<u>NOAA WORKING FORUM FINAL REPORT</u>

INTEGRATING SURFACE OBSERVING SYSTEMS (ISOS)

WEATHER & WATER AND CLIMATE GOAL TEAMS

FRAMING THE ISSUE
<u>A FIRST STEP AND BEYOND</u>

September 20, 2004

July 20-22, 2004
NOAA Integrated Surface Observing Systems (ISOS) Working Forum
Sponsored by
Weather & Water and Climate Goal Team Leaders

http://www.ncdc.noaa.gov/oa/isosmtg/isoswebsite.html

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Why This NOAA Working Forum Now?

Introduction

In order to maximize the potential value and benefit of observations and observing systems there is the need to integrate the planning, implementation, and life cycle support to existing and future observations and observing systems. To this end, corporate NOAA has established the NOAA Observing Systems Council (NOSC) and in collaboration with the NOAA Ocean Council (NOC) is working to define issues and procedures for corporate NOAA to adopt as "best business practices." Integrating NOAA observing systems is a high level concern of the NOAA Corporate Board.

Considerable work has been done regarding the integration of ocean observations as evidenced by the Integrated Ocean Observing System (IOOS) and the associated Data Management and Communications (DMAC) plans and recent legislation, such as HR 5001 – Ocean and Coastal Observations Systems Act of 2004. The NOSC has published the Strategic Directions for NOAA's Integrated Global Environmental Observations and Data Management, July 2004, go to http://www.nosc.noaa.gov/. The Interagency Working Group for Global Earth Observations (IWGEO) has prepared the Strategic Plan for the U.S. Integrated Earth Observation System of Systems, http://iwgeo.ssc.nasa.gov/draftstrategicplan/ieos_draft_strategic_plan.pdf, and the draft 10-year plan blueprint Global Earth Observing System of Systems at http://earthobservations.org.

The Climate and Weather & Water NOAA Mission Goal Team Leaders sponsored a NOAA Integrated Surface Observing Systems (ISOS) Working Forum, July 20-22, 2004 in Asheville, NC. This was the first across NOAA meeting to discuss and scope out core functions for consideration that will contribute to a corporate level NOAA Integration of Observing Systems Planning and Coordination Process. There were 40 participants from across NOAA, USGS, NSF/\, and DOD, including representation from each NOAA Goal Team, NOAA Line Office, and many of the NOAA Programs and Observing Networks.

Two principal factors influenced the scheduling of this NOAA ISOS working forum. First, Integrated Surface Observations (ISO) is a new activity listed in the FY 06 and the FY 07 PPBES Program Baseline Assessments (PBA) for both the Climate and Weather & Water Goals. The NOAA Planning, Assessment, and Evaluation (PA&E) FY 06 PBA review requested that a plan be provided to better define the ISO activities. Second, the VADM requested a plan describing how to pursue COOP Modernization (COOP-M) and U. S. Climate Reference Network (USCRN) integration in a more holistic manner vice individual "stove pipe" observing systems.

Working Forum

In planning for and during the forum discussions it became clear that there are fundamental "core" issues that are critical to planning related to integrating observing systems, before meaningful progress can be made regarding observations and observing systems. Participants broadly defined, "integration" as an end-to-end process to include beginning with the a review and validation of the requirements, the observations, the observing systems (sensors, site locations, and other common hardware), and associated data management processes and activities, such as quality control, metadata (station history), access, and archiving of NOAA data that have long term a value to the Nation. A wide range and large number of issues were reduced to a list of common functions relative to integrating observations and observing systems. The list was further refined to identifying critical up front fundamental “core” items that frame the foundation for all integrated planning efforts.

This report intentionally addresses only NOAA observing systems with a focus on observing systems related to the Climate and Weather & Water Goals. The issues discussed in this report can be extended to other NOAA observing systems, other U. S. national, regional, and state level observing systems, as well as global earth observing systems. It is the hope that NOAA principles of integration will be incorporated into the NOAA Business Operations Manual (BOM). Finally, there is recognition that the NOSC and NOC play a pivotal leadership role in guiding and promoting the decision making process leading to the development and implementation of a corporate NOAA approach to integrating NOAA observing systems.

This Working Forum Report addresses an examination of higher level critical “core” issues common to all NOAA observing systems and integration. Admittedly, at this point there is a bias in the writing toward surface observing systems. This report does not present a long detailed list of all the common functions and issues. This report does provide a list of “low hanging fruit” deliverables and describes early collaboration and integration efforts primarily between the Climate and Weather & Water Goal Teams.

Outcomes

- Improve coordination and collaboration within NOAA regarding the planning, evaluation, and implementation of NOAA observing systems.
- Reduce and eventually eliminate observing “gaps” through greater economy and efficiency by employing “Best Business Practices” across corporate NOAA.

Deliverables

- Define the fundamental “core” functions and recommend actions to facilitate integrated planning and implementation between the two Goal Teams.
- Identify short (12-14 months) and mid-term (2-3 years) action items that demonstrate successful integration planning and execution.
- Deliver (next 12-18+ months) defined, achievable tasks, building one success upon the next toward greater integrated NOAA Climate and Weather & Water goal team related observations and supporting activities, i.e., “low hanging fruit.”
- Develop and deliver an Integrated Surface Observing System (ISOS) Plan in response to the PA&E request.

Key Discussions

The four NOAA Mission Goal Team representatives provided an overview of observations and observing systems that are directly utilized to achieve outcomes outlined in their goal and associate programs. Each NOAA Line Office representative described the observing systems funded and operated by their respective line office. Discussions included key issues of interest regarding observing needs in support of their respective activities and the NOAA Strategic Plan. Agenda, presentations, and attendees list, go to http://www.ncdc.noaa.gov/oa/isosmtg/isoswebsite.html.

The purpose of this report is to highlight the most basic core considerations, present tangible recommendations, and identify short term deliverables.

The expectation is that follow-on working “focus” groups will address in detail each issue and specific needs required to adequately monitor and observe, in an integrated approach, the complex holistic earth environmental system, driven by both the physical and living sciences.

Though there are many issues, this report addresses the following topics as a starting point for developing a basic plan and process that can be followed by corporate NOAA when assessing and implementing the integration of current and future observing systems.

- A requirements and integrated process for use by the Goal Team sponsors.
- Dialog and coordination between Goal Teams, Program Managers, and LOs as part of the PPBES/PBA process on a regular basis throughout the year.
- Decision support tools and information that can be easily and conveniently accessed.
- Improved/coordinated web-based access and visualization tools.
- Minimum defined standards for station history data.
- Common quality control processing for measured parameters.
- Long-term value of NOAA observations to the Nation.

The working forum members believe that if this broad outline of a “few” first steps can be accepted and successfully implemented and employed by the two Goal Teams, then a more robust end-to-end NOAA Integrated Observing System (IOS) Implementation Planning Process can be defined and successfully used by all Goal Team leaders. Such a plan can be extended to other national, state, and local networks, as well as integrated with the Global Earth Observing System of Systems (GEOSS).

Target Audience

The target audiences are the NOAA leadership and decision makers and planners, to include but not limited to:

- NOAA Executive Council (NEC)/NOAA Executive Panel (NEP)
- Planning Programming and Integration (PPI)
- NOAA Planning, Assessment, and Evaluation (PA&E)
- NOAA Observing Systems Council (NOSC)/NOAA Ocean Council (NOC)
- NOAA Line/Staff Office AAs/DAAs
- NOAA Mission Goal Teams
- NOAA Program Managers
- NOAA Observing Systems Managers

<u>NOAA ISOS July 20-22, 2004 Working Forum – Final Report</u>

Climate and Weather & Water Goal Teams
Integrating NOAA Observing Systems – A First Step
"The Basics"

Vision

NOAA envisions an optimized, integrated system of earth observations for societal, economic, and environmental benefits.

Goal

An establish framework for NOAA managers to use when planning, implementing, and evaluating the integration of Earth observations and observing systems, the resultant data management of observations, and the delivery of information.

Outcomes

- Define a *core set* of functions/considerations and a process for integration, focusing on observations and observing systems, which support *multiple* NOAA and national/international observation plans (e.g., IWGEO and GEOSS).
- *Efficiently deliver information* to NOAA customers *meeting or exceeding benchmarks* for reliability, accuracy, timeliness, relevance, and accessibility in a comprehensive manner.

The Need Defined

A few of the recurring themes noted from the six NOAA Constituents meetings held across the country include the following questions from the public: *What data and information can NOAA provide to users? Where are the data and information located? How do I access and retrieve these data? How "good" is the data?* The last question addresses the level of confidence in the data and the degree of risk, defined by uncertainty, the user must consider relative to their respective investments and plans when utilizing NOAA data and information.

Each year NOAA issues thousands of water, weather, and climate forecasts to save lives, reduce property damage and to support the National economy and security. NOAA and other observations need to be available for immediate operational use to well defined circles of users. Climate and Weather & Water predictions and projections are critically dependent on accurate, reliable, and readily available physical and biological (living sciences) new and historical observations and data. A well managed NOAA Integrated Observing System (IOS), to include a robust metadata database, increases the longevity and value of NOAA observations to a wide variety of end-users with many diverse requirements. A fully implemented NOAA IOS, a system of systems, more effectively and efficiently supports the desired outcomes of all NOAA Mission Goals and contributes to a larger national and global network of networks.

While this report remains focused on NOAA observing systems, primarily those supporting the Climate and Weather & Water Goals, there is full recognition that the integration process will be expanded to include other national, state and local government agencies, public utility companies, research organizations, educational institutes, and private industries operating observing systems, often referred to as "mesonets." This expansion to a national level of networks reflects the need to leverage cost benefits through national and international partnerships with many organizations thus improving access to other densely spaced, real-time observations. The integration of non-NOAA observations into NOAA operational and research activities can dramatically increase the number and frequency of observations available to users and helps to "fill in the spatial and temporal holes" at the regional, national, and global scales.

Fundamental Considerations and Recommendations

This document presents the most fundamental considerations to consider during the Integration Process by senior and mid-level NOAA leadership. To be successful, a well defined, understood, and used Integrated Observing System (IOS) process addresses first the fundamental considerations when examining how best to integrate existing observations and observing systems. Future observations and observing systems planned and implemented on a national and global scale will lead to improved data quality delivered to the public and used in research and applications that address socio-economic and environmental issues now and throughout the 21st Century.

Societal Benefits

The first step in assessing the value of integrating observing systems is to identify the benefits to society. One approach is to examine strategic focus areas related to societal needs such as:

1. Improve Weather Forecasting.
2. Reduce Loss of Life and Property.
3. Protect and Monitor Our Ocean Resources.
4. Understand, Assess, Predict, Mitigate, and Adapt to Climate Variability and Change.
5. Support Sustainable Agriculture and Combat Land Degradation
6. Understand the Effects of Environmental Factors on Human Health and Well Being
7. Develop the Capacity to Make Ecological Forecasts
8. Protect and Monitor Water Resources
9. Monitor and Manage Energy Resources.

Requirements Process

Successful integrated planning and implementation begin with well defined and validated requirements endorsed by the NOAA leadership. One of the most significant contributors to program and project failure is related to poor requirements management. Therefore, the question "*What are the validated requirements?*" should be the starting point of all planning activities.

There is a consensus among the participants that the Goal Teams Leaders, Program Managers, Line/Staff Office personnel, and Observing System Managers need to meet periodically to discuss defining and validating observing requirements and analyze how best to integrate these requirements into a national network of existing and future atmospheric, terrestrial, and ocean observing systems. This evaluation of resultant integrated systems must always consider the contributions to societal needs.

Over the past year, a NOAA working group drafted a NOAA Requirements Management Process, (http://www.nosc.noaa.gov/) which was demonstrated and tested through a pilot implementation process at the request of the NOAA Executive Panel (NEP) and under the direction of NOAA's Program Planning and Integration (PPI) office. Parallel to this is the process of defining needs and requirements for all NOAA programs through the PPBES Program Baseline Assessments (PBA). This process has led to the internal identification of a large number of user needs and requirements drivers. A current drawback in the current requirements process is that the systematic *validation* of all the "needs" information has not yet been accomplished that will lead to a highly certifiable, prioritized, and cross-cutting validation of requirements to be supported by NOAA programs for the integration of observations and observing systems. A concerted effort to establish valid requirements for the IOOS is underway. It is important that these efforts be coordinated and integrated to realize the vision described in this framework. To the maximum extent suitable and practicable, standards, definitions, etc. endorsed by the international community should be accepted and used by NOAA.

An end-to-end requirements management approach for an IOS should include the following:

1. Collection of data and information on mandates, needs, and opportunities.
2. Interpretation and validation of these mandates, needs, and opportunities relative to the NOAA vision, mission, and goals.
3. Identification, prioritization, and validation of Goal Team and NOAA observing requirements.
4. Development of plans and programs to address how to satisfy the validated requirement(s) and where applicable initiate research and analysis to address potential solutions.
5. Selection of the most appropriate solution(s) and development of a prototype procedure/process.
6. Implementation of the solution and life cycle maintenance, as well as follow-up assessment of the implemented solutions and results.

Dialog and Coordination

Based on the discussions with the Goal Team and LO representatives the current level of dialog and coordination is inadequate. In order facilitate this dialog the participants identified three fundamental reference points necessary to begin the integration of observing systems decision process.

1. A common language, a set of definitions, regarding observations endorsed by NOAA for use within corporate NOAA would greatly facilitate discussions. The NOSA has adopted the use of the Global Change Master Directory (GCMD) List (http://gcmd.gsfc.nasa.gov). In response to a NOSA request, this report will use the term "parameter" (in place of "variable") when referring to elements to be measured, such as temperature, precipitation, etc. There are commonly used terms that are not well defined and do not appear in the GCMD. Supplemental terms need to be defined for use among the NOAA Goal teams and others. Example: Much time was spent on the term "surface" observations. Some participants believed it referred to only the ASOS, COOP, and USCRN. Others believe "surface" means any land and ocean based observations taken such as air temperature, pressure, wind speed/direction, sea surface temperature (SST), etc. Others included or excluded observations taken by radiosondes, wind profilers, etc. Other common misunderstood terms included In-situ and Remote observations and "metadata". Some

considered In-situ to mean observations taken by ground based stations, not necessarily to include NEXRAD or airborne (aircraft). Remote might include satellites, wind profiler, and NEXRAD. Metadata may be as basic as latitude, longitude, and elevation and/or detailed information on the station design and surrounding landscape, sensors, calibration, quality control, etc.

2. A need exists for a NOAA validated requirements list of atmospheric, terrestrial, ocean, and space physical, biological, and solar parameters addressing the strategic societal needs referred to above. NOSA has the most recent requirements list sorted by the four NOAA Missions Goals.
    a. Easy access to the NOSA list is needed.
    b. Each goal list needs to be validated by the goal team and endorsed by NOAA.
    c. An explanation of the requirements "validation" process needs to be documented and easily accessible.

3. Each parameter must be assigned a priority (not all parameters can be a priority 1).
    a. This prioritization by the goal teams does not currently exist in the NOSA database.
    b. Each goal team must prioritize their respective list.
    c. An explanation of the prioritization methodology and decision needs to be documented and easily accessible.

Recommendations

1. Develop a NOAA list of definitions to compliment the GCMD and provide easy access through NOSA. At the very least define the terms:
    a. "surface" observations.
    b. Land, Water (near shore and open oceans and Great Lakes) based, Airborne, and Space based.
    c. "In-situ" (to include how it is written: In-situ or *In-situ*, in-situ or *in-situ*) e.g., ASOS, COOP, USCRN, radiosonde, airborne (aircraft), buoys (fixed and drifting), fish stock, and other marine life observations and data.
    d. "Remote" e.g., Satellites only (space based), or include NEXRAD, others(?).
    e. "Metadata" – Information about Data.
    f. Data Management, Data Stewardship, and Scientific Data Stewardship (SDS) (These two terms currently being defined at the request of PA&E and NOSA).
    g. Perhaps further refine In-situ and Remote as "Direct" and "Indirect" measurements.

2. Goal Teams review, update, validate, and prioritize the current list of observing parameters available from NOSA.
    a. Present these validated and prioritize Goal Team Lists to NOAA leadership for consolidation into a consolidated corporate NOAA list approved by the NEP and NEC.
    b. NOSA provide easy access to the Goal Team and corporate NOAA lists.
    c. Goal Teams and corporate NOAA review and update at least yearly and as needed.
    d. There have been several such lists of parameters generated by various scientific (research and operational) groups that could be used as the starting point, e.g., IWGEO 10-year GEOSS plan, GCOS implementation plan, NRC, WMO, etc.

e. A draft prioritization criteria and evaluation process has been drafted by the IWGEO for use by the GEOSS.
f. The Ten Climate Monitoring Principles also provide some guidance, see Appendix A.
g. Easy and convenient access to these data bases, information, and resultant sorts needs to be part of the NOSA capability/capacity for use by all NOAA personnel.

Challenges

a. Each Goal Team must identify their respective "primary" and "supporting" parameters.
b. A standard prioritization process is needed for use by all the goal teams.
c. Each Goal Team must prioritize the parameters using some rating scale, e.g. 1, 2, 3, etc.
d. The creation of an endorsed corporate NOAA list of parameters and priorities for the full range of physical, biological (living), and perhaps space sciences.
e. A well written "requirements document" linked to the NOAA Mission Goal(s) for each current or proposed observing system is essential to any integrating activities.

Decision Support Tools

Effective communications and coordination by Goal Teams, Program Managers, and the Line/Staff Office representatives requires easy and convenient access to accepted definitions, data, information, and associated sort capabilities. A single common database and access portal are required to facilitate discussions, compare the different observing systems, and collaborate on planning, programming, budgeting, and execution that support the effective integration of existing and future observations and observing systems.

The NOAA Observing System Architecture (NOSA) database has the potential to provide exceptional information support tools. It is reasonable to expect that the NOSA database provide the required information and access capabilities with some additional programming enhancements. Typical "canned" and build "on the fly" products that users, particularly decision makers, need to have immediate access and retrieval should include as a minimum (table or spreadsheet format):

1. NOAA approved list of parameters and priorities.
2. NOAA approved list of parameters indicating primary and supporting status mapped to each of the four NOAA Mission Goals.
3. NOAA approved list of parameters and existing observing system (system name such as ASOS, Argo, etc. and the managing LO) with the respective parameter identified that are actually being measured.
4. All NOAA existing observing systems: Comprehensive alphabetical list by observing network name; Sort by Line Office; Sort by NOAA Mission Goal; and Sort by NOAA Program.
5. List of NOAA endorsed supplementary definitions will assist with maintaining consistency across the NOSA database and during integration discussions, planning, evaluation, and implementation.

Recommendation

Goal Team Leaders, NOAA LOs, and NOSC direct NOSA to provide the necessary support and direction to establish these decision level planning and programming information tools. This capability should become a dynamic part of the NOSA service to corporate NOAA.

Challenge
Goal Teams, NOAA program managers, NOAA LOs, and Observing System Managers must inventory and provide accurate information to NOSA and routinely update the information.

Data Access and Visualization

Data access includes direct access (and retrieval) to the most current observations and archived historical data, as well as simple links to the associated metadata (station history data) for each observing station and observing system. Participants demonstrated a wide range of web-based access capabilities within NOAA. The NOSA group and Ted Habermann (NGDC) www.nosa.gov, Joe Facundo (NWS, Chief Observing Systems Branch) http://www.mirs.nws.noaa.gov/mirsweb/), and Neal Lott (NCDC) http://cdo.ncdc.noaa.gov demonstrated excellent viewing, access, and retrieval capabilities regarding NOAA observations and observing systems. The Forecast Systems Laboratory (FSL) and NMFS Fisheries Information System (FIS) also provide excellent access capabilities. Many other NOAA activities have developed some level of web-based GIS capability for their respective data and products. Access portals share many common and unique capabilities, when made available on other NOAA portals, offer improved customer access, search, and retrieval capacities.

Individual efforts demonstrate initiative and innovative actions and there is no intent to discourage this level of GIS activities in support of respective centers of data. However, at the higher level of planning and integration, easy and convenient access and retrieval to most of NOAA's data and information to the widest range of users, can be greatly improved by pooling NOAA GIS intellectual resources (NOSA, NNDC, NCDC, NWS, FSL, etc.) into a coordinated and collaborative process in support of common user needs. This will approach will contribute to reduced training and contractor support costs while accelerating improved access and visualization tools.

While not an absolute necessity, adoption of file formats, standards, and tools can have an enormous positive impact on productivity within NOAA and quality of service to NOAA users. For example, simply converting the current climate normals and the CARDS data set to netCDF (abiding by the UDUNITS and CF naming conventions) and hosting them on an OPeNDAP server would make them available to all users. Samples of some available analysis and visualization tools are briefly described in Appendix B, some developed and prototyped by NOAA activities or with NOAA as partners.

Final Note: It is not always necessary for NOAA to develop and offer visualization tools. A companion strategy should include identifying industry groups that have developed visualization tools tailored to support their specific needs, such as the transportation industry. The key consideration for NOAA is to provide the means for the easy access and delivery of NOAA observation into these industry developed tools.

Recommendations

1. Climate and Weather & Water Goal Teams host an access and visualization "focus group" consisting of at least the NOSA group, NWS, FSL, and the NOAA National Data Centers (NCDC, NGDC, and NODC) to review the current status of GIS data access, display, and visualization development and future short and mid-term collaboration and plans.

2. Participants form a "core" collaborative NOAA working (focus) group with the intent of promoting and improving this aspect of the NOAA integration of observing systems process and management of resources.
3. Identify industry-based GIS and visualization capabilities that would benefit from the easy and convenient access links to NOAA data and information.

Challenges

a. Improve development, commonality, and delivery of capabilities without negatively impacting individual creativity and innovation.
b. Working closer together and with users.

The Quality of NOAA Data

What does it mean: How "Good" is the data and information from NOAA?

The answer includes documenting the levels of quality assurance (QA) and quality control (QC) processing beginning at the observing site, such as the ASOS and USCRN, to initial quality control done at centers of data, such as the NWS Hydrometeorological Automated Data System (HADS) and the National Data Buoy Center (NDBC), to more robust quality control processes of new and historical (archived) data performed at one of the three NOAA National Data Centers (NNDC). It also means the availability of qualitative information about the observing networks and each observing platform and individual sites covering the entire period of record, often referred to as metadata. A more recent development is the real-time monitoring of observing networks referred to as the "Health of the Network" program. Real time observations go through a rapid review for anomalies which indicate a sensor malfunction or other observing problems. Operational centers are alerted to potential problems before the observing errors become part of the archive and discovered many years later. One example of real time monitoring is the NWS Management Information Reporting System (MIRS). A similar concept of operations is part of the COOP Modernization Plan. The NCDC currently performs real time monitoring of three NOAA observing networks and will expand this program to more networks as part of the Climate Program.

For the purpose of this report "quality of data" is divided into two categories for consideration: Information about Data (Metadata/Station History) and Data Processing.

Information About Data (Metadata)

***Data about Data* -** The value of and confidence in data are greatly diminished if little is known about how the data was collected and processed and the conditions under which the data was measured. Appendix C describes three generally accepted categories of "data about data" typically archived at the three NOAA Data Centers. The working forum participants differed on what constitutes an adequate level of metadata, and what needs to be archived with the observations. A common set of definition remains unresolved and is a challenge.

A minimal level of station history (metadata) data contributes greatly to addressing the NOAA constituents question and concern: "How *good* is the data?" Metadata, coupled with the observations, constitute the long term archive and provide the economic and research value to NOAA data and information. Observations without station history data are always subject to higher levels of uncertainty and risk and lower probability of use and certainty when investing in present and future business and policy ventures.

Network managers often do not define and/or provide the most rudimentary level of documentation about the observing system. Metadata standards, such as the FGDC and ISO 19115, do not describe what information needs to be collected as metadata for a particular observing system. They only provide a framework for organizing metadata once it has been collected. Each observing network must specify the particulars of the metadata required and a general taxonomy should be established. Several levels of metadata, as well as how rapidly they change, should be considered. Slowly changing metadata are often referred to as "static", while metadata that needs to be transmitted with every data packet is referred to as "dynamic". For examples of complete taxonomies of metadata, refer to the EOSDIS documentation. A generic taxonomy can be found in the Open Archive Information System reference model (http://ssdoo.gsfc.nasa.gov/nost/isoas/ref_model.html) recently adopted as ISO 14721. Another reference source available is Guidelines on Climate Metadata and Homogenization, WMO Technical Document No. 1186 (also WCDMP No. 53), December 2003. Go to: (http://www.wmo.ch/web/wcp/wcdmp/html/wcdmpreplist.html)

The National Operational Hydrologic Remote Sensing Center (NOHRSC) provides a real world example of the extreme measures that are required to assemble both observations and the associated metadata. A user of a wide variety of surface observations, the NOHRSC continuously scours as many as 43 different databases (NOAA/NWS 28, other federal 7, international 3, state and local 8) for metadata (primarily longitude and latitude) associated with observations distributed over NOAAPort. During the first six months of CY 2004, 1,950 different reporting stations distributed observations across NOAAPort for which the NOHRSC could not find the metadata. During the same period, the NOHRSC was consequently unable to use 2,451,864 critical observations reported by the mystery stations because the metadata were not available. Frequently the same reporting stations are referenced in multiple databases with conflicting metadata (e.g., lat/long). Each year NOHRSC spends approximately 2 person-months simply trying to identify and update the metadata for more than the 20,000 surface reporting stations that the office uses in producing its operational snow products. From the director: "That time would be much better spent improving the quality of the snow products if the metadata for all surface observing systems were organized in a single, coherent, internally consistent, accurate, current, and readily accessible metadata database."

Three principal factors currently contribute to a negative impact on the level of NOAA documentation and access to station history associated with current NOAA observations and observing systems. These are:

1. *Lack of NOAA defined minimum metadata (station history) requirements to include adoption of standards.*
   The extent and level of detail of station history is often determined by the purpose of the observing system and the network managers. An "ad hoc" approach to documenting station history limits the potential value of observations and information, such as model predictions and projections. The inability to resolve data quality issues can forfeit the use of NOAA data due to higher uncertainties (reduced confidence) leading to greater risks to the user.

2. *Lack of an easy and convenient means of reporting and updating metadata.* A successful collaborative effort between NWS and NESDIS (NCDC) produced a web-based station history data entry form (digital data entry and transmitted form replacing the paper form) for the existing COOP network. The web server based form can be accessed and updated remotely from any location via the Internet and electronically submitted to the database manager and network manager for digital review and digital approval. When approved the data are automatically entered into the database. An accompanying relational database, resident at the NCDC, was developed and is easily enhanced to accommodate new fields of information and other observing networks. This database is referred to as the Metadata Integration and Improvement Initiative (MI³). The combination of the web-based form and MI³ is now referred to as the NOAA Stations Metadata System 1. The vision from inception several years ago was to modify (tailor) the COOP web-based form next for USCRN, then ASOS, and ultimately all NOAA observing systems, and expand the MI³ database accordingly and include links to digital photographs and satellite imagery for each station. The attributes of the web-based form and associated database are easily transportable to non-NOAA observing systems.

3. *No centralized NOAA comprehensive metadata (station history) database.* There are many stories of how much time and effort is expended gathering (or developing) the minimum level of metadata to facilitate simply placing observations on-line for direct user access. One example was the creation of station history for AWOS sites, done through the manual search of many different paper documents. Tom Carroll's NOHRSC story was told above. Joe Facundo, NWS, MIRS operations is another example. Refer to Appendix C for some links to a few current station history databases.

The NOAA Stations Metadata System 1, station history database structure and web-based digital entry and reporting form, for COOP has been successfully implemented and exercised. It can readily be enhanced and expanded for other NOAA networks to meet the detailed metadata needs of the more sophisticated business and research communities. Direct access to the detailed station history in this database is currently available through http://cdo.ncdc.noaa.gov and http://www.ncdc.noaa.gov/crn.html. Easy and convenient access to NOAA observations and the associated basic metadata information, such as latitude, longitude, elevation, sensors used, etc. are available through NOSA and other on-line portals. NOSA will not archive nor provide the long term data management services required for the detailed metadata and observations required for present and future business and research activities. This responsibility, mandated by legislation, will remain with the NOAA National Data Centers.

There is no need for NOAA network managers and others to expend precious resources (time and intellect) creating and maintaining network based station history databases or users seeking out this data from many individual and disbursed meta-databases.

Recommendations

1. Develop an accepted definition for metadata (station history) relative to NOAA observations. Where suitable use internationally accepted definitions.
2. Define the minimum level of documentation for NOAA observing systems. Where suitable use internationally accepted standards.

3. Document the NOAA definition and minimum standards in the NOAA BOM and make them available through NOSA.
4. Climate and Weather & Water Goal Teams expand the use of the web-based station history digital entry and reporting form and the associated MI³ system for those NOAA observing networks managed under their respective goal and programs.

Challenges

a. Defining different levels of metadata based on how it is used.
b. Establishing a minimum level (a standard) of station history must be defined for all NOAA observing systems. It is recognized that there are unique differences between observing stations installed on land verses those installed in a water and space environment. Therefore, each observing system (land, airborne, water, and space based) will require additional and perhaps unique fields of information specific to the type of observing system.
c. Moving platforms, such as radiosondes, aircraft, and drifting buoys, offer unique location data issues to consider.
d. Space based systems present a unique challenge and require additional thought and consideration.

Data Processing

Traditionally, observations from observing systems have been processed within the context of each observing system and subsequently inventoried, archived, and provided to customers as an observing system data set. Information technology (IT) provides the capability and capacity to reengineer this approach to data processing. Specifically, as customers become more sophisticated in their use of data, they are seeking data sets that incorporate the same observed parameter(s), such as surface air temperature and precipitation, from all the different observing systems. Therefore, NOAA must move toward Integrated Data Processing (IDP) by observed parameter(s) regardless of the source, e.g., the observing system.

Two examples of integrated data processing that merit examination are:

NWS Hydrometeorological Automated Data System (HADS) - 10,500 stations from over 23 national, state, and foreign operated networks participate in the HADS. On a 24/7 continuous basis HADS processes and provides access to more than 34,000 observations in less than four minutes from data receipt, converting a total of 1.5 million observations per day into a standard format. Go to: www.nws.noaa.gov/ohd/hads and hadssystem@gateway2.nws.noaa.gov.

FSL Meteorological Assimilation Data Ingest System (MADIS) – MADIS provides access and visualization capabilities of integrated surface observations including ASOS, COOP, maritime, SAO, and mesonet observations. Go to: http://www-frd.fsl.noaa.gov/mesonet and http://www-sdd.fsl.noaa.gov?MADIS.

An integrated data processing system that applies the same quality control to a specific parameter from ASOS, AWOS, USCRN, COOP, PORTS, Buoys (fixed and drifting), radiosonde sites, ecosystem networks, etc. produces a more uniform, comprehensive data set that has a wider range of applications and improves the confidence level of the QC processed data (along with the associated metadata). Taken to a mature concept, a similar integrated process can be employed to include observations from NEXRAD and satellites for any parameter.

In connection with an integrated data processing system, NCDC has developed an Integrated Surface Dataset (ISD), which includes many of the archived surface-based datasets reported to the Federal Climate Complex (FCC). ISD is a data archive, data format, and an operationally updated dataset. The emphasis thus far in ISD development has been on the U.S. and global hourly data, and some daily parameters. It will continue to be expanded to integrate additional data sources and networks, along with more daily and monthly parameters. ISD offers the advantages of a single "platform" for data processing, quality control, on-line access, and application development and can be applied to any time frequency of data recording and reporting.

At least in the near term, it is unlikely that network specific (e.g., ASOS, AWOS, COOP, USCRN, etc.) quality control (traditional stove pipe) will be discontinued. However, as NOAA's expertise grows with integrated processing, the traditional archive structure may change from (or added to) network specific datasets to Integrated Data Sets comprised of similar parameters from all observing networks, i.e., surface air temperature, surface precipitation, wind speed & direction, relative humidity, SST, ambient noise, etc.) and the associated metadata tags identifying the observing system and access to the essential abbreviated and detailed station history information.

Recommendation
Establish a NOAA strategy to encourage integrated data processing and produce the associated products and services.

Challenge
Identify (develop) an accepted common IDP through which NOAA observations (and eventually others) are processed as part of the tiered NOAA Quality of Services (QoS).

Value of NOAA Observations to the Nation

With the exception of special research observing systems (limited purpose and duration), it is assumed that all other NOAA observing systems produce data and information that has intrinsic and enduring value to the Nation. Therefore, the expectation is that NOAA will provide users with easy and convenient access to and retrieval of NOAA observations and associated metadata. NOAA meets this obligation by operating, under Congressional legislation, designated Federal Records Centers (FRC) that provide long term archive and access to the Nation's environmental observations and data and data from other countries. The responsibilities of the three NOAA National Data Centers (NCDC, NGDC, and NODC) are to preserve the Nation's ocean and atmospheric observations, provide access to these data and information, and conduct assessments using these data.

According to the NOSA team, many observing system managers have not been able to state with certainty whether the observations from their respective systems are archived at one of the three a NOAA Data Centers. Many networks maintain Centers of Data, data storage and access systems (and sometimes metadata information), that are heavily subscribed to by a well defined clientele for specific uses. This arrangement between the NOAA provider and users works are an important level of NOAA's Quality of Service, well suited for immediate operational and short term other uses for those select regions and users most familiar with these NOAA sources of information. However, NOAA data and information have far greater potential uses by a worldwide clientele who may or may not be aware of these Centers of Data. Furthermore, there is typically no long term data management plan or budget for these Centers of Data.

NOAA observations and associated station history data must be electronically submitted in digital format as soon as practical after the observations and/or changes to the station/site are documented. Today's communications capabilities and capacities can provide daily, even hourly, reporting of these observations nationwide, even globally. The three NOAA Data Centers are designed to perform inventories, quality control processing, place data on-line, provide easy and convenient access, and long term stewardship (archive and access) in perpetuity (if required) for all NOAA data and information. These services provide an economy of scales for NOAA, the taxpayers, and customers while making finite resources more available to NOAA system managers and research institutions. Maximizing the services available through the NOAA Data Centers greatly reduces (or eliminates) the possibility of permanent lose of NOAA data, support for the integrated data processing described above can be more effectively managed, and customers, regardless of need and level of expertise, have easy and convenient access to all data and information under the stewardship of NOAA.

Recommendations

1. All NOAA observations and metadata (station history data) of value to the Nation must be delivered in a timely manner to one of the three designated NOAA National Data Centers (NNDC) for long term data stewardship (processing, archive, and access). A Data Management Committee (DMC) under the NOSC has been established to facilitate the process for delivering current and future observations and metadata.
2. Climate and Weather & Water Goal Teams conduct an inventory of their respective NOAA observing networks and determine the status of delivery of observations and metadata to one of the three NNDCs.
3. Climate and Weather & Water Goal Teams establish a priority list and implementation date for those current networks not sending observations and metadata to one of the NNDCs.
4. NOSA maintain a NOAA wide inventory identifying which current NOAA observing systems deliver and do not deliver observations and metadata to one of the three NNDCs. This NOSA database needs to be sortable by system name and goal team.

What is Next?

The concept of a "network of networks" or "systems within a system" are terms used frequently to describe the vision of a global (or national) integrated observing system. The term Global Earth Observing System of Systems (GEOSS) is associated with the Group on Earth Observations (GEO) (http://earthobservations.org). A recent article "Managing Requirements for a System of Systems", Ivy Hooks, Compliance Automation Inc., Journal of Defense Software Engineering, June 2004, is a good article to read regarding issues about integration of systems. This article is posted at: (http://www.stsc.hill.af.mil/crosstalk/2004/08/0408Hooks.html). The NOSC published document, Strategic Directions for NOAA's Integrated Global Environmental Observations and Data Management, July 2004, (http://www.nosc.noaa.gov/) outlines NOAA's vision for an integrated end-to-end observations to archive and access data management enterprise system. The NOAA Observing Requirements Background Paper, also available at the NOSC web site, provides an overview description of the NOAA requirements process.

It is obvious that there are many ongoing integration planning and related activities that NOAA personnel have been and are participating in on a regular basis. The ISOS Plan for ASOS, COOP-M, and USCRN is one. A national and global planning meeting to include across NOAA and international representation, is being planned to address requirements and issues related to an Integrated Upper Air Observing System (IUAOS) that includes the NWS Replacement Radiosonde System (RRS) and a Reference Radiosonde. Most recently the Ecosystem Goal Team has created a NMFS/NOS Line Offices collaborative team to plan and implement the most comprehensive source of biological information on the Nation's Living Marine Resources (LMRs) and their habitats as part of the Ecosystem Observing Program (EOP). The Ecosystem Research Program (ERP) has partnered with the Weather & Water and Climate Goal Teams/Programs to begin integrating biological and non-biological information to fully parameterize ecosystem models and to develop synoptic forecasts using all physical and biological data. Extensively developed plans include the Integrated Ocean Observing System (IOOS) Plan (http://www.ocean.us/) and the U.S. GCOS Plan (http://www-ocean.tamu.edu/GOOS/publications/sw/appendix3.html). There is also the Arctic Ocean Observing System and the Alaskan Ocean Observing System (AOOS) plans.

The wide range of activities presents a serious challenge of coordination and effective use of NOAA personnel and resources. A defined systematic process is needed within NOAA, at the very least to assist Goal Team Leaders, Program Managers, and NOAA LO/SO Staffs.

About Integration

Regardless of the level of the integration being examined, all depend on having the cornerstones, common core functions and information, in place to be successful. NOAA integration activities can be pursued concurrently with the implementing the recommendations described in the above sections. The challenge facing NOAA is how to optimize the value of the investment in the physical and living sciences oriented observing systems for:

Existing observations and observing systems

Future (new) observations and observing systems.

As a matter of course, consideration needs to be given to how the new observation or observing system address one or more of the societal benefits listed at the beginning of this document. The

IWGEO has framed a “characterization of priorities” to include numerical scoring criteria as a function of benefits to society. This may be useful to the NOAA process.

<u>The Short and Near Term Integration View (next 10 years)</u>
Can an additional sensor be added to an existing observing site (regardless of the purpose of the observing network/station)?

Does this require an upgrade to the station (power, data logger, and communications)?

Does a new station need to be installed at an existing site (collocate or replace existing) that delivers enhanced capabilities and capacities while serving multiple requirements (cost benefit evaluation)?

Does a new station need to be installed where none currently exists? How many Goal/Program requirements (societal benefits) can be satisfied by this station, i.e. multi-uses?

<u>The Long Term Integration View (Planning for the future: Beyond 10-15+ years)</u>
What is the future vision and plan to replace existing networks with a more comprehensive, multipurpose “ecosystem oriented” integrated observing system (atmospheric, terrestrial, ocean/bays/Great Lakes, and space) that is more efficient, informative, and cost effective.

All observing systems have common attributes associated with a truly End-to-End Integrated Observations and Data Management System. These are:

1. Measuring physical and biological parameters – The characteristic of the sensor (precision, accuracy, and performance across the range of measurement) are part of the manufacturer’s design of the sensor. The degree of precision and accuracy is determined by the need to be satisfied, typically defined by the Goal Team/Program Manager and the scientific research and operations communities. In the case of biological data, the method used to observe and count, such as fish stocks, mammal migrations, etc., must be well documented.
   <u>This information needs to be documented as part of the Station History database for the station and observing system.</u>

2. Processing and Storing at the observing site – Converting engineering values (voltage/frequency) to Units of Measure (degrees, m/s, ppt, psi, etc.). This is typically determined by the manufacturer. Other processing activities include the sampling rate and how the units of measure are computed, stored, and reported (sample every few seconds, minute, minutes, etc. and averaged to 5- min, 15-min, hourly, compute a wind gust or sustained winds, etc. stored and reported values). Today, this typically is defined by the purpose of the observing system and the intended uses of the data.
   <u>This information needs to be documented as part of the Station History database for the station and observing system.</u>

3. Reporting – A communications issue which may influence the level and volume of recorded, stored, and transmitted measurements.

4. Processing at a collection/storage/dissemination facility (at the station site, the Center of Data, and/or the NOAA National Data Center) - Examples: ASOS and USCRN on site data

loggers process measurements, the National Data Buoy Center (NDBC) and the Air Resources Lab (ARL) perform quality control on buoy and surface solar radiation data respectively prior to delivery of these data to a NOAA Data Center. Date Centers perform various levels of a QC. This information needs to be documented as part of the Station History database for the station and observing system.

5. Ingest, Inventory, Processing, Archiving (long term stewardship), and Access – These are designated data management functions and responsibilities of the three NOAA National Data Centers for NOAA data and information. Typically, NOAA data are archived at one of the three NOAA Data Centers when it has been determined that the data and information has long term value to the Nation and more recently the earth's global climate system. Information regarding the processing (quality control) needs to be documented as part of the Station History database.

6. Production of Products and Services – The "End Game" of the investment in observations is the conversion of NOAA data and information into knowledge and understanding that is useful to and understood by the Public, businesses, researchers, operational users, and policy and decision makers. A "level of confidence" must accompany the NOAA data and information. Station History data greatly enhances the quality and value of the data and information through the documentation of the journey from observations through to the use in forecast models and resultant projections and predictions activities

The July 20-22 NOAA ISOS Working Forum outlined issues for consideration when engaging in discussions and integrated planning activities. Two specific activities are: 1) Integration related action items that can be completed in the short (next 12-14 months) and mid-range (next 18-30 months) and 2) The development and execution of a NOAA Integration of Surface Observing Systems (ISOS) Implementation Plan for three existing NOAA networks, ASOS, COOP, and USCRN. Refer to Appendix D for an outline that could be used during the integration of observing systems planning process. The participants recognize that the outline requires refinement and in the interest of brevity longer detailed lists under the broader issues for consideration are not provided.

Deliverables ("Low Hanging Fruit")

The working group was challenged to identify potential early deliverables with a focus toward the integrated efforts associated with the ASOS, COOP, and USCRN networks. The following Action Items were identified during the July 20-23 ISOS Working Forum. These short and mid term deliverables were identified as "doable" with little or no additional funding, but do require a commitment and in some cases a refocus of priorities. These "low hanging fruit" were selected to demonstrate that a wide range of NOAA activities, as well as several non-NOAA activities, can collaborate to promote and enhance more efficient practices that are cost effective and benefit the Nation and NOAA users.

A. Near Term Deliverable (next 12-24 months)

<u>Action Item/Lead Person</u>	**<u>Due Date</u>**
Integrated Surface Observing Systems (ISOS) Plan (ASOS/COOP-M/USCRN) (Ken Crawford/Tim Ross, NWS lead, NESDIS-USCRN Dave Easterling/Mike Helfert)	Oct '04

Ongoing ISOS Activities: NWS/NESDIS/OAR
(Ken Crawford, Tim Ross, Dave Easterling, Mike Helfert, and Bruce Baker, includes W&W and Climate Goal Teams/Programs)

- USCRN Summit Meeting – Invited NWS (ASOS and COOP-M) to participate.	Sep '04
- Propose establishing an ISOS subcommittee for ASOS, COOP-M, and USCRN under the NOAA Science Advisory Board (SAB). Make the current ad hoc USCRN advisory group a part of the ISOS subcommittee.	Feb '05

- Side-by-side ASOS/COOP/USCRN field configuration of similar sensors.
<u>Outcomes to date</u>:

- COOP Modernization (COOP-M) station will use USCRN surface air temperature, precipitation gauge, and wind speed sensors mounted ~1m above ground, possibly the same aspirated shield to house the temperature and relative humidity sensors.

- Instrument transfer functions between ASOS/COOP/USCRN similar sensors developed and under evaluation. To be formally provided to the scientific and research communities by NLT Oct 2005.

- USCRN and COOP-M (upgrade) adopting ASOS replacement relative humidity sensor.

- Like ASOS, COOP-M will employ wind speed and direction sensor at 10m height. In the future USCRN may also add the 10m height anemometer.

- COOP-M adopting USCRN standards of measurements/sensors, calibration and test facility infrastructure, and to the maximum extent suitable and feasible other procedures, such as site selection, site photographic documentation, display, and access techniques (metadata).

- Demonstration Project (FY 04-05), COOP-M prototype sites collocating with USCRN sites in the New England region.

- Canadian Reference Network will use the USCRN precipitation gauge and surface air temperature sensor with aspirated shield configurations.

- USCRN and Canadian Reference Climate Stations (USCRN/CRCS) are collaborating to implement and operate a North American Climate Reference Network (NACRN) in a manner that sets the standard for quantifying climate variability and change in the Global Climate Observing

System (GCOS) in addition to data management and exchange between Canada and the U.S. Currently, there are two USCRN and CRCS collocated sites one in the USA and one in Canada.

Requirements Documentation:

- NOSA Team provides the Climate and Weather & Water (W&W) Goal Teams with the current goal's observing parameters list currently in the NOSA data base. (Eric Miller) — Nov 04

- NOSA publish and provide access to a NOAA definition of Data Management and Scientific Data Stewardship (SDS). (Eric Miller) — Jan '05

- Climate and W&W present draft definitions for NOAA endorsement for additional terms: "surface" observations, In-situ (to include how it is written: In-situ or *In-situ*, in-situ or *in-situ*), Remote, Metadata and other common terms that facilitate dialog and discussions. (Dace Green – W&W, John Jensen – Climate) — Mar '05

- NOSA provides access to this supplemental NOAA list of terms/definitions. (Eric Miller) — Apr '05

- Climate* and W&W Goal Teams review, update, and deliver their respective Goal Team validated observations parameters list to NOSA. Identify in the list principal (P) and supporting (S) parameters. (Dave Green - W&W, Tom Karl – Climate) — Mar '05
*Refer to Appendix E and the GCOS Second Adequacy Report, April 2003, Table 1, page2 and Appendix 1, (http://www.wmo.ch/web/gcos/Second_Adequacy_Report.pdf), for examples of the Climate parameters list. Also, a review of Appendix E would reveal that there may be missing parameters that are important to Climate, as well as Weather & Water and Commerce & Transportation, such as:

Physical Element	Spatial Domain	Threshold Horizontal Resolution	Threshold Measurement Accuracy	Objective Horizontal Resolution	Objective Measurement Accuracy
Snow cover	CONUS, Hemispheric, Global	CONUS, Hemispheric, Global	Hemispheric	Global	CONUS
Snow depth	CONUS, Hemispheric, Global	1.0 km	5.0 cm	0.1 km	2.5cm
Snow water equivalent	CONUS, Hemispheric, Global	1.0 km	5.0 cm	0.1 km	1.0 cm

- Climate and W&W prioritize the list of respective parameters and deliver the goal team priority list to NOSA. Document the prioritization process and rationale. Not all variables can be a priority 1. (Dave Green – W&W, Tom Karl – Climate) — Apr '05

Decision Support Tools: NOSA (Eric Miller)

- Provide easy and convenient "point and click" NOSA access to decision support information planning aids. — Jan '05
    a. Observing parameters lists (and when available indicating primary and supporting parameters) sorted by the four NOAA Mission Goals.
    b. Merged observing parameters list for the Climate and W&W goals.

c. Observing parameters list identifying priorities for each Goal Team (when available).
d. Alphabetical list by name (ASOS, COOP, SURFRAD, etc.) of each NOAA observing system with the respective parameters identified that are actually being measured. Table format could be useful.
e. NOAA observing systems: Sort by Line Office, Sort by NOAA Mission Goal, and Sort by NOAA program name. Option for a comprehensive table combining the three sorts.
f. Network sort listing which NNDC receives the observations or whether not delivering to a NNDC. Information not currently available. Sort not available until Jan '06

- NOSA provide a listing of NOAA observing networks grouped under the current three categories being examined by NOSA: ISOS, IOOS, and IUAOS. (Eric Miller) Jan '05

- NOSA provide training and instruction on how to maximize the use of the NOSA database information and decision support tools. (Eric Miller) Mar '05

Data Access
- Climate and W&W schedule collaborative "focus group" meeting between at least NOSA, NWS, NOAA Data Centers, and FSL to examine and capitalize on current capabilities and plans. Develop near term plans with specific deliverables for maximizing resources and future developments. (Coordinate: J. Jensen, NCDC) Feb-Mar '05

NOAA Data Quality
- Climate and W&W establish a minimum level of metadata requirements for NOAA observing system within the Climate and W&W Goals/Programs. May '05
(Tim Ross – NWS, Krisa Arzayus – OAR, and Wayne Faas/Howard Diamond – NESDIS/NCDC)

Web-based station history data entry/submission electronic forms. (Tim Ross)
- Modify the COOP web-based metadata digital reporting/submission form. Test and operationally implement for the **USCRN (Dec '04) and ASOS (Feb '05), AWOS (Mar '05)** observing networks. (Note: Requisite modifications for the USCRN have been identified and delivered to the NWS) Mar '05

- FAA ASOS/AWOS would consider using of an easy and convenient method of documenting and reporting station history data at FAA sites. FAA decision forthcoming. Jan '05
(Paul Armbruster, Aerospace Weather Policy and standards Division)

- Develop a priority list and delivery schedule for other NOAA observing systems i.e., PORTS, SURFRAD, Upper Air, NEXRAD, Profiler, Buoys, etc. Jun '05
(Tim Ross with network managers)

- Complete station history updates and submissions with 18 months after a web-based form is provided and the associated database fields are updated. (Network Program Managers)
Note: NWS Training Center has a curriculum in place for training users of the web-based electronic form.

NOAA Comprehensive Station History Database (Wayne Faas/Gus Shumbera - NCDC)

- Climate and W&W goal teams/programs use the NOAA Stations Metadata System 1 — 02/06 '05
Develop the web based form and enhance the MI³ for the **USCRN (Feb '05)**, **ASOS (Jun '05)**/**AWOS (Jun '05).** Participate in the testing of the each new web-based form. Operationally implement concurrently with the form. (Tim Ross – NWS, Gus Shumbera – NESDIS/NCDC and others)

- Enhance the MI³ comprehensive NOAA station history database for each new network and participate in the testing of the each new web-based form. Operationally implement concurrently with the form. (Wayne Faas/Gus Shumbera – NCDC) — As it occurs

- Ensure the MI³ station history database is FGDC compliant to the maximum extent possible. — Sep '05

Integrated Data Processing

(Pete Steurer, Neal Lott, Wayne Faas, Steve DelGreco, USAF and USN FCC reps)

- Incorporate all newly reported surface air temperature and precipitation observations from all ASOS, AWOS, and USCRN stations into the existing Integrated Data Quality Control Processing System. — Sep '05

- Explore inclusion of the above two observed surface met parameters reported by other NOAA observing systems, such as SURFRAD, PORTS, buoys, etc. — Dec '05

- Explore the observations from the COOP-M Northeast Region demonstration project when they become available. — Dec '05

- Incorporate COOP-M observations as stations become operational. — As it occurs

- Develop a list (and order of priority) of networks and future parameters to be incorporated into an integrated data processing system. (In cooperation with the Goal Teams and Program Managers.) — Oct '05

NOAA Data - Where is it?

- Climate and W&W Goal Teams determine which of the three NOAA Data Centers archive the data reported by NOAA observing systems listed under the two goals. (Dave Green – W&W, John Jensen – Climate) — Apr '05

- NOSA complete survey of NOAA observing networks that send observations and metadata to one of the three NNDCs. — Jan '06

- Using the Data Stewardship Committee under the NOSC begin to incorporate missing observing networks (observations that have long term value to the Nation) into the one of the three NOAA Data Centers. A relatively straight forward example (test case) could be the PORTS meteorological observations (Richard Edwing, NOS), not the water level/tides information that are archived in the National Water Level Database. (NOSC Data stewardship Committee and NOAA Observing Network Managers.) — '05-'07

- U. S. Army ASOS stations digitally deliver in near real time observations to the Federal Climate Complex (FCC), Asheville, NC via the USAF AFCCC partnership. (Pam Clark, U.S. Army Research Lab and Jon Whiteside, USAF AFCCC) Jan '05

- U. S. Navy ASOS stations digitally deliver in near real time observations to the Federal Climate Complex (FCC), Asheville, NC. (CDR Ken Schwingshakl, CNMOC and LT Brian Riverbark, FLENUMMETOC, Asheville, NC) Dec '05

B. Potential Others

- Replacement Radiosonde System (RRS) integrated planning meeting of national and international parties of interest.. (Dave Helms – NWS, Dian Seidel, OAR, and others) Early '05

- OFCM assists with developing and facilitates topic specific ad hoc focus group discussions particularly between federal agencies, much like the NWS Lightning detection planning group meetings. (Lt Col Bob Rizzo, Assistant OFCM coordinator/Sam Williamson OFCM Director)

- Address metadata and processing documentation for buoys, (fixed, drifting, coastal and open ocean) to include QC processing performed at the National Buoy Data Center (NBDC) before delivery of data the to the NOAA Data Center, NODC and/or NCDC.
(Paul Moersdorf, Jeff Payne, Richard Edwing, Mike Johnson, John Calder, Data Center reps.)

- Expand the ground truth benchmark site at the EROS Data Center to include more surface based observing systems. Develop experience with correlating satellite surface observations with benchmark. (Mike Crane, EROS Remote Sensing Systems Characterization.)

- NESDIS Satellite Integrate Program Office (IPO) develop with network managers (NOAA, Non-NOAA – multidiscipline atmosphere, land, bio-systems, oceans, etc.) to develop a spatial distribution plan for reference network observations that will optimize the number of surface locations per day that can be used to monitor satellite based sensor performance and provide correlated transfer coefficients to improve the utility and confidence of the satellite ground (surface) measurements. Preferably while identifying sites, such as USCRN and possibly select COOP-M sites.(John Cunningham, NESDIS IPO, EROS Data Center, Reference Quality observing network managers both land and ocean.)

- Examine additional U.S. Army observing system data sources not yet included in the FCC ISD database. (Pam Clark, U.S. Army Research Lab). Some of these data are already included in the FCC ISD historical database and routinely updated, such as stations that transmit METAR and/or synoptic observations. Similar list may exist for the U.S. Navy.

RANGES (http:\\www.atec.army.mil/atec/where_we_are.html)

1. Aberdeen Proving Ground, MD
2. Dugway Proving Ground, UT
3. Yuma Proving Ground, AZ
4. Ft. Greenley, AK
5. White Sands Missile Range, NM

6. Tropics Region Test Center, Panama
7. Redstone Arsenal
8. Ft. Belvoir, VA (?)

Corps of Engineers (COE)

1. Network of surface obs (including soil)
2. Water monitoring (relayed by SATCOM from MS River watershed)

U.S. Army Air Traffic Services (ATS)

1. Some surface obs (Huntsville, AL)
2. ATS mobile towers (data not placed on network

Army TRADOC and FORSCOM

1. ASOS at Ft. Rucker and Ft. Hood, TX
2. Op testing at Ft. Sill and Ft. Bragg

ARTYMET

1. Limited surface obs - local to support MLRS batteries

ARMY RESEARCH ("potential big payoffs")

1. Partnered Univ. Sites
   - CSU (Colorado State University)
   - University of Alaska
   - Physical Sciences Lab (NMSU, New Mexico)
   - Howard University (new)
2. Master Environmental Library (I can provide more info on this)
3. ARL Sources
   - Met data collected at Blossom Point, MD
   - LIDAR
4. Urban Experiments (J2003, etc.)
   - Data sets

APPENDIX A

Climate Monitoring Principles

Effective climate monitoring systems should adhere to the following Climate Monitoring Principles:

1. The impact of new systems or changes to existing systems should be assessed prior to implementation.
2. A suitable period of overlap for new and old observing systems is required.
3. The details and history of local conditions, instruments, operating procedures, data processing algorithms and other factors pertinent to interpreting data (i.e., metadata) should be documented and treated with the same care as the data themselves.
4. The quality and homogeneity of data should be regularly assessed as a part of routine operations.
5. Consideration of the needs for environmental and climate-monitoring products and assessments, such as IPCC assessments, should be integrated into national, regional, and global observing priorities.
6. Operation of historically-uninterrupted stations and observing systems should be maintained.
7. High priority for additional observations should be focused on data-poor regions, poorly-observed parameters, regions sensitive to change, and key measurements with inadequate temporal resolution.
8. Long-term requirements, including appropriate sampling frequencies, should be specified to network designers, operators and instrument engineers at the outset of system design and implementation.
9. The conversion of research observing systems to long-term operations in a carefully-planned manner should be promoted.
10. Data management systems that facilitate access, use, and interpretation of data and products should be included as essential elements of climate monitoring systems.

Furthermore, satellite systems for monitoring climate need to*:*
a. Take steps to make radiance calibration, calibration-monitoring and satellite-to-satellite cross-calibration of the full operational constellation a part of the operational satellite system; and
b. Take steps to sample the earth system in such a way that climate-relevant (diurnal, seasonal, and long-term interannual) changes can be resolved.
Thus satellite systems for climate monitoring should adhere to the following specific Satellite Climate Monitoring Principles:

1. Constant sampling within the diurnal cycle (minimizing the effects of orbital decay and orbit drift) should be maintained.
2. A suitable period of overlap for new and old satellite systems should be ensured for a period adequate to determine inter-satellite biases and maintain the homogeneity and consistency of time-series observations.
3. Continuity of satellite measurements (i.e. elimination of gaps in the long-term record) through appropriate launch and orbital strategies should be ensured.
4. Rigorous pre-launch instrument characterization and calibration, including radiance confirmation against an international radiance scale provided by a national metrology institute, should be ensured.
5. On-board calibration adequate for climate system observations should be ensured and associated instrument characteristics monitored.
6. Operational production of priority climate products should be sustained and peer-reviewed new products should be introduced as appropriate.
7. Data systems needed to facilitate user access to climate products, metadata and raw data, including key data for delayed-mode analysis, should be established and maintained.
8. Use of functioning baseline instruments that meet the calibration and stability requirements stated above should be maintained for as long as possible, even when these exist on de-commissioned satellites.
9. Complementary *in situ* baseline observations for satellite measurements should be maintained through appropriate activities and cooperation.
10. Random errors and time-dependent biases in satellite observations and derived products should be identified.

APPENDIX B

Examples of Community Software Management, Analysis, and Visualization Tools

Community software management for end-to-end CM
The BigSur System (Science Tools Corporation) supports users by leveraging existing resources to provide a comprehensive scientific knowledge platform, unifying a scientific enterprise, connecting researchers throughout the world, and aiding comprehensive access by the public.

File Management
OPeNDAP has developed a software framework that simplifies all aspects of scientific data networking, allowing simple access to remote data regardless of local storage format. Existing, familiar data analysis and visualization applications can be transformed into clients. OPeNDAP allows files to be opened, closed, and manipulated for analysis and visualization using a URL. NetCDF and HDF files are to fully utilize OPeNDAP tools. Earth Science Markup Language (ESML) can be used to convert proprietary formats (e.g., satellite specific level 1b formats) into OPenDAP readable files and thus open up all NOAA's data sets to the public.

Semantics
Existing semantic standards UDUNITS and CF naming conventions set by Unidata working groups are available now. Semantic web trials being conducted, may not be ready for another five years.

Analysis and Visualization
OPeNDAP enabled tools can provide much of the current analysis and visualization needs.
The GrADS Data Server (GDS), formerly known as GrADS-DODS Server, is a stable, secure data server that provides sub-setting and analysis services across the internet and makes local data accessible to remote locations. The GDS unifies GRIB, Binary, NetCDF, HDF, BUFR, and GrADS data formats. The GDS sub-setting capability allows users to retrieve a specified temporal and/or spatial sub-domain from a large dataset, eliminating the need to download everything. The GDS analysis capability allows users to retrieve the results of an operation applied to one or more datasets on the server. Examples of analysis operations include basic math functions, averages, smoothing, differencing, correlation, and regression.

Unidata IDV - The Integrated Data Viewer (IDV) from Unidata is a Java(TM)-based software framework for analyzing and visualizing geoscience data. The IDV brings together the ability to display and work with satellite imagery, gridded data, surface observations, balloon soundings, NWS WSR-88D Level II and Level III RADAR data, and NOAA National Profiler Network data, all within a unified interface.

Ferret LAS - The Live Access Server (LAS) is a highly configurable Web server designed to provide flexible access to geo-referenced scientific data. It can present distributed data sets as a unified virtual data base through the use of DODS networking. Ferret is the default visualization application used by LAS, though other applications (Matlab, IDL, GrADS).

APPENDIX C

"Data about Data"

Generally, "data about data" can be considered as one of three types.

Metadata	
	Data about data, i.e., Data that describes the content, quality, condition, and other characteristics of data. Metadata files carry documentation about data sources, types of measurements made, how the measurements are taken and recorded, the sensors and sensor characteristics, sensor configurations, sensor calibration, processing algorithms and methodologies, surrounding conditions at the site, and other information that are important to the quality use of the data. Although metadata files typically contain similar types of information, they also contain observing network specific information. The Federal Geographic Data Committee (FGDC-STD-001-1998) sets standards utilized in creating and managing metadata.
Auxiliary Data	
	Data that supports other data. Examples include constants and calibration parameters, time correlations, earth pointing, and satellite orbital parameters.
Ancillary Data	
	Data that relates data to other data improving the utility of many data sources and accounting for differences in observed values. For example, this is information that would allow satellite data to be blended with in-situ data (spatial and temporal correlations). It provides a means to compare observations between different observing systems using instrument and geographic separation transfer functions.

Examples of metadata sites/databases:
NWS COOP Density Database: POC: Ken Crawford/Dave Helms
Contains ASOS, COOP, RAWS, SNOTEL, GCOS, and AWS station metadata
http://nwshqgis.nws.noaa.gov/website/coop/viewer.htm

NWS Management Information Reporting System (MIRS): POC: Joe Facundo/NWS
Contains ASOS (NWS, FAA, USAF, and Navy) and AWOS, official ASOS metadata change management database for NWS http://www.mirs.nws.noaa.gov/mirsweb/

METAR Management Database: POC: Howard Diamond/NESDIS
Contains ASOS http://metar.noaa.gov

Data Collection Platform (DCP) HADS Processing: POC: Larry Cedrone/NWS
Contains DCP stations decoded for hydrologic applications http://www.nws.gov/ohd/hads

Meteorological Assimilation Data Ingest System (MADIS): POC: Patty Miller/FSL
Contains over 20 mesonet's metadata including real-time quality control.
http://www-frd.fsl.noaa.gov/mesonet/

APPENDIX D

Outline of a Generalized ISOS Planning Guideline

- Establish a Vision
- Establish a framework for NOAA managers for planning and evaluating integration of observing systems.
- Objectives:
    - reliable
    - accurate
    - timely (real time; near-real time)
    - representative for intended use
    - accessible
- Requirements
    - Relationship to the NOAA List of requirements/variables
    - Relationship to Societal Benefits
    - Relationship to NOAA Goals and Programs
    - Relationship to other national and international observations and/or observing systems (as applicable)
- Current Status
- 100% Requirement (Include Benefits to Society)
- Gap Analysis (Commonalities and Deltas)
- Blueprint for Closing Gap
    - Priorities and Milestones
    - Performance Measures and Outcomes (linked to societal benefits)
- Implementation Strategy
    - Cost Estimates
    - Cost Benefits Analysis (Is it worth doing?)
    - Schedules
- Governance

<u>Bullets for Current Status, 100% Requirement, and Gap Analysis</u>

- Requirements process
    - Is there one?
    - What should it be?
- Science and Technology Infusion:
    - Available studies to draw upon?
    - What is the science capability needed to support IOS?
- Standards (existing, planned, adherence)
    - Are there any standards to adopt?
    - Are there NOAA approved standards?
    - Are the NOAA Observing systems complying?
- Network Design (physical location of stations relative the 100% solution)
    - Is it optimally sited?
    - Is this validated?
- Physical Characteristics (site selection, instrumentation)
- Metadata: Interoperability between systems, collection, archive, and access, calibration and transfer functions
- Data collection, Ingest, Archive, and Access
- Quality Assurance (network health) approaches
- Database Architecture
- Maintenance and System Monitoring (e.g. AOMC)
- Use of NOAA Enterprise IT (communications, computing)
- Product Development
- Product Distribution

APPENDIX E

Climate Related Parameters

State and feedback variables required for the major components of climate observations and analysis. Parenthesis, (I/S) denotes measurements made by **I**n-situ and Remote (**S**pace-based) instruments.

STATE VARIABLES (PARAMETERS)	FEEDBACK VARIABLES
(1) ATMOSPHERE	
• wind (I/S)	
• upper air temperature (I/S)	• land surface soil moisture/temperature (I/S)
• surface air temperature (I/S)	• land surface structure and topography (I/S)
• sea level pressure (I)	• land surface vegetation (I/S)
• upper air water vapor (I/S)	
• surface air humidity/wv (I/S)	• evaporation and evapotranspiration (I/S)
• precipitation (I/S)	• snow/ice cover (I/S)
• clouds (I/S)	• SW and LW radiation budget - surface (I/S)
• liquid water content (I/S)	• solar irradiance & SW/LW radiation budget (S)
(2) OCEAN	
• upper ocean currents (I/S)	• ocean surface wind & wind stress (I/S)
• sea surface temperature (I/S)	• incoming surface shortwave radiation (I/S)
• sea level/surface topography (I/S)	• downwelling longwave radiation (I/S)
• sea surface salinity (I/S)	• surface air temperature/humidity (I/S)
• sea ice (I/S)	• precipitation (fresh water/salinity flux) (I/S)
• wave characteristics (I/S)	• evaporation (I/S)
• mid and deep ocean currents (I)	• fresh water flux from rivers & ice melt (I/S)
• sub-surface thermal structure (I)	• CO2 flux across the air sea interface (I)
• sub-surface salinity structure (I)	• geothermal heat flux - ocean bottom (I)
• ocean biomass/phytoplankton (I/S)	• organic & inorganic effluents (into ocean) (I/S)
• sub-surface carbon (I), nutrients (I)	
• sub-surface chemical tracers (I)	
(3) LAND & WATER (NON-OCEAN)	
• topography/elevation (I/S)	• incoming shortwave radiation (I/S)
• land cover (I/S)	• net downwelling longwave radiation (I/S)
• leaf area index (I)	• fraction of absorbed photosynthetically active radiation
• soil moisture/wetness (I/S)	• surface winds (I)
• soil structure/type (I/S)	• surface air temperature & humidity (I/S)
• permafrost (I)	• albedo (I/S)
• vegetation/biomass vigor (I/S)	• evaporation & evapotranspiration (I/S)
• water runoff (I/S)	• precipitation (I/S)
• surface ground temperature (I/S)	• land use & land use practices (I/S)
• snow/ice cover (I/S)	• deforestation, (I/S)
• sub-surface temp & moisture (I/S)	• human impacts - land degradation (I/S)
• soil C,N,P, nutrients (I)	• erosion, sediment transport (I/S)
• necromass (plant litter) (I)	• fire occurrence (I/S)
• sub-surface biome/vigor (I)	• volcanic effects (on surface) (I/S)
• land use (I/S)	• biodiversity (I/S)
• ground water (& subterranean flow) (I)	• chemical (fertilizer/pesticide & gas exchange) (I)
• lakes and reservoirs (I/S)	• waste disposal & other contaminants (I)
• rivers and river flow (I/S)	• earthquakes, tectonic motions (I/S)
• glaciers and ice sheets (I/S)	• nutrients and soil microbial activity (I)
• water-turbidity, N, P, dissolved O (I/S)	• coastal zones/margins (I/S)