's on-line data request, automatically processing that request, and providing the requested data via the most appropriate medium. This system will provide standardization in security, media, interfaces, timeliness, formats, and processes for the very large data sets produced by satellites and radars.

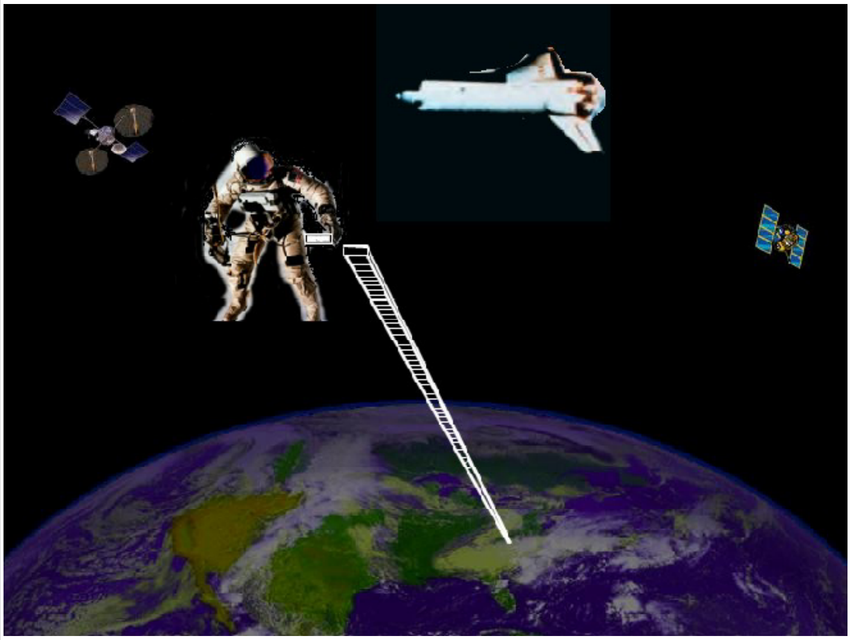
Effective systems must be in place to support scientific research in the government, commercial, educational and private sector communities, as well as address data management issues that are associated with massive volumes of data. NOAA will implement an architecture for an integrated, national environmental data access and archive system to support the ingest, archive, access, and distribution of its environmental data and information. The size, number, and frequency of data sets to be stored and distributed will require significant expansion of capacity for moving, storing, processing, and distributing the data.

NOAA will adopt a comprehensive data management strategy to accomplish two goals: (1) to capitalize on efficiencies and economies afforded by implementation of current technologies, and (2) incorporate end-to-end environmental data management functions. These functions include: planning, ingesting, metadata, cataloging, calibrating, validating, storing, accessing, distributing, and migrating. The NOAA architecture will be compliant with the appropriate policies, standards, and procedures in effect at the time to ensure a common framework and to minimize duplication. A goal will be to focus on reengineering rather than designing completely new systems. In addition, user access will include an Internet-based virtual "gateway" to access data, regardless of geographical storage location.

Preservation of environmental data is an important mission of NOAA. NOAA must ensure that the data are exercised and migrated to avoid media obsolescence. These data sets must be preserved due to their importance in research related to such tasks as monitoring the frequency and severity of tornadoes, floods, hurricanes, and droughts; managing our coastal zones; and managing and conserving stocks of fish and other living marine resources.

Data do not become archived and available for dissemination to users simply because they are delivered to NOAA. Data ingest, the process by which data are received, processed, and prepared for archive, may be relatively straightforward or complex and time-consuming, depending upon the characteristics of the data and the delivery medium used. Today, the vast majority of environmental data are provided in digital form. Even this, however, does not mean that these data are readily usable.

Agencies and researchers who develop observing systems and instruments are primarily concerned with obtaining observation data for their mission -- they may have little interest in facilitating the archive and re-use of their data because that is not their mission. Therefore, the data formats they design tend to be optimized for the program's use, and the archive delivery system and media chosen by the program are the most cost-effective from the standpoint of the program. This usually results in inflated archive and dissemination costs over the full life cycle of the data. For example:



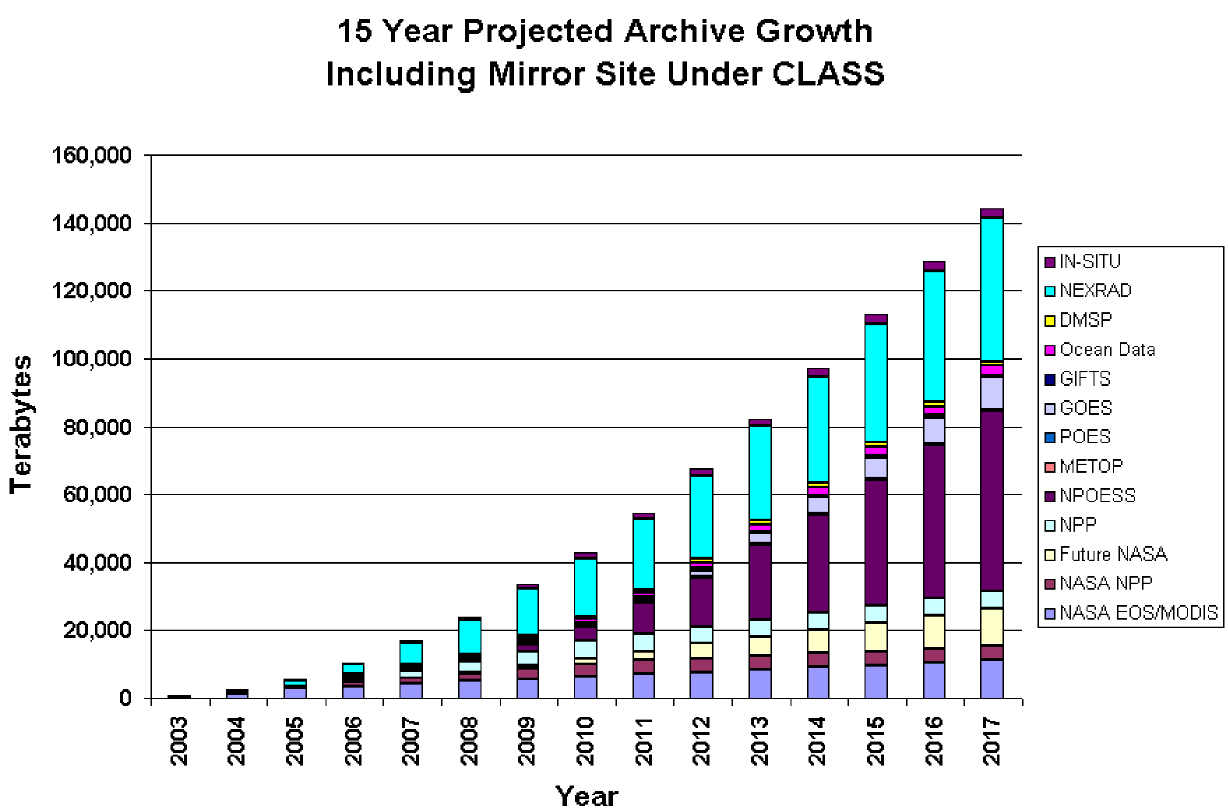
The standard hard disc drive in one of today's personal home computers typically can hold 40 GB of data. The 15 year projected NOAA archive growth (including backup) is anticipated to exceed 140 PB, which is equal to 140,000 terabytes (TB) or 140,000,000 GB. That equates to the storage capacity of over 3,500,000 home computers. Assuming a 2-inch height for a 40 GB hard disc drive, that would be a stack of drives over 583,000 feet (177,699 meters) high. That's over 110 miles (177 kilometers)!

- Most NEXRAD Doppler radar data are received in digital form on 8mm tapes. Each tape contains approximately 2 to 3 days of data for one station, and data are reported for approximately 164 stations. Due to the extremely slow tape speed, reading or copying just one tape takes at least 4 hours. The labor-intensive nature of this process limits the distribution of this data set (to other users) to small amounts of data.
- NOAA has more than 38,000 U-matic tapes containing the GOES data collected over more than 20 years. Use of this antiquated, 25-year-old tape technology for data storage means that the data

are practically inaccessible for today's researchers.

The actual data provided for archive are changing, requiring more human resources to make the data useful and accessible to users. The content of the data to be archived is becoming more complex, with new types of measurements being introduced. Increased data complexity brings with it a requirement for more human resources – and in some cases, new or different skills – to manage the data than was previously required.

Another area of major emphasis is the Nation's marine sanctuaries. Both the volume and the complexity of the data being gathered from these areas will increase, and management of these new data sets will require additional investments that are presently unidentified. In addition, NOAA is involved in characterizing and mapping freshwater, estuarine, and marine species communities and their habitats on local, regional, and national scales to meet mandated responsibilities for Essential Fish Habitat regulations. This effort is growing rapidly and requires significant collection and management of spatial data in GIS-compatible formats.



Access to some of NOAA's data sets must be restricted or they may only be distributed in aggregate form due to confidentiality or legal requirements. For example, the locations of cultural resources such as shipwrecks within National Marine Sanctuaries, catch information voluntarily provided by commercial fishers and the fishing industry, and information related to on-going legal cases cannot be freely disseminated. In such instances, special data security measures must be employed to ensure adherence to the appropriate confidentiality or proprietary restrictions for each data set.

New emphasis is being placed upon the standardization of data set structure and data accessibility so that relevant data sets from diverse sources can be readily identified, accessed, and analyzed together to solve pressing environmental issues. The use of GIS's will increase dramatically as NOAA strives toward a holistic approach in analyzing spatial data from an ecosystem perspective.

Because data sets are becoming more complex, there is a growing amount of information that must accompany the new data to make them useful. Both the metadata and the data themselves must be managed in a way that ensures not only their preservation and availability, but also ensures that they are related to each other and that the relationship is helpful to users. This activity requires on-going human resources to maintain the metadata and to manage the data for active data sets.

Rescuing Data and Information

NOAA conducts many environmental data rescue activities to preserve historical data before they are lost or have become unrecoverable, thereby preserving these data to assist in finding solutions to today's – and tomorrow's – environmental problems. This involves rescuing data from around the world, and converting data from deteriorating media to modern media.

Less than 50 percent of the hydrographic surveys are available in digital format for use in GIS applications. Paper chart and source data archives need to be scanned, geographically rectified, cataloged, supplemented by metadata, and made accessible to users to facilitate charting efforts, environmental research, and environmental resource management. Although much historical tide, water-level gauge height, and water current data have been the subject of previous data rescue efforts, much data remains in need of rescue.

Rescue efforts are underway to convert more than 10,000 historical shoreline maps into digital format. However, the rescue of the 600,000 aerial photographic images of coastal areas, airports, and some sites of natural disasters has not yet been addressed. Much historical data of importance to understanding fisheries stocks, such as commercial vessel logbooks and old data sheets from fisheries research vessels, are in danger of being lost due to deteriorating physical media.

NOAA also conducts environmental data rescue activities to preserve historical data from countries around the world. At the end of the Cold War, millions of extremely valuable, historical climate records became available to scientists around the world. NOAA utilizes international organizations, such as the United Nations, and bilateral agreements between nations to collect and preserve data from many of these countries. It is imperative that these data be rescued before they are lost forever due to physical deterioration, and to make the data available for use.

Russia has a wealth of historical environmental records, mostly in manuscript form, dating back 100 years. With as many oceanographic stations as the rest of the world combined, these data can fill many of the gaps in NOAA data sets, enabling improved understanding and prediction of both oceanic and atmospheric change. NOAA has begun to digitize some of these records to preserve the data and to make the data available to researchers and industry. However, other valuable data sets have yet to be rescued from many countries – as well as from the United States.

The increasing volumes of incoming data are outgrowing NOAA's storage capabilities and technologies, and they are affecting NOAA's data-rescue capabilities as well. With new media and mass storage technologies being introduced at an ever-accelerating pace, NOAA's ingest and storage capabilities – as well as its media migration capabilities – are falling farther and farther behind modern technology. There is an urgent need to migrate much of our archived data to new media before these data are unrecoverable.

D. Seamless Uses of Geospatial Data

"Geospatial data" means information that identifies the geographic location of natural or constructed features and boundaries on the Earth. As a simple example, a hiker with a portable GPS receiver has information about the latitude, longitude, and elevation above sea level of his/her location. Recording this information as the hiker walks along the trail creates a series of data points that are geospatially referenced.

To group spatially enabled data from a variety of environmental observations into a seamless database requires common horizontal and vertical geographic references. Unfortunately, the variety of geodetic and tidal vertical datums in use around the Nation has severely limited the usefulness of bathymetric, topographic, and shoreline data. Important applications, such as storm surge modeling, hurricane evacuation planning, and the permitting activities of coastal resource managers depend upon integration in a standardized geographic information system. This capability does not presently exist in NOAA, and must be developed.

Such data can only be integrated if they are referenced to the same geodetic datum. (A geodetic datum defines the size and shape of the Earth and the origin and orientation of the coordinate systems used to map the Earth.) Thus, for NOAA to integrate bathymetric and topographic data sets with those data sets from other mapping agencies, the data must be easily and accurately transformed to a common vertical datum. Once datum transformation tools become available, data sharing and cost efficiencies can be realized with agencies such as the U.S. Geological Survey, Federal Emergency Management Agency, and the National Imagery and Mapping Agency, as well as numerous coastal state agencies.

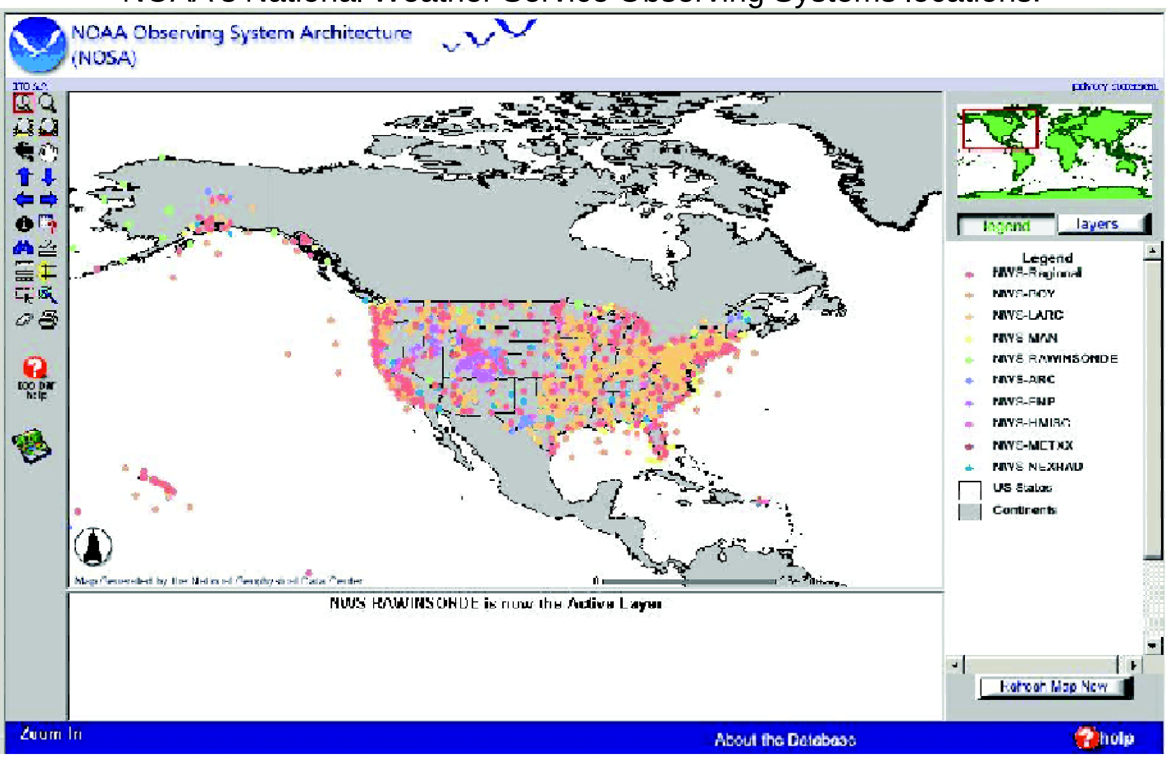
Recently, discussions have begun on the development of a NOAA-wide enterprise-wide GIS to address such issues. This discussion has been prompted by the growing awareness by NOAA senior management that a variety of activities either currently underway or being proposed throughout NOAA involve integrated delivery systems (e.g., Mapfinder for spatial data, traditional map and boundary data, and observing and monitoring system data). One impetus for the need for an enterprise-wide GIS in NOAA has been the development of the comprehensive NOSA system. NOSA was developed to enable NOAA to document its multiple observing systems and identify ways in which to evolve them in an integrated management approach. A key component of NOSA is a GIS capability that allows users to pose complex queries of a geospatially enabled database of observing systems, resulting in easily interpretable maps of information.

The core principles for a NOAA Enterprise GIS will build upon existing standards and efforts, most importantly the Office of Management and Budget's (OMB) E-Government Geospatial One-Stop portal, and the interoperability standards and protocols developed in consultation with the OpenGIS Consortium (OGC). NOAA is a key player in the one-stop portal activity. NOAA is also a charter member of the OGC's Technical Committee, where open-architecture industry standards for GIS and web mapping applications are vetted and published. An approach using OGC, Federal Geographic Data Committee, and International Standards Organization standards is a key element in the creation of an enterprise-wide GIS.

The core principles for an enterprise-wide GIS for NOAA include:

- Accelerating development and implementation of the National Spatial Data Infrastructure (NSDI);
- Ensuring that existing geospatial data has been documented and published (the documentation is referred to as metadata);
- Establishing interoperable data access and visualization services based upon OGC web mapping and web feature service standards and protocols;
- Providing an on-line geospatial data portal for geospatial information discovery, access, and mapping.

NOAA's National Weather Service Observing Systems locations.



Geospatial One-Stop is a part of the new OMB e-government initiative to improve effectiveness, efficiency, and customer service throughout the Federal Government. The strategy, adopted by the President's Management Council in October 2001 implements the "Expanding Electronic Government" reform outlined in the President's Management Agenda. Geospatial One-Stop will revolutionize e-Government by providing a geographic component for use in all Internet based e-government activities across local, state, tribal and Federal Government. The implementation of the Geospatial One-Stop will: (1) provide standards and models for the geospatial framework data content; (2) provide an interactive index to geospatial data holdings at the federal and non-federal levels; (3) initiate interaction between federal, state, and local agencies about existing and planned spatial data collections; and (4) provide an online access point to geospatial data. Geospatial data covers information that identifies the geographic location and characteristics of natural or constructed features and boundaries on the Earth. This information may be derived from, among other things, remote sensing, mapping, and surveying technologies.

NOAA is a full federal partner in the development of framework data standards associated with the Geospatial One-Stop effort as well as the inventorying, documentation, data collection, data discovery, and access to these framework layers. The effort includes other non-framework yet geospatially enabled and/or associated environmentally related data layers at three levels: (1) overall coordination activities; (2) actual framework development work on the geodetic control level of which NOAA is the primary lead agency; and (3) the sub-framework layer development work in three areas involving: (1) shoreline data (as part of the hydrography framework layer); (2) bathymetry (as part of the elevation framework layer); and (3) marine boundaries, as part of the cadastral framework layer.

The Geospatial Information One-Stop Project will enable citizens and government to only need to go to a single location to access Federal Government and other geospatial data assets. The project will accelerate the development and implementation of the NSDI. Participants include state, local, and tribal governments along with the private sector and academia. By making current and accurate place-specific information readily accessible locally, nationally, and globally, NSDI will provide the groundwork for a geographic information component for e-government. The initiative supports a variety of efforts, ranging from economic development, environmental quality and stability, and social progress. The Goals of Geospatial One-Stop are to: (1) provide fast, low cost, reliable access to geospatial data needed for government operations; (2) facilitate government-to-government interactions needed for vertical missions such as homeland security; (3) facilitate alignment of roles, responsibilities and resources; and (4) establish a methodology for obtaining multi-sector input for coordinating, developing and implementing geographic data and service standards.

This initiative will have substantial involvement of state, local, and tribal governments; the private sector; academia; and citizens in the implementation of the Project. In addition to NOAA, other federal agencies involved are the:

- U.S. Geological Survey
- U.S. Bureau of Land Management
- Bureau of the Census
- Department of Transportation
- National Aeronautics and Space Administration
- U.S. Environmental Protection Agency
- Federal Emergency Management Agency
- Department of Agriculture
- Department of Defense

The prime objective of the Geospatial One-Stop initiative is to develop and implement data standards for the seven NSDI Framework Data. These seven framework layers are: (1) administrative boundaries; (2) cadastral data; (3) elevation; (4) geodetic control; (5) hydrography; (6) digital orthoimagery; and (7) transportation. The other objectives of the initiative are to then: (a) fulfill and maintain an operational inventory of NSDI data and publish the metadata records in the NSDI Clearinghouse Network; (b) publish metadata for planned data acquisition and update activities; c) develop and deploy prototypes for enhanced data access and web mapping services for geospatial data; and (d) establish a comprehensive electronic “portal” as a logical extension to the NSDI Clearinghouse Network.

There are a number of challenges relating to Geospatial One-Stop that include:

- Better involvement of state and local governments and the private sector in an effective Geospatial One-Stop data standards development, data collaboration, and portal design process while maintaining traceability to business requirements;
- Better facilitation of improved geospatial data access and collaboration, via the Geospatial One-Stop portal and other mechanisms;
- The development of policies regarding appropriate private sector use of the Geospatial One-Stop portal, for example, those dealing with the licensing of data to vendors;
- The development of interoperable web GIS interfaces and services (such as mapping and analysis) for the portal; and
- Anticipation of user demands for geospatial data access through the portal.

The success of Geospatial One-Stop will be dependent upon cooperation and collaboration between different agencies of the Federal Government; and between the federal, state, and local governments, and the private sector (e.g., utilities). Shared effort needs to occur on a number of levels including data standards development, geospatial database construction, development of geospatial data archives, and development of an interoperable geospatial data portal. That portal will provide access to data in archives maintained by various entities. This standards based, collaborative, interoperable Geospatial One-Stop portal and related data archives also need to be sized and managed to support the performance requirements of its intended user organizations. Governance of the initiative is an issue because of the large number of involved organizations at various levels of the government and in the private sector.

E. Scientific Stewardship

The Need for Climate Monitoring and Evaluation

The President's CCSP, NOAA's Council on Long-term Climate Monitoring, and the IPCC 2001 Third Assessment Report identify the need for improved climate monitoring and evaluation using a suite of measured climate observations that are critical to describing climate variations and changes.

Effective utilization of climate data and information and long-term stewardship requires the ability to scientifically manage the Nation's climate records and provide relevant utility to a wide range of customers. Scientific stewardship can be characterized as maintaining scientific integrity and long-term utility of climate records through monitoring, improving quality, and the extraction of select key parameters from new observations and the historical records. Scientific stewardship is principally a data management discipline designed to maximize the benefit of data beyond the initial and immediate short term uses. It is an important process encompassing the transformation of data to meaningful information; information to knowledge; and ultimately knowledge to understanding. Knowledge and understanding enhance the formulation of sound economic and environmental policies and decisions.

Why Scientific Stewardship?

The practice of scientific stewardship is essential for maximum utility and long-term preservation of data records leading to increased levels of confidence in climate model projections. To date, too little attention has been given to data mining long-term satellite and radar data and information. In part, limited use of these observations has been the consequence of technologies lacking the capabilities of adequately processing these very large volume producing observing systems. Until recently, long-term stewardship has not been able to meet the challenge of capitalizing on the true potential value and use of information and knowledge derived from new measurements and the historical climate data records, i.e., data mining and fusion described below. Scientific stewardship, practiced by scientists and data managers knowledgeable of different types of data, will provide effective data management where data are: 1) initially processed, reprocessed, and reapplied for purposes both intended and newly discovered; 2) improved through repeated analysis and evaluation; and 3) made more accessible with new technologies and innovative structures.

A new and evolving approach to data management is Scientific Data Stewardship (SDS), which encompasses the end-to-end management of data and information designed to address the need to effectively utilize past, present, and future data and information. One aspect being developed under the SDS concept is data mining. Essentially, scientists require the means to extract specific measurements and information that will contribute to climate monitoring and evaluation and other searches that will lead to the production of informative products and information supporting economic, environmental, and business activities. Techniques are being developed to capitalize on the benefits of data mining as current observations arrive in real-time and to rapidly data mine through the historical records. Another aspect of SDS is the ability, both in real-time and using historical data, to merge or fuse data from a wide range of data and information sources. This will provide a holistic view of climate at a given place and period of time. The NOAA NCDC has established a new activity that will specifically develop techniques to perform data fusion, leading to informative products for real-time business uses, as well as climate related monitoring and evaluation activities. Some of these environmental indices and products and reports are being introduced to support businesses and policy planners. Examples include: the monthly and annual State of the Climate Reports, the North American Drought Monitoring Reports, the monthly and seasonal Residential Energy Demand Temperature Index, the Moisture Stress Indexes for Corn and Soy Bean, and in Fiscal Year 2003, the prototype Air Quality Index for the western United States, and Airborne Disease Vector Predictions. Also planned is the development of a new generation of dynamic Climate Normals, which can be used by planners and decision makers in many sectors of the economy that are dependent on current conditions and trends.

Access to complex physical computer simulation models of the Earth's systems requires an infrastructure for collaboration and systematic evaluation of models across multiple institutions. The NOAA Operational Model Archive and Distribution System (NOMADS) is a demonstration network of data servers using established and emerging technologies to access and integrate model and other data stored in heterogeneous formats and at geographically distributed archives. Developed by computer and research scientists, NOMADS enables the sharing and inter-comparing of model results and the comparing of model results with observations. It is a major collaborative effort spanning multiple government agencies and academic institutions. The NOMADS, combined with the increased computational power and improved models at the NOAA Geophysical Fluid Dynamics Laboratory, will provide the tools required to greatly improve the performance of future climate projections.

The goal for a unified climate model community is to reduce uncertainties and increase the level of confidence in the support provided to planners responsible for developing long-term strategies for viable environmental and economic policies. In line with NOMADS work, at its meeting in May 2002, the Committee on Earth Observing Satellites' (CEOS) Working Group in Information Systems and Services

(WGISS) established a Grid Task Team. Grids are persistent computing environments that enable software applications to integrate instruments, displays, computational and information resources that are managed by diverse organizations in widespread locations. While this in many cases is associated with high-end super computing, it is probably the next step in the evolution of the Internet for the dissemination of information in a more seamless manner.

This technology forms the infrastructure for the 21st century and will essentially facilitate collaboration in a more seamless distributed processing environment with uniform data access. The ultimate goal for WGISS is to have all the CEOS Data Centers on an interconnected Grid with seamless and consistent authentication by 2010. NOAA has been involved with the CEOS Grid team from its inception, due to the work of NOMADS, and NOMADS is in fact one of the first four systems that comprise the CEOS Grid test bed. This joint venture between NOAA and CEOS will reap major benefits for NOAA and the Nation regarding better, more seamless access to the expected petabytes of new environmental data expected over the next 10-15 years.

Scientific Stewardship

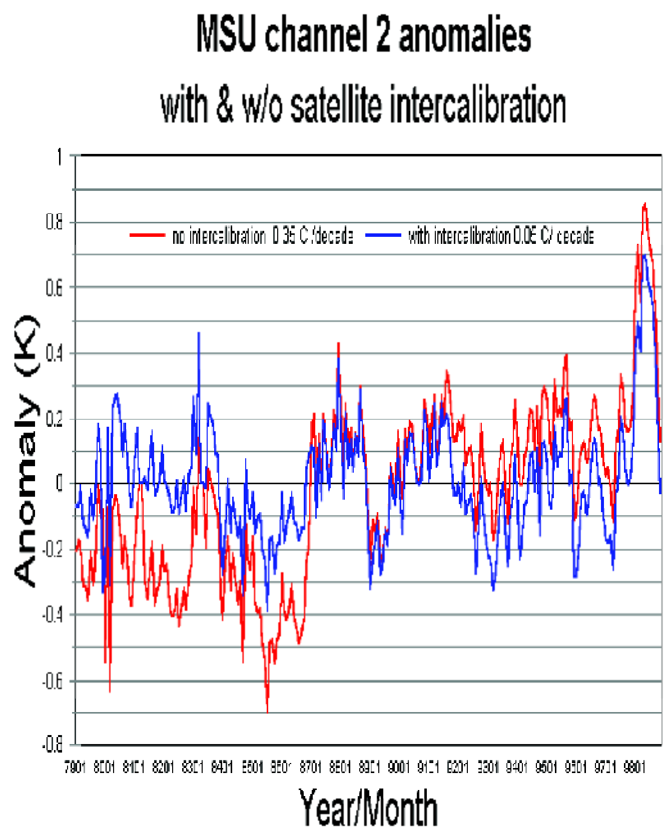
The concept of scientific stewardship within NOAA means providing the data and information services necessary to answer global change science questions of the highest priority, both now and in the future. High quality, long-term records are needed to address important monitoring and prediction issues. The NOAA *in-situ* observations, such as surface temperature and precipitation, have long been subjected to extensive scrutiny, quality control, adjustment, and analysis. These steps created the confidence in the quality of these data used by decision makers. Similar stewardship functions are required for all the NOAA observations. Then, long-term records from all the NOAA observing systems will reveal their respective maximum potential usefulness regarding a range of critical environmental monitoring and prediction issues, such as atmospheric and oceanic climate change, terrestrial change detection in response to climate changes, space and solar variability, and ecosystem and coastal management.

There are five fundamental principles associated with the NOAA Scientific Stewardship Program:

- ***Ensure Observing System Quality.*** Provide real-time monitoring of climate-scale biases for the global suite of satellite, airborne, and *in-situ* (atmospheric and ocean) observing systems by monitoring the observing system's performance. Subtle spatial and temporal biases can contribute to serious data quality problems. Automated Network Monitoring to discover these biases as soon as possible are the first line of defense, before the data becomes part of the long-term historical records. Programs to seek out existing biases in the historical records provide the second level of monitoring necessary for improving the climate data records. Time dependent and other biases can be minimized or eliminated through efficient and effective early processing and periodic reprocessing leading to improving and maintaining the quality of the observing systems.

- ***Develop a Climate Processing System.*** Provide the necessary algorithms to ensure that understanding of key climate processes can be derived from space-based systems and the fusion of space-based and *in-situ* systems. The best possible scientific understanding of critical climate and global change issues can only be reached when many opinions and perspectives are explored. Essential to this end is an active program that engages the research community, establishes partnerships with industry, and facilitates interactions with local, regional, and national governments, agencies, and institutions.

- ***Provide Basic IT Support.*** Technology now provides the capabilities to implement, maintain, and access the most comprehensive and highest possible quality historical data and information records, critical to the support of effective analysis and prediction activities. A dynamic and flexible strategic plan for the efficient use of IT resources will support rapid adaptation to evolutionary and revolutionary IT changes (e.g., new sensors, telecommunications, storage, commercial-off-the-shelf software, and interoperable hardware). The creation of long-term, contiguous, and quality data records requires the commitment of resources to accomplish these tasks.



The graph of Microwave Sounder Unit (MSU) Channel 2 anomalies illustrates one of the challenges of scientific data stewardship (SDS). Satellite sensors (MSUs) can degrade with time after launch and there are often discontinuities between different satellites measuring small climate change signals. The red line on the graph shows the MSU data without calibration. The blue line represents calibrated data from multiple satellites. Environmental data adjusted for various systematic differences between instruments not only results in better data analysis, but also represents the best of scientific data stewardship principles.

- ***Document Earth System Variability.*** Documenting the Earth's integrated climate system, variability, and change on global, regional, and local scales depends on creating, using, and maintaining the highest quality climate databases and deriving the best historical perspective from these records. This will optimize data and information services in order to make research easier and more effective by ensuring that those services are simple, straightforward, direct, and responsive. Success will be achieved by establishing end-to-end accountability for establishing long-term, scientifically valid, and consistent records for global change studies. This will ensure that our data and information are available to the maximum number of users.

- ***Enable and Facilitate Future Research.*** Climate and global change is a long-term societal imperative. Questions and answers often take many years into focus due to the nature of the "feedback" and "forcing" systems influencing the global and regional climate systems. This aspect of stewardship encompasses providing the quality climate observations over years and decades, recurring basic information technology hardware and software improvements, and improved models, that can guarantee the preservation of and access to the data, information, and gained knowledge for future generations of scientists and policy makers. Today the Internet, NGI, and the emerging grid technology will provide the access for today and the near future. Newly developed data sets will be used to update scenarios and assessments, and identify and respond to emerging questions that the scientific community is expected to answer.

Scientific Stewardship Functions

The five fundamental principles provide the framework for the NOAA Scientific Stewardship Program. However, full exploitation of the scientific value of observations requires implementing five Scientific Stewardship functions, each with several constituent components. The first function provides real-time monitoring for long-term applications of the observing systems' performance. Such monitoring requires the implementation of automated processes that will detect and notify when unusual changes occur in the performance of the observing system and the sensor measurements. One example is the immediate detection of small biases in the reported instrument observed values. These "errors" can be minimized or eliminated before the problem becomes larger in the archived records.

The second function addresses data quality and product generation. Environmental, economic, and social issues need an authoritative source of information to establish long-term trends and to detect significant changes in the environmental conditions. Authoritative long-term records provide that information by fusing the information content derived from high quality satellite measurements with ground based measurements and merging these with data from the irreplaceable historical records. Rigorous analysis of historical and current records using advanced physics based methods is essential. The authoritative nature and vitality of these data and products require periodic reviews by the scientific community, which may recommend reprocessing of the original record and generation of new products.

The third function, the use of authoritative records, assesses the current state of the environment and puts the assessments into a historical perspective. Long-term trends on local, regional, national, and global scales can be determined and used to estimate likely scenarios for the future. Authoritative records can detect significant changes in environmental conditions and regimes. These first three functions taken together are known as SDS.

The fourth function is concerned with documenting the history of the observing system and the data processing and storage methods and procedures. Ensuring long-term data archival and access capabilities require that metadata records, direct observations, and fundamental measurements from satellite, airborne, and *in-situ* platforms are comprehensive, complete, and preserved in perpetuity. Open, efficient access to the metadata records, products, and data streams must be guaranteed and data made available in useful formats. These functions and their components will at all times maintain a strong emphasis on the physics of the instrument, as well as the parameter measured. This group of constituent components form the fourth stewardship function known as Information Stewardship.

The fifth and last function addresses "data archeology" activities that are designed to rescue the information content in the historical records archived in an analog (non-digital) format. The full scientific value of these archives can only be achieved if the data are digitized and used in data assimilation schemes with complementary data sets. The CDMP is a critical contributor to the data archeology activities. This fifth function is known as Data Rescue Stewardship.

The implementation of scientific stewardship has begun and covers not only the archiving plans for all the various satellite and *in-situ* data sources, but it also involves applications with a number of groups and activities as follows: (1) data character; (2) mission groups; (3) interdisciplinary groups; and (4) external grants. The data character group has the mandate for long-term calibration, inter-calibration, and validation of all sensors; collaborates with existing national and international observing system groups; and assures that customers get the highest quality basic data while also responding to data quality questions. The mission groups are specific to each observing platform (e.g., NPOESS), ramp up during the implementation of the observing platform, and then transitions to the data character group when stable operations are achieved. These first two groups possess the competencies in the specifics of each mission and produce the documented metadata. The interdisciplinary groups address major theme areas (e.g., water and energy cycles), use all the instruments, and blend (fuse) data from multiple sources to address climate and global change science questions in order to help provide data and information assessments and options. Finally, the external grants program uses expertise from existing NOAA grants and contracts to assure the involvement of academia and industry. Grant program members work with other scientific stewardship groups to take advantage of directed research with cooperative institutes.

Challenges and Recommendations

Scientific stewardship, with an emphasis upon satellite and radar data and information, is a new era in data management consisting of an integrated suite of functions to preserve and exploit the full scientific value of environmental data and information entrusted to NOAA. These functions provide effective observing system design, careful monitoring of observing systems performance for use in long-term applications, improved quality control, generation of authoritative long-term quality data and records, assessments on the state of the environment, and archive and access to data, metadata, products, and services. Successful implementation of scientific stewardship will ensure maximum use and public benefit of environmental data and information, now and in the future.

Careful thought and support is required to achieve the desired end-to-end observation data management process (i.e., collecting, monitoring, processing, product development, access/distribution, archiving, assessing, etc.). An integrated suite of functions to preserve and exploit the full scientific value of the environmental data and information under the stewardship of the NOAA will evolve provided the basic resources are committed to the goals and objectives. The two primary goals are: 1) the careful monitoring of observing system performance for long-term applications, and 2) the generation of authoritative long-term records. A third and new component, the effective integration of observations from modern satellite and radar systems with targeted *in-situ* and long-term historical data, is ambitious, yet achievable. High quality, long-term records and targeted products relevant to society's needs today and tomorrow will address important environmental monitoring and prediction issues. Scientific stewardship will provide the means to raise the level of confidence in the quality of the data and associated forecasts to be used by decision makers.

Maximizing the public benefit of the Nation's operational satellites, radars, and past proxy data sets requires implementing the scientific stewardship program. The involvement and consensus of the research community are essential to accomplish these objectives. Implementation of stewardship of environmental data from the NOAA observing systems will ensure the quality, usefulness, and accessibility of this national information resource treasure for current and future generations.

F. Homeland Security

NOAA, as with many federal, state, and local agencies, as well as private industry, faces the challenge of doing business in a world of heightened security concerns and terrorist threats following the horrific events of September 11, 2001. Clearly, NOAA as an environmental agency, has found itself in a situation of new data and information needs, customers, and procedures. Many of NOAA's data sets are used to support forecasting of and response to natural hazards, as well as their use in climate studies, marine applications, and a variety of industries (e.g., construction), and are essential in support of homeland security activities that include emergency response, monitoring, predicting, and modeling in times of national emergencies.

For example, as gateways to our largest cities and industries, U.S. seaports are vulnerable choke points and strategic targets for attack. The U.S. economy is dependent upon the uninterrupted and efficient flow of goods and services. Commercial ports also serve as logistical centers for rapid deployment of U.S. military forces and material, and must, therefore, remain open and protected. NOAA can offer assistance that is of great benefit to the U.S. Coast Guard, the Navy, and port authorities through its mapping and charting products.

Modern electronic information systems will be key to maritime security, port safety and uninterrupted maritime commerce. Mariners need accurate, real-time information displays such as NOAA's ENC's integrated with differential GPS positioning, weather conditions, forecasts, and water level and current data in order to make informed and safe decisions. When integrated with GPS technology and accurate charting information, these data can be used to calculate underkeel clearances for a vessel's transit, thereby reducing the possibility of ships going aground, blocking other vessels and channels, spilling contaminants, or becoming additional targets.

NOAA's models of atmospheric, oceanographic, and water-quality conditions provide crucial advance data for re-routing of vessel traffic, port condition forecasts, and low visibility navigation to keep traffic moving. They also are critical to air and water dispersion efforts. As an example, NOAA works closely with first responders by providing modeling information for incidents such as oil spills, toxic atmospheric conditions, and smoke plume trajectory so that decisions related to population and environmental safety can be made.

Another NOAA responsibility is fishery management and enforcement of commercial fishing regulations, as well as seafood inspections. NOAA works closely with the U.S. Coast Guard to ensure vessel traffic is kept in appropriate waterways and fishing grounds. Currently, seafood inspectors monitor the fishing industry to ensure the safety of their product upon entering the United States. This monitoring aspect also is valuable to homeland security since NOAA personnel may be some of the first to notice any unusual activity in unauthorized coastal areas.

With a general presentation of just a few of the activities NOAA does routinely, it is easy to understand how many of them are related to security and well-being of the Nation. But, open policies for data sharing can provide challenges to assuring that environmental information and NOAA's other products are not used to create harm. Therefore some of the things that must be considered in the new security environment are:

- Who are NOAA's customers? Are there additional agencies that now have new missions for homeland security, including intelligence agencies that now need to share information more broadly without compromising sources; state and local emergency responders who need good information that is unclassified; private industry trying to develop products and services to work within this new area of concern?

- How does NOAA work with the new Department of Homeland Security?
- What is no longer benign information, or an accepted way of doing business? How are data handled differently (mapping, port information, dispersion models for example)?
- How does NOAA provide adequate security without seriously impacting open data sharing policies?
- NOAA must now deal with its own homeland security concerns and responsibilities. How does its environmental data assist with this? The agency must try and understand that there may be potentially new, harm-inflicting applications for standard data. There may be hostile "customers" who are not friendly toward U.S. policies or interests. As a result, they may be trying to use the data to threaten U.S. interests.
- However, others may be using the information (for detection, monitoring, response to an environmentally based terrorist threat), to protect the Nation. Or, traditional customers may be using NOAA environmental data in new ways to meet their new homeland security requirements.

Today the new threats can create uncertainties about current policies for data distribution. Are they still valid or should they be rethought? What scrutiny needs to apply to NOAA customers? Data once openly available may now be considered sensitive; posing challenges for how NOAA will maintain its "full and open" policy for data and information in a new era of heightened sensitivities.

NOAA is taking initial steps:

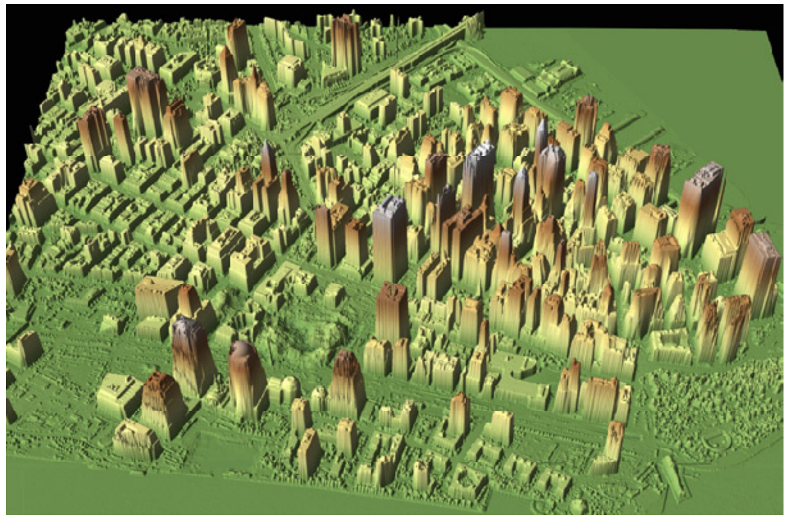
- The agency has implemented interdiction software as a way of trying to limit selling data and information to known terrorists;
- It is reviewing its Internet sites for sensitive information (launch schedules, modeling programs, etc.,) which might be used adversely. This type of information is being removed or put in protected areas and customers are being dealt with off-line;
- It is improving protections for Internet sites through information technology methods. This includes methods for providing mission partners with their products and services while ensuring security of information being delivered.

Availability of Data

The problems facing NOAA to ensure its data are available when needed are numerous. Certain data streams must be delivered in real-time and, therefore, clean and uninterrupted communications are essential. For instance, the New York/New Jersey PORTS® system used to rely on data lines that ran through the World Trade Center. When the buildings were destroyed, access to those data were interrupted. Robust and redundant lines of communication must be established in advance of any emergency and tested on a regular basis. Systems must be put in place for 24x7 quality assurance of real-time data, based upon defined parameters, with the ability to discontinue data dissemination if quality or accuracy are in question. Systems need to incorporate knowledge-based expert software. Continued enhancements will be required as new sensor data are added. Also, back-up delivery and archive sites must be maintained to deliver the critical non-real-time data in a timely manner.

Considerable resources are required to manage the archive, perform archive preservation, and to access and distribute the vast array of environmental observations that are currently available to NOAA. As new observing systems become operational, particularly new environmental satellite systems producing large volumes of data, there will be increasing demands placed on NNDC resources for archive management and access operations.

It is essential that an orderly review and approval process be in place to provide guidance and oversight for archive management activities. Given the challenge of managing increasing volumes of data, coordination among the NNDCs is necessary to meet data archive management requirements. This review and approval process will support decision making to establish priorities and address the science community requirements for environmental data sets managed by the NNDCs.



NOAA aircraft mapped the entire area of lower Manhattan, New York using aerial photography and Light Detection and Ranging (LIDAR) technology after the events of September 11, 2001. The data collected by the LIDAR equipment helped produce 3-D images of the World Trade Center site to identify the height of rubble so that the appropriate cranes could be used to remove it. This image was rendered September 27, 2001, by the U.S. Army Joint Precision Strike Demonstration from data collected by NOAA. (Photo credit: NOAA/U.S. Army JPSD)

A Data Archive Management Board has been formed to address those issues and opportunities that require coordination among the NNDCs to implement NOAA archive management responsibilities. The Board's objective is to provide clear guidance for managing the NOAA NNDC data archives. Its function is to review, coordinate, and determine data archive management requirements and priorities for the NNDCs. Specifically, the Board:

- Establishes data archive management and distribution policies;
- Reviews and approves science requirements;
- Sets priorities for determining which data are to be included and preserved in the archive;
- Coordinates system architectural implementation; and
- Addresses legal requirements and best practices.

III. Challenges for the Future: Internet Sites

American Association of State Climatologists
http://www.ncdc.noaa.gov/oa/climate/aasc.html

Next Generation Internet (NGI) Initiative
http://www.ngi.gov/pubs/

NOAA Comprehensive Large Array-data Stewardship System Demonstration Site
http://www.saa.noaa.gov/cocoon/nsaa/products/welcome

NEXRAD Radar Archive & Access
http://www.ncdc.noaa.gov/oa/radar/radarresources.html#ABOUT

NOAA Fisheries Statistics and Economics Division
http://www.st.nmfs.gov/st1/

National Spatial Data Infrastructure- Geospatial One-Stop
http://www.geo-one-stop.gov/

Federal Geographic Data Committee
http://www.fgdc.gov/

North American Drought Monitor
http://lwf.ncdc.noaa.gov/oa/climate/monitoring/drought/nadm/

National Climate Impact Indicators
http://lwf.ncdc.noaa.gov/oa/climate/research/cie/cie.html

NOAA Operational Model Archive and Distribution System (NOMADS)
http://lwf.ncdc.noaa.gov/oa/ams/NOMADS-ams02.pdf

Committee on Earth Observation Satellites- Working Group on Information Systems and Services
http://www.ngdc.noaa.gov/seg/tools/gis/gldatatthome.shtml

Physical Oceanographic Real Time System (PORTS)
http://co-ops.nos.noaa.gov/d_ports.html