J3.3 NETWORK OF WEATHER AND CLIMATE OBSERVING NETWORKS (NOWCON)

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ABSTRACT

Society increasingly demands weather and other environmental information on a fine spatial scale, and environmental modelers and applications scientists have significantly improved our ability to generate products meeting these demands. However, observations on which to base fine-scale numerical models and other applications are often not available because they are not taken on the appropriate scale or those that are do not make it into appropriate databases. The recent National Research Council report, "Observing Weather and Climate from the Ground Up: A Nationwide Network of Networks," addressed this issue and provided recommendations on integrating various networks.

The Office of the Federal Coordinator for Meteorological Services and Supporting Research (OFCM), through its Committee for Integrated Observing Systems (CIOS), is working with the federal agencies to establish the Network of Weather and Climate Observing Networks (NOWCON). The goal of the NOWCON is to develop a federal strategy to integrate disparate observing systems to meet multiple national needs in a cost-effective manner and to provide an organizational framework for coordination, integration and interoperability. The group has identified steps needed to network the existing networks of mesoscale observations into an integrated, flexible, adaptive, and multi-purpose national mesoscale network. This approach enables observations to be readily available for weather and climate prediction and for use by multiple clients for both operations and research in functional areas such as energy security, public health and safety, transportation, water resources, food production, and other relevant sectors.

This paper reviews CIOS work done thus far and presents the committee's approach to implementing NOWCON.

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1. INTRODUCTION

In late 2008, the National Research Council completed a study of mesoscale weather observing resources and requirements in the United States and published the report, *Observing Weather and Climate from the Ground Up—A Nationwide Network of Networks* (NRC 2009). The study considered the current state of mesoscale networks in the US and the broad requirements for mesoscale observations. Noting that most of those requirements are not being met, the authors made a series of wide-ranging recommendations to fill the gaps. Addressing these recommendations presents a significant challenge to the nation's weather and climate enterprise.

Shortly after the release of the NRC report, representatives of the National Weather Service (NWS) met with OFCM staff to begin the process of formulating and executing a federal response to the report. That federal response is called NOWCON, for Network of Weather and Climate Observing Networks.

This paper presents a review of the NRC report (the challenge) and summary of actions taken and under way by federal agencies to address that challenge (the response).

The basic statistical analysis has been completed, and a high-level look at the results of that analysis is presented here.

2. THE CHALLENGE

The report described the current mesoscale observing situation in the US as "energetic and chaotic," and suggested that we should

- Find a way to make better use of existing mesoscale observations
- Augment the current observations to fill the gaps
- Provide an organizational framework to oversee the effort across the weather enterprise

The ultimate goal would be to create a network of networks serving multiple applications, jointly

provided and used by government, industry, academia, and the public. Multiple applications include monitoring and prediction of weather and climate, energy security, public health and safety, transportation, water resources, and food production, as well as support to research.

2.1 Key Needs

In terms of filling the gaps, the study pointed out that in addition to "spatial gaps" (i.e., data from conventional weather sensors is not available on a fine enough scale), parameter gaps exist. Parameters for which the greatest need and for which some need exists were articulated as follows:

- Most needed:
  - Height and structure of planetary boundary layer
  - Soil moisture and temperature profiles
  - High resolution vertical profiles of humidity
  - Air quality and related chemical composition (carbon monoxide, sulfur dioxide, ozone, and particulate matter <2.5μ) above the surface layer
- Also needed:
  - Direct and diffuse radiation
  - High vertical resolution profiles of wind and temperature
  - Sub-surface temperature profiles (e.g., under pavement)
  - Icing near the surface
  - Surface turbulence parameters

2.2 Recommendations

The report articulated 15 recommendations to meet the goal of creating a network of networks serving multiple applications. In particular, Recommendation 2 called for the identification of a centralized authority to provide core services to support the network of networks, and it listed 13 core services the NRC committee considered most crucial to success. Figure 1 provides a summary of the 15 recommendations. See the NRC study for a more complete explanation of these recommendations. Figure 2 lists the 13 core services associated with Recommendation 2.

The NRC committee went to significant effort to lay groundwork for responding to Recommendation 7, investigating options for an organizational structure for the initiative and dedicated an entire chapter of the report to "organizational attributes and options." After considering eight specific candidate organizational structures representing various combinations of federal, industry, and non-profit entities as well a "seeded viral" ap-

NRC Network of Networks Study Recommendations

1. Stakeholders develop and implement plan
2. Identify centralized authority (core services—see Figure 2)
3. Require Metadata
4. Develop architecture
5. Accommodate research and education
6. Employ testbeds
7. Establish organizational structure
8. Deploy lidars/RF profilers
9. Observe chemical weather
10. Observe soil moisture
11. Employ collaborative-adaptive sensing
12. Improve geostationary observations of the boundary layer
13. Augment transportation observations to provide WMO parameters
14. Implement VII (IntelliDrive)
15. Conduct end-user assessments

Figure 1. Summary of NRC Network of Networks Recommendations.

Network of Networks Core Services Associated with Recommendation 2

- Define standards for observations in all major applications
- Define metadata requirements
- Certify data for appropriate applications
- Conduct periodic "rolling review" of requirements
- Define/implement communications pathway
- Design/implement data repository
- Generate limited set of products
- Provide pointers to more sophisticated products
- Provide pointers back to data providers
- Establish like to NCDC for archival
- Provide tools and connectivity for searches, data mining, bulk data transmission
- Provide tools for default and custom network data configuration
- Provide data quality control service

Figure 2. Core Network of Networks services to be provided by centralized authority.

proach, they recommended either a publically or privately chartered non-profit corporation. As an example, they invited consideration of a "Corporation for Environmental Monitoring" modeled after such organizations ad the Corporation for Public Broadcasting.

3. THE RESPONSE

In the Spring of 2009, OFCM began working with the NWS to lay the groundwork for a federal response to the NRC network-of-network challenge. It was clear that NWS had a large stake in promoting the network-of-network concept, but how other federal agencies would be involved, and in what way, was less clear.

3.1 Committee for Integrate Observing Systems (CIOS) Foundational Meetings

To inform the agencies of the network-of-network initiative and consider the potential for their involvement, OFCM convened two "foundational meetings" of CIOS, which was refocused on responding to the NRC report. During these meetings in May and July 2009, agencies were invited to discuss the state of environmental observing within the agency, what observations they leverage from other organizations, unmet observing needs, and, especially for those agencies that do not take observations, the importance of the weather observations taken by other organizations. Over the course of two meetings, participants heard input from 22 organizations representing eight departments and two agencies (Figure 3). Although all participants showed an interest in cooperating at some level consistent with their missions and needs, the excitement and level of commitment varied considerably based on the potential usefulness of leveraging observations that are not currently available. In any case, it was clear that the basis existed for moving forward with a coordinated federal response to the NRC challenge, and the name Network of Weather and Climate Observing Networks (NOWCON) was coined for the federal response.

Federal Agencies Presenting Agency Information at CIOS Foundational Meetings

- Department of Commerce/NOAA:
  - National Weather Service
  - Office of Oceanic and Atmospheric Research
  - US Group on Earth Observations
  - Integrated Ocean Observing System
- Department of Defense:
  - US Navy
  - US Air Force
  - US Army Corps of Engineers
- Department of Homeland Security
  - Office of Science and Technology
  - Customs and Border Protection
  - US Coast Guard
- Department of Transportation
  - Federal Aviation Administration
  - Federal Highway Administration
- Department of the Interior
  - US Geological Survey
  - US Bureau of Reclamation
  - National Park Service
  - Bureau of Land Management
- Department of Agriculture
  - Office of the Chief Economist
  - US Forest Service
- Department of Health and Human Services
  - Centers for Disease Control and Prevention
- Department of Energy
- Environmental Protection Agency
- National Aeronautics and Space Administration

Figure 3. Twenty-two federal agencies brief the CIOS foundational meeting on their interest in mesoscale observations..

3.2 CIOS Working Meetings

Having established agency interest in pursuing a federal response to the NRC Network of Networks report, CIOS transitioned from foundational meetings to working meetings, the first two of which were convened in September and November 2009.

3.2.1 Federal Responsibility for Addressing Recommendations

The first step was to understand in some detail the recommendations of the NRC committee and consider the role of the federal government in addressing them. Toward this end, the CIOS members reviewed each recommendation and determined among the various potential players (federal government, state/local government, industry, academia, individuals, non-

governmental organizations) what role each might take in acting on the recommendation. Potential roles were lead, co-lead, collaborate, and support. Because of resources, infrastructure responsibilities, agency mission, breath of reach, available expertise, and other considerations, the CIOS members determined that the federal government should play a lead or co-lead role in responding to most of the recommendations. It was clear, however, that successfully addressing most of the recommendations would require the participation of several sectors across the weather and climate enterprise.

3.2.2 Engaging Non-federal Players

OFCM's mission to is to provide infrastructure for interdepartmental cooperation and to support, coordinate, and facilitate that cooperation. Because of the broad and deep involvement expected of non-federal players in the Network-of-Networks initiative, it was deemed necessary to deliberately consider an approach to engaging those players. The AMS *Ad Hoc* Committee on Nationwide Network of Networks was an obvious vehicle to interface with the broader weather community. Indeed, the chairman of the AMS Committee had been participating in the CIOS meetings. Detailed protocols for working with the AMS Committee and it's subordinate working groups have not been worked out (and may not, in fact, be necessary). However, CIOS agreed on the general approach of continuing to exchange members at the committee level (the Federal Coordinator serves on the AMS committee along with several other federal representatives), inviting selected AMS working group chairs to CIOS meetings, and connecting subordinate groups (AMS working groups and CIOS joint action groups) with similar charters so that they can consider coordinating and collaborating on their work.

3.2.3 CIOS Goals and Priorities

Having carefully considered and discussed each of the 15 recommendations, the CIOS members established their goals for the next several years and prioritized them to help create timelines for the work. The first goal, to be addressed within the next two years, is to integrate existing mesoscale observing systems/ networks. This effort involves the following actions:

- Developing an observing network inventory of existing inventories
- Facilitating architecture and data management standards
  - Coordinating metadata standards for observations
  - Establishing a framework for interoperability and sharing
- Developing an approach to quality assurance
- Exploring opportunities for an interoperability integration pilot project
- Developing approaches for cooperation with non-federal stakeholders

As we pursue these actions to "harvest the low-hanging fruit," work will start on addressing the second goal: to explore gaps, opportunities, and technologies for improving mesoscale monitoring/prediction. This goal, to be accomplished within the next three years, lays the groundwork for addressing the third goal: to develop justification and a framework for cooperation, and collaboration, and investment in observing systems. Completing this effort, in conjunction with similar work by non-federal collaborators, would set the weather enterprise on a course to significantly enhance the availability and usefulness of mesoscale observations in the coming years.

3.2.4 Next Steps

In order to start work on the first goal, the CIOS members asked OFCM to establish two subordinate joint action groups (JAGs). These groups would be composed of subject matter experts from the participating agencies and exist until work is completed on the particular action for which they were formed.

Metadata JAG. The first JAG is focused on metadata, and is charged with surveying existing metadata practices and developing a flexible metadata specification that can serve all types of NOWCON data. If it is determined to be impracticable to derive one specification for this purpose, the group will attempt to develop a family of related specs based on the same underlying philosophy and constructs. JAG members have been asked to consider such issues as the architectural aspects of associating metadata with the data; redundancy and managing storage, bandwidth, and processing requirements; and implementation schemes.

Architecture and Data Management JAG. The second JAG will address two related tasks. They will survey current architecture and data

management practices, investigate options, and develop a concept that will result in a flexible and extensible infrastructure that supports NOWCON as it evolves. In addressing architecture, JAG members have been asked to consider how metadata is managed (coordination between JAGs will be necessary); impacts on bandwidth, throughput, responsiveness, and rapid accessibility; and security, extensibility, and cost. In addressing data management constructs, JAG members have been asked to consider the advantages and disadvantages of aggregating data, a potential mixture of centralized and distributed data storage, the challenges of achieving cooperation and standardization from diverse data hosts, protection of proprietary data, and responsive discovery and access of data and metadata.

3. SUMMARY

OFCM's Committee for Integrated Observing Systems (CIOS) has been refocused on coordinating a federal response to the NRC's Network of Networks report, and is moving forward with the initiative, referred to as the Network of Weather and Climate Observing Networks (NOWCON). To promote a coordinated effort across the weather enterprise, CIOS is working with the AMS *Ad Hoc* Committee on Nationwide Network of Networks to engage the academic, industry, and other key sectors. Initial steps involve making existing observations available to multiple users by addressing metadata and infrastructure issues.

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