Towards a Sustained US Arctic Long-term Observing System: Perspectives from the Study of Environmental Arctic Change (SEARCH) Program

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Summary

This document outlines a potential framework for design and implementation of an aggregated Arctic observing network. We first describe several key problems that are unique to Arctic observing networks, such as the need for both fundamental scientific research and information relevant to decision makers and stakeholders. The second section outlines an implementation hierarchy of observing system priority and design. The hierarchy includes (1) setting priorities through the concept of Arctic System Services that builds on established programs, (2) the strategy of developing specific programs, (3) the tactics of coordinating activities within and across programs, and (4) specific implementation design and logistics. We discuss the potential role of the Study of Environmental Arctic Change (SEARCH) and agencies in the implementation of activities. Specific examples illustrate implementation of observations related to long-term observations in the context of improved prediction of the climate system, resource management, human activities, and ecosystem impacts. More detailed examples and descriptions of this framework and the associated references are available from: http://www.arcus.org/search/aon.

Statement of Problem

Three major challenges set Arctic observing systems apart from most efforts at lower latitudes. First, the degree of interconnection between different components and processes in the Arctic system requires a cross-disciplinary approach that transcends discipline or sector-focused observing efforts. Currently, long-term observations that are underway occur mostly as a patchwork of activities, with project-level interactions at best. There is little programmatic integration and prioritization across the entire range of observing activities. Second, the magnitude of challenges and opportunities springing from recent rapid interconnected Arctic changes have led to consensus among the scientific community and stakeholders that a dual-purpose observing system is needed—one that that serves both fundamental scientific research interests as well as information needs of decision-makers and stakeholders that have to respond to change. Third, the remoteness and harsh environment of the Arctic presents logistical challenges unique to high-latitudes.

Arctic observing efforts that provide critical data and information require coordination and integration to: (1) link projects within themes (e.g., terrestrial permafrost, landcover, hydrology and atmospheric observations), (2) link different disciplinary approaches and spatial scales of observation across themes, and (3) tie activities into research priorities at national and international levels. The lack of such coordination has rendered the nation vulnerable to large-scale disasters, slow-onset events, and widespread degradation. Reducing such vulnerabilities has been identified as a matter of national priority and is a key goal of an integrated observing network.

Framework for Implementation

We propose a unified framework for observing system priorities and design that is based on a hierarchy of approaches outlined by the Arctic Observing Network (AON) Design and Implementation Task Force (ADI Task Force 2012; Fig. 1).

(1) Problem definition and setting priorities

It is crucial to set priorities and define problems at the system-wide level to achieve a streamlined network that maintains relevancy, persistence and adaptability. Arctic System Services can be used as a concept to structure and guide priorities. For example, terrestrial permafrost serves key functions in helping retain surface freshwater that creates important habitats and hydrologic reservoirs used by industry and others, thus providing relevant ecological and economic services. At the same time, permafrost "locks up" globally relevant amounts of carbon and helps stabilize Arctic coasts and landscapes. Arctic system services can therefore act as an interface between outcomes desired by stakeholders and scientific understanding of the Arctic system.

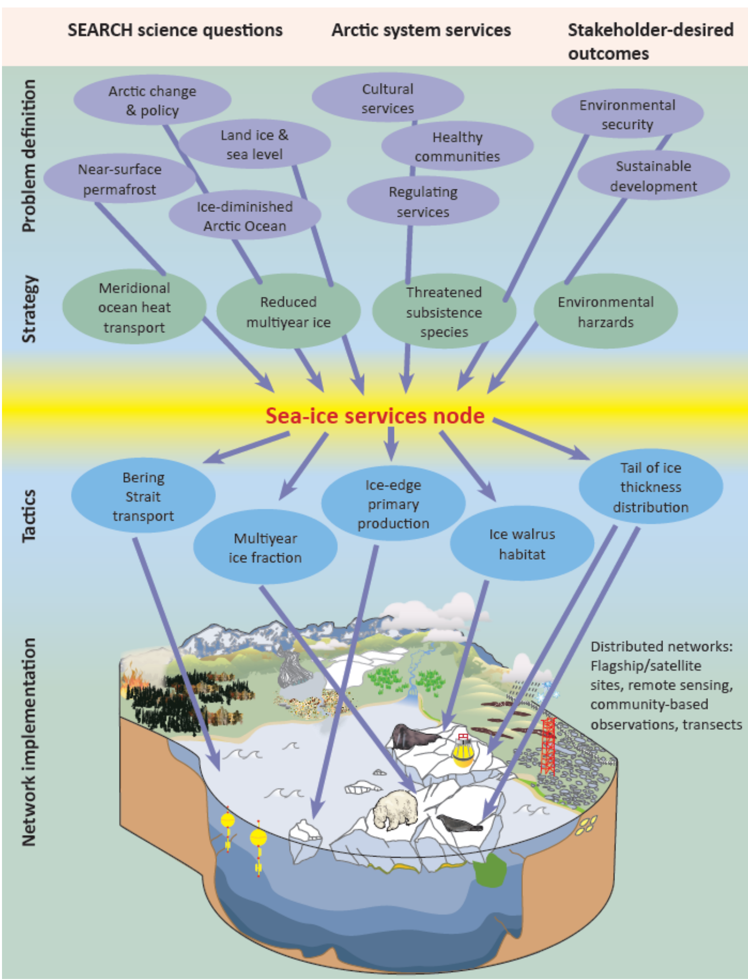

Figure 1: Schematic of observing network design and implementation hierarchy, role of implementation nodes and example for a sea ice services node.

Specific approaches can include scenario planning, analysis of institutions and regulatory frameworks, or feedback and impact assessments. SEARCH and different agencies, as well as the Interagency Arctic Research Policy Committee (IARPC) have already reached broad consensus on priority science themes, as outlined in the IARPC and SEARCH 5-year strategies and implementation plans. At the international level, these plans tie into long-term observations under the auspices of the Arctic Council Sustaining Arctic Observing Networks (SAON) and the International Arctic Scientific Council's (IASC) International Study of Arctic Change (ISAC).

***Example**:* Drivers and impacts of long-term ecosystem and ocean-ice-atmosphere variations in the oil and gas lease areas in the northeastern Chukchi Sea have been recognized as high priority themes by a range of federal agencies and stakeholders as well as by SEARCH. The U.S. Arctic Observing Coordination Workshop in 2012 identified this region as the target for a showcase project among scientists, data managers, stakeholders, decision-makers and local, state and federal representatives present at the meeting (Payne et al. 2013; Perovich et al. 2013). The workshop and a recent report by an Interagency Working Group on Coordination of Domestic Energy Development and Permitting in Alaska (Clement et al. 2013) provide initial guidance on key problems and priorities. More specific guidance can be obtained from a series of planning and assessment efforts currently in the early stages of implementation. These include the North Slope Science Initiative's (NSSI) scenario planning effort and stakeholder input to the Alaska Ocean Observing System's (AOOS) Spatial Tools for Arctic Mapping and Planning (STAMP) initiative. SEARCH can also help in the development of priority actionable questions by linking multiple agency interests gathered from science plans or specific agency priorities (e.g., Bureau of Ocean Energy Management (BOEM) Alaska Annual Studies Plan) with existing or planned policy goals such as the International Maritime Organization Polar Code, or relevant international standards (e.g., ISO 19906). Higher priority may be given to observing activities that meet multiple scientific and stakeholder needs or policy requirements. Finally, SEARCH synthesis activities such as *Arctic Futures 2050* bring together multiple stakeholders to address cross-disciplinary information needs.

(2) Strategy

At the strategy level, specific observing activities goals, outcomes and associated information products would be defined. This work would lead to a high-level scoping of activities and an evaluation of network data and information products. In addition, funding and support strategies would be part of strategic considerations. Hence, IARPC, including key members of IARPC Implementation Groups, the SEARCH Science Steering Committee (SSC), and the Arctic Council's SAON initiative would be key entities involved in advancing strategy.

***Example**:* Building on the example discussed above, a prioritized list of required information products and guidance on spatial distribution of observing activities can be derived from geospatially explicit scenario development under the NSSI or the AOOS STAMP project that uses geospatial analysis tools and database resources to identify broad priority regions. Within the priority regions, observing activities can be linked with policy goals. Coordinated science and stakeholder observing needs in the Chukchi Sea will allow observing activities to go beyond specific agency interests and support understanding of larger-scale Arctic change. The SEARCH SSC can work with agencies to match agency resources and priorities with academic research efforts.

(3) Tactics

At this level guidance from the upper tiers of the hierarchy is translated into specific action with respect to sensor placement, observation protocols, data management, standards and interoperability. Much of the actual integration of networks across disciplines, regions and observing projects—including sharing of logistics resources—takes place within this tier of the hierarchy. This integration will be achieved with the help of "nodes". Nodes can be thought of as communities of practice that are emerging around key themes or interrelated sets of Arctic system services, such as those derived from sea ice (Fig. 1). The SEARCH Action Teams, which include representation by agencies and stakeholders, and the IARPC Implementation Groups will lead the nodes, with input as warranted from other panels and working groups. Other key partners developing nodes will be international programs that have developed protocols and best practices with respect to network design, instrumentation, and data curation.

***Example**:* Flagship sites can serve as nucleation points for the cross-disciplinary integration that is central to nodes. The broad range of long-term programs active at Barrow or Toolik, Alaska may serve as an example of the significant value that integration could add to existing programs, which include observations of key climate and atmospheric chemistry variables at the NOAA and DOE ARM sites, reference sites for international programs (e.g., International Tundra Experiment), NSF-supported LTER and AON projects as well as long-term observations supported by the North Slope Borough and industry.

In addition to flagship sites, the SEARCH Sea Ice Action Team can act as a coordinating body for the sea-ice services node by bringing together current and planned sea ice observing networks (e.g., Sea Ice Prediction Network, U.S. National Ice Center forecasts, industry-based consortia). The focus on sea ice services within the sea ice node allows broader participation from other observing networks that transcends disciplines, but that remain inherently related to changing sea ice conditions. Support for data interoperability among networks could build on existing working and advisory groups established under IARPC, SEARCH, the Advanced Cooperative Arctic Data and Information Service, and data managers subsumed under the Alaska Data Integration Working Group (ADIwg). At the international level data management structures and practices developed by international groups, such as the International Arctic Systems for Observing the Atmosphere can serve as valuable prototypes.

(4) Network implementation at the operational level

Activities at this level will be driven primarily by individual funded research projects, oversight groups for observatory flagship sites, and funded agency and operations-focused activities. At this level in the hierarchy, the focus is on optimizing and sustaining observations with respect to operational and logistic constraints. Planning at this scale is typically on a project-specific basis; however, by integrating project-level efforts within nodes that focus on Arctic system services, small changes to a project's observing protocol or the addition of sensors to a planned deployment can create large benefits to stakeholders and the broader observing community. Ideally, coordinated observing activities within a node will also result in a unified data management plan that facilitates the identification of specific datasets for the development of stakeholder-relevant products and tools. Establishing greater data interoperability at the strategy and tactics levels will also improve how easily data can be ingested from individual observing networks.

***Example**:* Prioritization and optimization of specific observing activities may take different approaches depending on the best practices within a discipline (e.g., Observing System Simulation Experiments for optimizing observations of ocean currents, or coordinated protocols for community-based observations of subsistence harvest effort). The SEARCH project office could support coordination for the sea-ice node by encouraging network communication and providing resources to individual researchers on best practices and measurement protocols, keeping track of established priority sites, or sharing community suggestions on how to improve existing observing arrays. Such coordination can help agencies and PIs plan future research or broaden the utility of funded projects to meet multiple stakeholder needs.

The Role of SEARCH

SEARCH's role in the implementation of a sustained Arctic observing system can build on its strengths as a long-standing, cross-cutting, integrating program that explores questions central to long-term climate variability and change as well as responses by people and ecosystems. This approach can help frame long-term observations in the context of pan-Arctic processes and change. The SEARCH Arctic-systems approach allows SEARCH to synthesize research findings, but also brings together the research community and stakeholders to coordinate and prioritize a range of different observations in a unified context.

As in the past, NSF-supported AON projects will explore and develop new measurement methodologies or observing protocols that may be of value as agencies decide upon best practices for core measurements. With a sustained U.S. Arctic observing network both urgently needed and largely feasible, SEARCH and NSF-supported AON projects can play an important role by (1) identifying a set of core Arctic system "state" variables that are essential in understanding, predicting and responding to rapid, system-wide Arctic change, (2) leading implementation of the backbone of a cross-disciplinary observing system that focuses on key Arctic system variables, and (3) exploring innovative approaches in sensor development and deployment, data curation and dissemination, and synthesis of information derived from the network to improve prediction and response. In addition to these specific observing system roles, the SEARCH role also includes (1) identifying emerging issues and promoting inter-disciplinary science, (2) integrating national research activities from local to global scales, and (3) providing science-based information that can be used by stakeholders and policy-makers to help them respond to Arctic change.