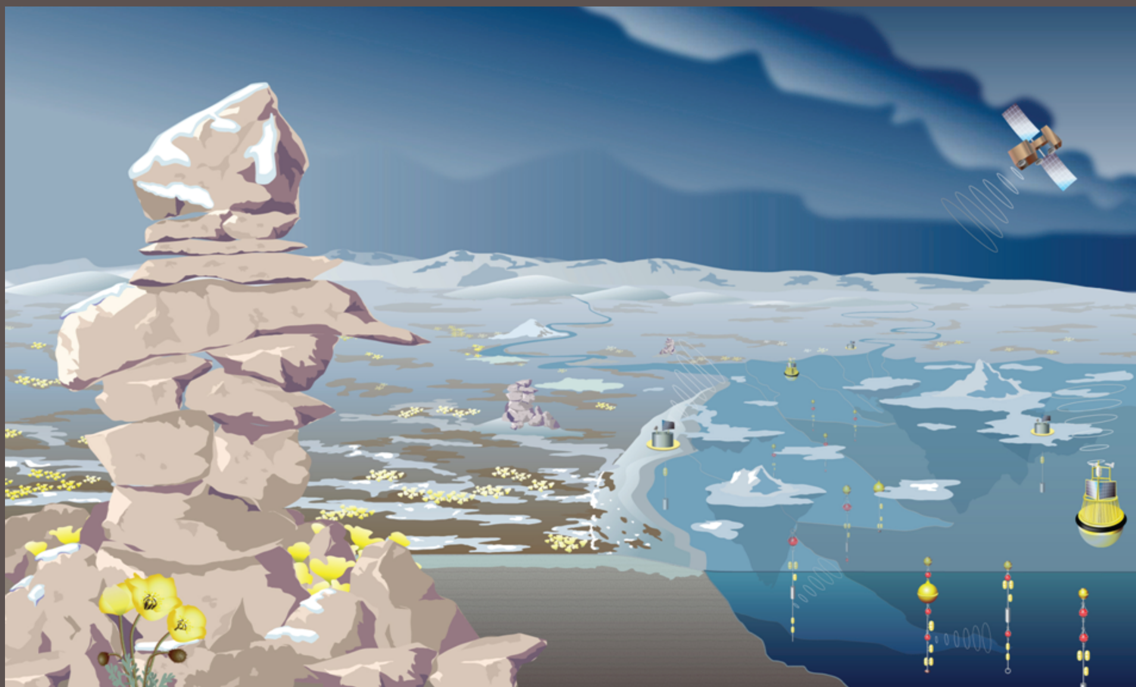

Arctic Observing Network (AON) Program Report-Highlights

(Draft, March 5, 2010)

Results from the third AON PI Meeting; 30 November - 2 December 2009; Boulder, CO

This material is based upon work supported by the Division of Arctic Sciences of the National Science Foundation. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of the National Science Foundation (NSF) or the University Corporation for Atmospheric Research (UCAR).

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Arctic Observing Network (AON) Program Report - Highlights

Results from the Third AON Principal Investigators (PI) Meeting
30 November – 2 December, 2009, Boulder, CO

1. Introduction and Overview

The Arctic Observing Network (AON) has been envisioned and is now being implemented as a system comprising atmospheric, land- and ocean-based environmental monitoring capabilities – from ocean buoys and community-based observations to satellites and terrestrial flagship observatories – that will help answer urgent questions posed by the scientific community, Arctic stakeholders and society at large. The AON serves the broader aims of the U.S. inter-agency Study of Environmental Arctic Change (SEARCH, *www.arcus.org/search*). Through a series of community workshops and other interactions, SEARCH identified overarching questions centered around improving understanding and informing responses to the complex, systemic change currently underway in the Arctic. The SEARCH Implementation Workshop Report (SIW, 2005) defined the AON as a key component of the broader SEARCH science strategy whose activities would be guided by modeling and synthesis efforts subsumed under the heading of "Understanding Change", and by input from scientists and a range of stakeholder groups concerned with "Responding to Change" (i.e., studies of both observed changes in system behavior driven by change, as well as adaptation to and mitigation of such change).

The International Polar Year (IPY) 2007-09 motivated increased observational efforts, funded in the U.S. through investments by the agencies that are part of SEARCH. The National Science Foundation (NSF) provided extensive support through the Office of Polar Programs' AON Program. The National Oceanic and Atmospheric Administration (NOAA) and several other agencies also contributed to these efforts, such that the AON included over 40 projects at the start of 2010.

Following implementation of the first dedicated AON projects in 2007, annual meetings have focused on coordinating and integrating observing activities. The first of these meetings, held in 2007 in Boulder, Colorado, established a foundation for effectively communicating plans and activities among AON investigators and provided guidance for the implementation of the Cooperative Arctic Data and Information System (CADIS, *www.aoncadis.org*), the designated portal for AON data dissemination and curation. The Second AON PI Meeting, held in Palisades, New York was jointly organized by the European DAMOCLES Program (Developing Arctic Modeling and Observing Capabilities for Long-term Environmental Studies) and SEARCH and sought strong international participation with the overarching goal of fostering broad network integration. This meeting included workshops designed to explore the potential role of autonomous and Lagrangian observation platforms and to synthesize the current state of knowledge and understanding of Arctic change. The resulting workshop report (Arctic Observation Integration Workshop Report, 2008) summarizes important outcomes and recommendations stemming from these meetings.

Building on past activities, and reflecting on needs identified during the first three years of the AON Program, the Third AON PI Meeting, held 30 November to 2 December 2009 in Boulder, Colorado, focused on: (i) producing a broad assessment of AON activities at the close of the IPY 2007-09, (ii) exploring the needs and contributions of a broad range of federal agencies, (iii) placing U.S. AON efforts in an international context and (iv) learning from the experiences of lower-latitude programs that successfully designed and implemented long-term observing systems. The meeting was attended by a total of 91 participants, with presentations by AON PIs, representatives of international programs (e.g., DAMOCLES, the Canadian ArcticNet Program and the International Study of Arctic Change, ISAC) and representatives of U.S. agencies engaged in SEARCH and AON-relevant activities.

A full report that provides an AON status report and summarizes presentations, deliberations and recommendations from this meeting is in preparation. This abbreviated Highlights/Summary Report provides a brief overview of key activities, findings and recommendations as relevant in the context of ongoing planning efforts and international meetings, such as the State of the Arctic Conference, 16-19 March 2010 in Miami, Florida.

2. Status of the AON

Due to its inter-agency support, the total number of AON projects depends somewhat on how AON-related efforts are defined at the agency level; however, the core of the program currently includes over 40 projects, several of which have sub-projects led by different investigators. NSF-supported AON components are required to make their data available in a timely fashion through the CADIS portal and/or one of the other established facilities that offer data dissemination and curation (e.g., the National Ocean Data Center). The CADIS website thus provides an up-to-date overview of the current project roster, including further information on project scope, contributors and data access (*http://www.aoncadis.org/projects/*). A representative, though incomplete, chart of observation sites (Figure 1) provides a sense of the broad scope and geographic distribution of U.S. AON activities (see also project listing in Table 1). Both individual AON projects and the overall AON program are closely coordinated with a range of international observing system activities. Although the chart (Figure 1) does not reflect these ties, they are outlined in Section 4.

A brief review of the status of the AON themes follows below. These categories – atmosphere, ocean and sea ice, hydrology and cryosphere, terrestrial ecosystems and human dimensions – were defined in the Search Implementation Plan (SIW, 2005). The divisions reflect practical considerations, such as efficiencies achieved when networking projects with similar science foci and compatible methodologies and measurement approaches. The level of activity, evidenced by the number of projects supported, varies between these five themes. The factors driving this distribution include urgency associated with key questions (e.g., the mechanisms and impacts of recent, rapid summer sea ice retreat), limitations imposed by existing capabilities and complementarity with other observing programs not described here (such as those by agencies managing land use in Arctic Alaska). AON investigators agreed that distribution of effort should adapt in response to changing science priorities and societal needs, which could require significant realignment of resources.

The complete version of this report also includes brief summaries from AON projects. These detail individual efforts, highlight commonalities and identify next steps at the project, theme and system level.

Atmosphere (based on summary presentation by T. Uttal at AON PI Meeting). The present roster of up to ten atmospheric AON projects encompasses a range of research topics with coverage through the depth of the atmosphere, ranging from snow chemistry to the stratosphere-mesosphere. In contrast with the proliferation of automated ocean and sea ice sensor systems, atmospheric observations are significantly more reliant on instruments that require regular operator support for successful operations. Despite these challenges, and building on international collaborative frameworks, wide geographic coverage throughout the Arctic region has been achieved (see also Figure 1), including sites at Barrow, Cherskii, Summit, Eureka, Toolik, Atqasuk, Ny Alesund, Andøya, Chatanika, Kangarlussuaq and over the Arctic Ocean. The projects have identified several common themes. Logistical support is an on-going challenge, especially for programs that collect samples across international boundaries. The project investigators have noted a need for consistent data processing/formats and a desire to coordinate research activities with international collaborators. They also recommend the organization of topical workshops and development of mechanisms that allow for future site co-location and integration into global networks and programs.

Ocean and Sea Ice (based on summary presentation by M. Steele at AON PI Meeting). A total of 15 NSF-supported AON projects focus on long-term characterization of sea ice thickness and extent, Arctic Ocean circulation, stratification, heat and freshwater content and biogeochemical properties, with the goal of quantifying, understanding and ultimately predicting change on seasonal to decadal timescales. Activities include measurements at two critical gateways (Bering Strait and Davis Strait, an integration point for the Canadian Arctic Archipelago), intensive systems in the Beaufort Gyre, Bering and Chukchi Seas and North American shelf/slope system, a North Pole Observatory and arrays of drifting buoys that collect distributed, pan-Arctic measurements. Many of these systems exploit recent developments in autonomous ocean observing technologies to provide extensive, efficient, long-endurance measurements. Partly due to limitations imposed by sensor technologies, measurements currently favor basic physical parameters (e.g., temperature, salinity), with selected biogeochemical variables measured autonomously and a larger suite limited to annual (or longer time scale) hydrographic surveys. AON investigators identified accelerated implementation of biological and biogeochemical observing systems (ideally in conjunction with physical measurements) as a top priority. Such observations will be needed to address scientifically- and societally-driven tasks, such as documenting and understanding changes in Arctic ecosystems and investigating acidification of Arctic and sub-Arctic waters. Geographically, measurements focus largely on the North American Arctic, with greater emphasis on the open-basin than on the extensive shelf-slope system. AON investigators recommended greater engagement with, and participation in, international Arctic observing efforts irrespective of geographical proximity. Given that most human activity radiates from population centers and thus concentrates near the coasts, and that decreasing summer sea ice extent heightens the importance of the marginal ice zone, AON investigators also recommended increased attention to the shelf/slope system. Lastly, meeting participants noted that AON might benefit from ties with well-established lower-latitude ocean observing programs such as ARGO, CLIVAR and the Ocean Carbon Program, both by drawing on these programs' experience or, perhaps, by facilitating extensions into the Arctic.

Hydrology and Cryosphere (based on summary presentation by M. Holmes at AON PI Meeting). To date, NSF AON has funded eight hydrology/cryosphere projects, three of which are part of the same over-arching effort (*Thermal State of Permafrost, TSP*). Three of the projects are pan-Arctic in scope (*Arctic Great Rivers Observatory [Arctic-GRO], TSP and Circumpolar Active Layer Monitoring Network, CALM*). While there is some uncertainty with regards to continuation of four projects that are at the end of their grant cycle (with potential options to submit proposal requests for renewal), substantial progress has been made to date. For example, the Arctic-GRO is now in a position to establish baselines in hydrological and biogeochemical fluxes against which future changes can be compared. The TSP and CALM work is progressing towards good pan-Arctic coverage of assessing the thermal state of permafrost. Recommendations by the Hydrology/Cryosphere investigators at the AON PI meeting were based on a review of how well SEARCH science questions have been addressed to date. While activities are underway to address most of the high-priority questions, these have not yet been integrated into a cohesive network with at least one dedicated flagship site.

Terrestrial Ecosystems (based on summary presentation by G. Shaver at AON PI Meeting). The AON terrestrial group currently consists of four projects implemented over the past three years, with three projects part of international networks and/or presence at a number of circumpolar sites (International Tundra Experiment [ITEX] carbon, water and energy cycles in Arctic landscapes at flagship observatory sites and in a pan-Arctic network, and the Terrestrial Circum-Arctic Environmental Observatories Network, CEON). A fourth project examines the role of fire in the Arctic landscape. These projects form a well-structured, multi-scale monitoring system for plant and soil processes, vegetation community composition, and regulation of terrestrial carbon, water cycling and surface energy exchanges; however, neither aquatic ecosystems nor catchment-scale biogeochemistry are well-represented. In addition to regional and pan-Arctic scale monitoring, e.g., through remote sensing, the greatest need is for a clear system of priorities in selecting new projects that facilitate complementarity of new projects with ongoing AON research. This is being addressed in part through the AON Design and Implementation (ADI) effort but much remains to be done.

Human Dimensions (based on summary presentation by M. Murray at AON PI Meeting). The AON includes only a single project focused on the human component of the Arctic System, "IPY Collaborative Research: Is the Arctic Human Environment Moving to a New State?" (PIs J. Kruse, University of Alaska Anchorage, Lawrence Hamilton, University of New Hampshire). Phase One of the project includes an assessment of whether exiting data are adequate to meet arctic research needs and to support development of adaptive response strategies, with specific emphasis on commercial fisheries, tourism, harvest and consumption of local resources (especially marine mammals), oil, gas, and mineral development and marine transportation. The project also involves selection of community indicators, including modeling to support indicator selection and the development of an integrated GIS database accessible to arctic researchers and arctic organizations. To date the project has resulted in the creation of the Northern Places: Circumpolar Human-Dimensions Data Framework (*http://www.carseyinstitute.unh.edu/alaska-indicators-northern.html*).

This level of human component observing in the AON is inadequate. The AON can and should be envisioned as a program that encompasses a broad, well-defined set of relevant observations designed to improve understanding and projections and inform responding to change initiatives.

This will require expanding the vision of human system observing beyond statistical data on health, demographics, and quality of life, moving outside the traditional community of Arctic investigators to bring in fresh perspectives, new ideas and the participation of new investigators. Willingness to take creative and scientific risks is required to facilitate progress. The AON ADI effort should drive some improvement in human component observing, but there also needs to be integration with ongoing understanding and responding to change activities if this element of the AON is to become operational.

3. AON Investigator Perspectives on Network Design and Urgent Needs

As the AON expands and implementation decisions become more complex, issues of optimal system design and identification of critical shortcomings acquire new urgency. Meeting participants thus devoted significant time to assessing different design approaches, learning from examples taken from outside the Arctic (e.g., ARGO) and evaluating the more 'bottom-up' approach to network design and implementation followed by the AON to-date. This contrasts with efforts to examine network design from a systemic, model-driven perspective – such as the elements of the AON Design and Implementation effort currently underway. The value of reviewing bottom-up approaches rests in the vast store of specialized, sometimes region-specific, knowledge that typically lies behind these design decisions. The resulting systems are likely to be more cognizant of local- and regional-scale constraints on sensor deployment, effective at exploiting potential synergies derived from co-location, and more efficient when developing adaptive approaches that rely on data from the observing network for optimization.

Key findings of these discussions include:

(1) Further work is needed to understand the optimal balance between flagship observatory sites and distributed observing networks within the AON. While flagship sites foster co-location of diverse measurements and lead to improved understanding of processes driving change, they require substantial investments in infrastructure and may have only a limited sampling footprint. Distributed observatories composed of numerous, low-cost, autonomous sensor systems would likely provide better coverage for the detection of spatially complex signals of change. However, such systems would be restricted to quantifying a limited range of variables. Strong guidance from modeling and synthesis studies, analysis of historical data and remotely-sensed fields will be required to inform these design decisions.

(2) Although significant progress has been made in developing robust, reliable oceanographic instrumentation to measure biological and biogeochemical variables from moorings and mobile platforms, integration of biological, chemical and physical measurements remains challenging. Critical observing programs, such as NOAA-led efforts focused on marine mammals and fisheries, depend on such integration. Interdisciplinary concerns should become an integral component of network design considerations.

(3) Optimization of an AON capable of sustained, decadal-scale observing will require improved coordination between the agencies that foster and support Arctic observing. These concerns were examined both from the PI perspective and that of key agencies, with presentations provided by representatives of NSF, NOAA, NASA, Office of Naval Research, several Department of

Interior agencies and the inter-agency North Slope Science Initiative. Summaries of these presentations are included in the full report.

(4) Ongoing AON design efforts need a community-based mechanism for identifying new observing priorities and reprioritizing existing activities should environmental change or advances in understanding render them irrelevant or demonstrate them to be unimportant. The SEARCH Panels (Observing Change, Understanding Change, Responding to Change) have a key role to play in this context.

(5) Several sub-groups identified a need for better standardization and coordination of measurements. For example, coordinated atmospheric and cryospheric measurements were identified as necessary for improving the tracking of black carbon and other aerosols in the snow cover. Such standardization would require early engagement of agencies charged with maintaining climate reference station networks and observations.

(6) More rigorous efforts to integrate human dimensions into network design are both necessary and feasible given new statistical models that facilitate integration of data from different domains (climate, economics, ecosystems). The lack of key Arctic human dimensions data, such as data lacking from the U.S. census, will challenge these investigations.

(7) Participants recommended promoting and aiding the northward expansion of established, lower-latitude observing systems that offer the potential to meet some AON needs.

Disciplinary groups also identified infrastructure and support issues that currently limit development of a sustainable observing network. This activity produced prioritized lists of urgent needs that will be included in the complete AON PI Meeting Report.

4. International Collaboration and Coordination

Arctic research benefits from a tradition of strong international collaboration driven by the clear benefits of shared logistics, cooperative measurement programs and free exchange of data and information. However, the lack of international implementing agreements and issues surrounding security, customs and visa regulations of individual countries, the U.S. included, hamper pan-Arctic science efforts. This affects (i) physical access to regions of scientific interest, (ii) standardization and exchange of data and joint support of network science, and (iii) development of international science collaborations. Based on these findings, a series of recommendations emerged from the meeting:

(1) There is a growing web of bilateral Memorandums of Understanding and Agreements between different countries and agencies. Although these documents generally do not provide authorization for actions such as transferring funds, clearing customs, acquiring data or granting permissions for physical access and data sharing, it would be useful to inventory these agreements. Building on past successes and emerging needs, NSF, NOAA and other agencies might consider drafting preliminary requirements for a multi-lateral Arctic science agreement that will facilitate international research collaboration, access and open data exchange. The requirements document could be submitted to the Sustained Arctic Observing Network (SAON)

Steering Group to carry forward to the Arctic Council, and to the U.S. Arctic Research Commission (USARC) to carry forward to the U.S. Congress.

(2) Where appropriate, NSF/AON should contribute (or maintain contributions) to existing data archives for topical data sets such as Baseline Surface Radiation Networks (BSRN), Global Atmosphere Watch (GAW), the Arctic Monitoring and Assessment Program (AMAP), the ARGO Float Program and the International Arctic Buoy Program (IABP).

(3) AON researchers should take advantage of NSF Office of International Science and Engineering (OISE) programs, such as Partnership for International Research and Education (PIRE), that promote international research collaborations. NSF/AON program managers should study the OISE program "International Collaboration in Chemistry between US Investigators and their Counterparts Abroad (ICC)" with an eye toward instigating a similar Arctic-centric program.

(4) All disciplines repeatedly indentified the need for additional mid-basin measurements in the Arctic Ocean. An ice station capable of collecting such observations would require international partnership and financial contributions. If established, it would provide a focus for developing research partnerships and collaborations across national boundaries and disciplines. The SHEBA and Russian drifting station programs should be reviewed as a proof-of-concept exercise. U.S. agencies should consider developing a partnership for a permanent ice station to define key components, implementation protocols and also identify foreign agencies that could provide long-term support.

5. Data Dissemination, Use and Archiving

The Arctic Observing Network's primary output is the multi-disciplinary data produced by the many projects that form the network. By construction, all AON projects must provide their data to the community in a timely fashion, without embargo periods. By providing rapid, open access to quality-controlled, fully-documented data AON hopes to promote broad, community-wide use of these valuable holdings. All AON investigators are required to adhere to the SEARCH Data Policy (*http://www.arcus.org/search/searchscience/data.php*), thereby maximizing community-wide data access, integration and, ultimately, long-term preservation. AON also strives for changes in the practice of science by emphasizing the need for both the community and data users to properly recognize and credit data providers.

The diverse, extensive outflow of AON data requires a management strategy and motivated the development and implementation of the Cooperative Arctic Data and Information Service (CADIS) (*http://www.aoncadis.org/*). CADIS aims to incorporate community standards, visualization tools, data archiving and curation expertise into AON support and data management activities. It creates a foundation for long-term access to data archives, discovery, delivery and analysis by the Arctic science community and other users. AON Investigators had archived more than 160 data sets from 37 Investigators and 12 nations in CADIS by the end of 2009 (Figure 1). CADIS reached a major milestone in fall 2009 with the release and implementation of the user interface for metadata and data upload via the CADIS Data Portal. Primary features include an advanced metadata authoring tool, web portal, data upload tool, semantic search, dataset download, interoperability with selected Arctic archives (e.g., NSIDC, NCAR/EOL, Norway, British Antarctic Survey) and visualization tools for browsing project overview information. User support is provided to assist AON investigators with all aspects of the CADIS applications.

After 3 years of system development and support to the AON community, the CADIS Team used a questionnaire as part of the evaluation of the Service. Positive comments suggest that CADIS has become a central location for accessing AON data and metadata. Reponses also noted that the support team has been very helpful in assisting data providers to organize and publish their data and metadata. A majority of AON investigators are willing to consider a structured ASCII data format for AON data, though it is also clear that flexibility in acceptable data formats is desired. Some areas of suggested improvement include how searches are handled, both within the archive itself and for queries originating from outside CADIS; increasing community awareness of CADIS and its capabilities; developing more effective support for AON social science data and information; organizing data format conversion capabilities and improving map based search and visualization utilities. The AON investigators also recommended that CADIS expand links to other related datasets that will be used when analyzing basin-wide phenomena.

Support for AON data management will continue to evolve as AON grows to produce a rich legacy of Arctic data. CADIS must continue to offer a systematic approach that supports the data providers while improving efficient access to these data. CADIS will have effective metadata and data entry tools, visualization techniques (map based, parameter based, project based) and improved search capabilities for the discovery and access to this diverse data archive. There will be increasing opportunity to link to and/or provide supplementary or supporting datasets that are relevant to AON. These data could include remote sensing data and products (e.g. imagery, ice concentration), integrated datasets produced by the AON PIs or other groups, operational data from state or federal agencies and model results from intercomparison projects, reanalysis or other special efforts. These datasets would typically be linked via existing web sites and not require CADIS to directly archive the data.

AON faces an upcoming challenge to define and implement a process for meeting stakeholder needs with useful products. In addition, discussions at the PI meeting suggest that there is a growing interest in distributing AON data products local Arctic communities and other potential end users. The AON group proposed a small pilot study in which CADIS would provide near real time data for access by interested users. One possibility would be to provide local meteorological and sea ice state products to a community that might use this information to establish fishing and hunting schedules or time the shipping of goods in and out of their locale.

6. Summary and Outlook

Existing AON projects align with the scientific priorities and broad design criteria laid out in the SEARCH implementation documents (in particular SIW, 2005). AON investigators and the broader scientific community now face the challenge of integrating these diverse components into a broader network that is part of an over-arching, international observing system. Discussions at the AON PI meeting identified four near-term issues that will have to be addressed to progress toward this goal:

(1) Design optimization efforts should draw from: (i) bottom-up approaches driven by individual projects and incremental refinement of measurement sites based on data, model results and local expertise, and (ii) top-down approaches driven by rigorous approaches to observing system design and optimization such as Observing System Simulation Experiments (OSSEs) and other modeling or synthesis efforts, to tailor an integrated approach for the AON.

(2) Implementation of an effective, sustained observing network that adheres to design and implementation principles defined by activities such as outlined in (1) may prove challenging for existing support mechanisms that rely solely on peer review of short-duration projects that focus on individual components of the system and reference the overarching science goals. Although this system is integral to much of NSF-supported science, AON may need to look towards the methods that other large observing programs have successfully employed to build comprehensive, highly integrated networks. Approaches include reliance on steering committees for additional guidance, strong partnering with government agencies capable of supporting sustained measurements and development of guidelines and practices that foster coordination.

(3) Given the important role of agencies and other entities, such as Arctic communities and industry, in sustaining long-term observations, progress needs to be made in developing effective approaches to foster coordination, joint planning and partnered implementation of Arctic observing systems.

(4) At the international level, existing efforts such as coordination through the World Climate Research Program's Climate and the Cryosphere (CliC) Program, or the International Arctic Systems for Observing the Atmosphere (IASOA) Project may provide important guidance and frameworks for the implementation and optimization of an observing network.

A major challenge, unique to AON in relation to other observing systems with a more disciplinary focus, is the broad, inherently inter-disciplinary nature of the driving questions. While SEARCH has been structured to meet this challenge, effective techniques for promoting inter-disciplinary synthesis and integration still need to be explored. Stakeholders and mission-oriented government agencies can provide some guidance, since many of the questions they face in the context of Arctic change cut across disciplines.

Coordination with agencies and stakeholders will also be crucial because of their important role in sustaining longer-term observations and their focus on questions of immediate societal relevance. Owing to the rapidity of Arctic change and the urgency of some of the challenges it presents, the AON is ideally positioned to generate information of potential value to those affected. However, improved communication and coordination among the scientific community, government agencies and stakeholder groups will be required to meet this challenge. A review of successful approaches for fostering communication and joint planning in other settings may help in building the required institutions and support structures for such an integrated system. At the more practical level, there is a need for a discussion to identify the products stakeholders and agencies expect from an AON and to scope the level of effort that will be required to deliver these products.

Similarly, effective channels and mechanisms for joint planning and coordination of observing system activities must be developed. This will involve discussion of over-arching scientific questions and development of science plans, such as through the International Study of Arctic Change. Equally important are questions revolving around international agreements and other approaches that can help ensure data exchange, standardization and inter-comparability of measurements, coordination of logistics, improved access for deployment of observing system components and related questions.

Table 1. List of NSF-AON Projects
(current and immediate past projects, as compiled on CADIS portal)

Please note: Only the lead PI is listed, even for collaborative projects which may have several co-PIs with leading roles at collaborating institutions

Lead PI Last Name	Lead PI First Name	Report Title
		Atmosphere
Bales	Roger	Core Atmospheric Measurements at Summit, Greenland Environmental Observatory
Bales	Roger	Continued Core Atmospheric and Snow Measurements at the Summit, Greenland Environmental Observatory
*Bernhard	Germar	UV Monitoring Project
*Collins	Richard	Pan-Arctic Studies of the Coupled Tropospheric, Stratospheric and Mesospheric Circulation
Eloranta	Ed	Development of Data Products for the University of Wisconsin High Spectral Resolution Lidar
Eloranta	Ed	A Replacement Laser for the Arctic High Spectral Resolution Lidar
*Matrai	Patricia	The Collaborative O-Buoy Project: Deployment of a Network of Arctic Ocean Chemical Sensors for the IPY and beyond
*Shepson	Paul	Halogen Chemistry and Ocean-Atmosphere-Sea Ice-Snowpack (OASIS) Chemical Exchange During IPY
*Walden	Von	Cloud Properties Across the Arctic Basin from Surface and Satellite Measurements - An Existing Arctic Observing Network
Walden	Von	Integrated Characterization of Energy, Clouds, Atmospheric State, and Precipitation at Summit (ICECAPS)
		Ocean and Sea Ice
*Eicken	Hajo	The State of the Arctic Sea Ice Cover: An Integrated Seasonal Ice Zone Observing Network (SIZONET)
Eicken	Hajo	Collaborative Research on the State of the Arctic Sea Ice Cover: Sustaining the Integrated Seasonal Ice Zone Observing Network (SIZONET)
Gofman	Victoria	Bering Sea Sub-Network: International Community-Based Observation Alliance for Arctic Observing Network (BSSN)
*Gofman	Victoria	Bering Sea Sub Network: A Distributed Human Sensor Array to Detect Arctic Environmental Change
*Lee	Craig	An Innovative Observational Network for Critical Arctic Gateways: Understanding Exchanges through Davis Strait and Fram Straits
*Morison	James	North Pole Station: A Distributed Long-Term Environmental Observatory
Morison	James	Aerial Hydrographic Surveys for IPY and Beyond: Tracking Change and Understanding Seasonal Variability
*Pickart	Robert	An interdisciplinary monitoring mooring in the western Arctic boundary current: Climatic forcing and ecosystem response
*Proshutinsky	Andrey	The Beaufort Gyre System: The Flywheel of the Arctic
Proshutinsky	Andrey	Continuing the Beaufort Gyre Observing System to Document and Enhance Understanding Environmental Change in the Arctic
*Richter-Menge	Jacqueline	Ice Mass Balance Buoy Network: Coordination with DAMOCLES
Richter-Menge	Jacqueline	Autonomous Ice Mass Balance Buoys for an Arctic Observing Network
*Rigor	Ignatius	Coordination, Data Management and Enhancement of the International Arctic Buoy Programme (IABP)
*Schlosser	Peter	A Modular Approach to Building an Arctic Observing System for the IPY and Beyond in the Switchyard Region of the Arctic Ocean
*Stanton	Tim	Ocean-Ice Interaction Measurements Using Autonomous Ocean Flux Buoys in the Arctic Observing System

Stanton	Tim	Toward Developing an Arctic Observing Network: An Array of Surface Buoys to Sample Turbulent Ocean Heat and Salt Fluxes During the IPY
*Steele	Mike	UpTempO: Measuring the Upper Layer Temperature of the Arctic Ocean
*Timmermans	Mary-Louise	Observing the Dynamics of the Deepest Waters in the Arctic Ocean
*Toole	John	Design and Initialization of an Ice-Tethered Array Contributing to the Arctic Observing Network
Toole	John	Towards an Arctic Observing Network: An array of Ice-Tethered Profilers to sample the upper ocean water properties during the International Polar Year
Toole	John	Continuation of the of Ice-Tethered Profiler contribution to the Arctic Observing Network
Woodgate	Rebecca	Comparison of Water Properties and Flows in the U.S. and Russian Channels of the Bering Strait - 2005 to 2006
*Woodgate	Rebecca	The Pacific Gateway to the Arctic - Quantifying and Understanding Bering Strait Oceanic Fluxes
Woodgate	Rebecca	An Ocean Observing System for the Bering Strait, the Pacific Gateway to the Arctic - an integral part of the Arctic Observing Network
Hydrology/Cryosphere		
Kane	Douglas	Long-term Measurements and Observations for the International Arctic Research Community on the Kuparuk River Basin, Alaska
*Peterson	Bruce	Arctic Great Rivers Observatory (Arctic-GRO)
*Pfeffer	Tad	Dynamic Controls on Tidewater Glacier Retreat
Romanovsky	Vladimir	Thermal State of Permafrost (TSP): The US Contribution to the International Permafrost Observatory Network
*Romanovsky	Vladimir	Development of a Network of Permafrost Observatories in North America and Russia: The US Contribution to the International Polar Year
Romanovsky	Vladimir	Thermal State of Permafrost (TSP) in North America and Northern Eurasia: The US Contribution to the International network of Permafrost Observatories (INPO)
*Shiklomanov	Nikolay	The Circumpolar Active Layer Monitoring Network--CALM III (2009-2014): Long-term Observations on the Climate-Active Layer-Permafrost System
*Sturm	Matthew	A Prototype Network for Measureing Arctic Winter Precipitation and Snow Cover (Snow-Net)
Terrestrial Ecosystems		
*Oberbauer	Steve	Study of Arctic Ecosystem Changes in the IPY using the Interantional Tundra Experiment
*Oberbauer	Steve	Sustaining and amplifying the ITEX AON through automation and increased interdisciplinarity of observations
Shaver	Gus	Carbon, Water, and Energy Balance of the Arctic Landscape at Flagship Observatories and in a PanArctic Network
*Shaver	Gus	Fire In the Arctic Landscape: Impacts, Interactions And Links To Global and Regional Environmental Change
Tweedie	Craig	Development and Implementation of the Terrestrial Circumarctic Environmental Observatories Network (CEON)
Human Dimensions		
*Kruse	Jack	Is the Arctic Human Environment Moving to a New State?
Data Management and Coordination		
*Gearheard	Shari	ELOKA: Exchange for Local Observations and Knowledge in the Arctic
*Moore	James	Cooperative Arctic Data and Information System (CADIS)

* *Projects for which a summary report of activities has been submitted for publication in the forthcoming full AON Status report.*

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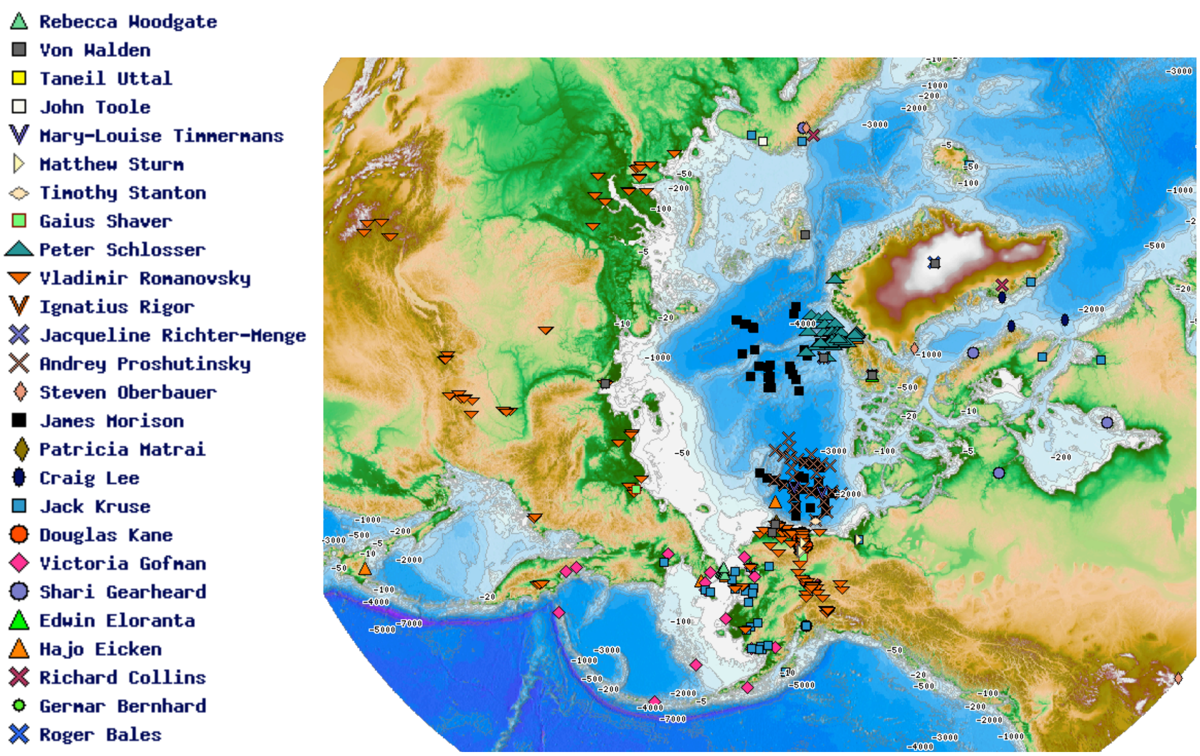

CADIS

Figure 1. The AON Network measurement locations on a polar projection as of the end of 2009 (obtained from the CADIS GIS Mapserver tool). Observation sites, moorings, and the general region of drifting buoys are assigned a symbol unique to each investigator.