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REPORT IN BRIEF

Toward an Integrated Arctic Observing Network

Rapid changes in the arctic region—due to climate change, pollution, and other factors—are having social and environmental impacts both regionally and globally. To understand and respond to these changes, it is essential that observational records be relatively complete. However, the current observing network and long-term records are patchy and inadequate. A new arctic observing network should be developed that delivers more complete pan-arctic observations.

The arctic region is undergoing rapid changes. Pollution and social changes are taking a toll, as are climate-related changes that have attracted recent international attention. Increases in mean surface air temperatures have been pronounced in the higher latitudes, with associated widespread changes. Sea ice extent and thickness, as measured by satellites, have been at historic lows in the last 5 years. Examples of other changes include a longer growing season in Scandinavia, a two-fold increase in wildfires in Canada and Alaska since the 1970s, and a doubling of burned acreage in Russian boreal forests since the 1990s.

These changes have both local and global consequences. Drying soils and warming temperatures are increasing the prevalence of shrubs over tundra, which in turn creates more warming because dark vegetation traps more solar energy. Reduction in sea ice extent may expand shipping, fishing, and oil extraction opportunities, but could be devastating for polar bears, seals, and subsistence hunters. Melting glaciers, ice caps, and the Greenland Ice Sheet contribute to sea level rise, which threatens coastal communities around the world.

Given that these and other changes are rapid and have regional and global significance, and because they are expected to continue, it is vital to have observational records that are sufficiently complete to both understand what is happening and guide decision makers in responding to change. Unfortunately, the Arctic only has a limited record of observations and those available are often few and far between, short-term, and not coordinated with related observations. With the current infrastructure, it is difficult to describe current conditions in the Arctic and their connections to the rest of the Earth system, let alone to anticipate, predict, and respond to future changes.

At the request of the U.S. National Science Foundation, this report explores the potential scope, composition, and implementation strategy for an arctic observing network (AON) that could serve to better measure arctic change. The report envisions a network built on existing national and international efforts that would deliver accessible, complete, reliable, timely, long-term, pan-arctic observations. The system would be an observational infrastructure—including satellites, terrestrial observatories, ocean buoys and moorings, weather stations, hydrologic monitoring stations, ecological sampling networks, arctic residents, and other data sources—that will collect, check, organize, and distribute arctic observations while taking the necessary measures to continuously adapt and improve the network.

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Limitations with Current Arctic Observations

Despite the long history of arctic observations, long-term records are incomplete, and there are measurement gaps in all domains. It is also difficult to compare data across disciplines. Many voids exist because measurement programs are inadequate or because of technological limitations created by the harsh conditions and remoteness. In addition, some areas have lost measurement capabilities as gauges and observatories have been decommissioned due to lack of resources. Declines in surface-based observations erode the capability to validate satellite imagery, thus also undermining the usefulness of that data source.

Many of the observational data that do exist come from specific research projects that collected data in limited areas for short periods of time. As such, continuity in time and space is rarely the result of a larger plan. Most existing science planning efforts address specific questions, processes, time scales, or regions, and they gather just the data needed for the specific project. The overlay of a comprehensive AON

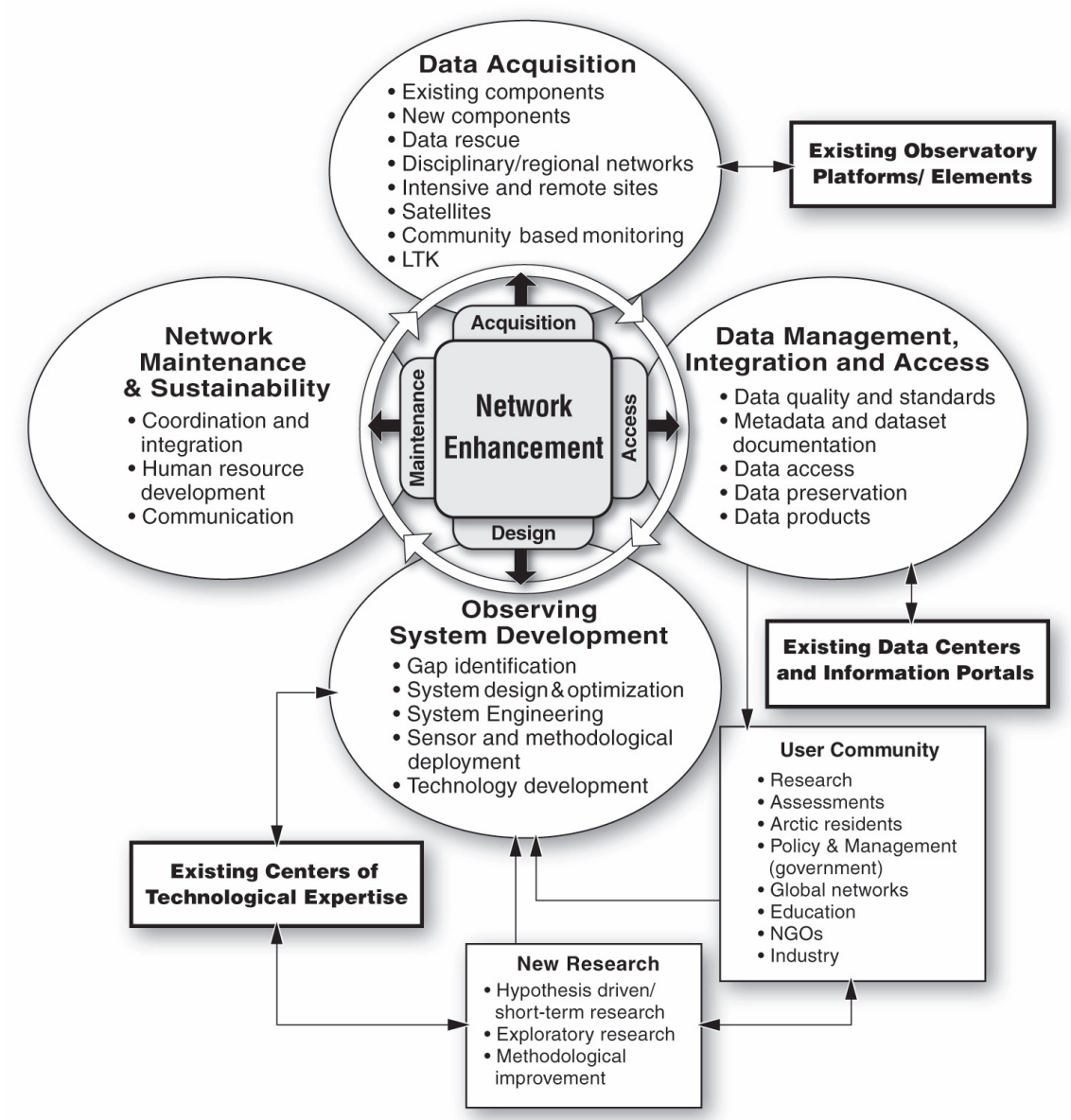

Figure 1. This flow diagram shows how the four essential functions of the AON (large ovals) relate to each other and the broader stakeholders. The direct connection of AON functions to the stakeholders indicates that the AON builds on and enhances existing capabilities. The placement of network enhancement at the center of the diagram and its connectivity to all elements of the network shows how the AON plays an central role in tying together many existing components, strengthening ties among observation platforms, data centers, and users, and generally supporting and enhancing observing activities of all participants. Graphics by N. Hulbirt and B.G. Bays, jr, University of Hawaii.

could supply the wide-area, long-term observations needed to track the state of the Arctic and understand how the system functions as part of the global environmental system.

Building the New Arctic Observing Network

An integrated, complete, dynamic, and multidisciplinary environmental observing network will improve society's understanding of and ability to respond to ongoing systemic changes in the Arctic and its capability to anticipate, predict, and respond to future change both in the Arctic and around the globe. The data flowing from this network could contribute to a wide range of programs and activities, including research studies, decision-support tools, and integrated environmental assessments that help decision makers understand what is happening and, as appropriate, adopt adaptation and mitigation measures.

Recommendation 1: An arctic observing network should be initiated using existing activities and with the flexibility and resources to expand and improve to satisfy current and future scientific and operational needs. In its initial phase, the network should monitor selected key variables consistently across the arctic system.

A number of important internationally coordinated efforts with relevance to observing the arctic system are being planned for the International Polar Year 2007-2008 (IPY). During the IPY, there will be a burst of new and intensive monitoring for a two-year period that will help jump-start the AON. Experience, knowledge, and infrastructure gained through the IPY could advance the AON beyond its existing core components (e.g., Arctic Monitoring and Assessment Programme, Co-operative programme for monitoring and evaluation of the long range transmission of air pollutants in Europe, International Arctic Buoy Programme, International Tundra Experiment, etc). Several emerging activities provide timely opportunities to enhance and better coordinate the AON because they offer access to international partners and capabilities. These include the Global Earth Observation

Box 1. General Recommendations that Relate to Network Implementation and Operation

Recommendation 3.1a: A system design assessment should be conducted within the first two years of AON development—that is, as a component of IPY—to ensure a pan-arctic, multidisciplinary, integrated network. This effort should be undertaken by a diverse team, with participation and input from multiple disciplines, stakeholder groups, and those involved in related international observing activities. The assessment should use existing design studies, models, statistical approaches, and other tools.

Recommendation 3.1b: The AON should be continuously improved and enhanced by taking advantage of the findings and recommendations in the system design assessment and performance metrics and data provider and user feedback that will become an enduring feature of the network.

Recommendation 3.2a: The first phase of AON development will require sustaining existing observational capabilities (including those under threat of closure) and filling critical gaps.

Recommendation 3.2b: The AON should support development, testing, and deployment of new sensors and other network-related technology. In parallel with recognizing the importance of systems engineering and instrument validation and calibration, this will require supporting (i) expert groups to track advances in technology that satisfy overarching network needs and (ii) centers of excellence and a technology incubator program to adapt and develop needed technology.

Recommendation 3.3: A data management system initially built on existing data centers and resources must be designed and implemented immediately by an AON data management committee to support major functions of the network. This system should be accessible through a single portal that connects data across disciplines and themes and should seamlessly link information from arctic sensors, historical datasets, and researchers and other users across space and time.

Recommendation 3.4a: For the AON to realize its potential, long-term, coordinated, international resources and efforts should be dedicated to sustaining observing platforms, providing incentives for contributions to the network, network coordination and integration, communication, and human resource development.

Recommendation 3.4b: Arctic residents must be meaningfully involved in the design and development of all stages of the AON. From the outset, the system design assessment should cultivate, incorporate, and build on the perspectives of human dimensions research and arctic residents. The AON must learn what is needed to facilitate the involvement of local communities and create an observing network that is useful to them as well as to scientists and other users.

System of Systems, the Study of Environmental Arctic Change, the International Study of Arctic Change, and the Arctic Council's Consortium for coordination of Observation and Monitoring of the Arctic for Assessment and Research.

Recommendation 2: Work to design and implement an internationally coordinated arctic observing network should begin immediately to take advantage of a unique window of opportunity created by a convergence of international activities during the International Polar Year that focus on observations.

The AON will build on existing efforts and will require new resources (including dedicated personnel) to fuel its development. The details of who should take responsibility for such efforts are outside the report's purview. Instead, the report presents fundamental activities that must be organized at the heart of the network and will need constant and focused activity to maintain and enhance observations and data flow. It is not necessary that one international body coordinate all of these activities, but these activities must be developed under a common framework. The AON would have four essential functions (see Figure 1, p. 2):

1. observing system development (which includes assessing complete coverage, system design and optimization, technology development, and sensor and observer deployment);
2. data acquisition (which includes maintaining existing observational capabilities and filling critical gaps);
3. data management, integration, access, and dissemination; and
4. network maintenance and sustainability (which includes network and observation sustainability, personnel development, coordination and integration regionally and globally, and communication).

Progress on all four of these functions is needed in parallel—in part because different communities and disciplines are at different stages of development, but also because each function is critical to development of a comprehensive network. Flexibility to accommodate technological improvements and changing sensor density is needed from the outset. The report presents detailed implementation ideas for these essential functions in its report. Box 1 (p. 3) contains examples of recommendations specific to network implementation and operation.

Conclusion

Building the Arctic Observing Network will require international cooperation and support. Because some areas of the Arctic have more developed monitoring and information systems than others, it will be critical to engage all arctic nations from the outset. This report provides a broad vision for such a network and the next step is for the international community of scientists, operational and research government agencies, other governmental and nongovernmental groups, arctic residents, and industry to take what they find useful from this vision, refine it, and implement the ideas. Because many potential components of the network already exist or are being planned, and because of the surge of activity during the International Polar Year, there is an immediate opportunity for major progress.

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This report brief was prepared by the National Research Council based on the committee's report. For more information, contact the Polar Research Board at (202) 334-3479 or visit http://dels.nas.edu/prb. Copies of *Toward an Integrated Arctic Observing Network* are available from the National Academies Press, 500 Fifth Street, NW, Washington, D.C. 20001; (800) 624-6242; www.nap.edu.