Arctic Observing Network (AON) Design and Implementation (ADI)

Project Plan

Phase I
September 2009-February 2010

Phase II
January 2010-July 2010

Hajo Eicken
Geophysical Institute (GI)
University of Alaska Fairbanks
PO Box 757320
903 Koyukuk Drive
Fairbanks, AK 99775-7320
Phone: 907-474-7280
Fax: 907-474-7290
E-Mail: hajo.eicken@gi.alaska.edu

John E. Walsh
International Arctic Research Center (IARC)
University of Alaska Fairbanks
PO Box 757340
Fairbanks, AK 99775-7340
Phone: 907-474-2677
Fax: 907-474-2643
E-Mail: jwalsh@iarc.uaf.edu

Peter Schlosser
Lamont-Doherty Earth Observatory
Columbia University
61 Route 9W
PO Box 1000
Palisades, NY 10964-8000
Phone: 845-365-8707
Fax: 845-365-8176
E-Mail: schlosser@ldeo.columbia.edu

With support from the
National Science Foundation Office of Polar Programs (http://www.nsf.gov/dir/index.jsp?org=opp) and Joint Office of Science Support of the University Corporation for Atmospheric Research (http://www.joss.ucar.edu/index.html)

EXECUTIVE SUMMARY

With U.S. agencies and others maintaining complementary observation efforts in the Arctic, there is now an urgent need for coordination, consolidation and optimization of the existing observing system elements, as well as for development of a broader strategy that includes more detailed design studies to enhance and sustain the observing system.

This paper outlines a two-phase 12-month process to provide guidance to the National Science Foundation, the scientific community and others engaged in Arctic environmental observations on how to best achieve a well-designed, effective and robust Arctic observing system. An Arctic Observing Network (AON) Design and Implementation (ADI) Task Force, composed of researchers with observing-system expertise both within and outside of the Arctic, will work with other key experts to meet these objectives. Activities include a combination of virtual and in-person meetings, two workshops and a small array of proof-of-concept or exploratory studies overseen by the Task Force, culminating in a summary report with recommendations for the next steps in optimizing, coordinating, and enhancing the existing components of an international Arctic environmental observing system with emphasis on the U.S. AON.

The ADI activities will develop an overarching concept that will guide the next, necessary step in design and implementation of the U.S. AON as part of a coordinated, international, multi-disciplinary, long-term Arctic Observing System. The Task Force will explore and evaluate different approaches and methodologies of potential use in system design. Challenges that will be addressed include the broad, interdisciplinary scope of the AON, the goal to meet scientific as well as stakeholder needs, and the requirement to be adaptive during a period of rapid change.

The ADI process will help ensure that the AON efforts will yield results that will advance scientific understanding of the Arctic system and its variability and change, and at the same time aid individuals, communities and the nation in adapting and responding to rapid environmental change in the Arctic. Involvement of experts from outside the Arctic research community will broaden impacts by strengthening the ties between Arctic and lower-latitude observation programs. A report and recommendations will be circulated widely to further stimulate the discourse about the refinement of the Arctic Observing System towards optimal design and implementation.

1. Introduction and Background

The need for an Arctic Observing Network (AON) that tracks and fosters understanding of the complex of rapid Arctic environmental change presently underway, thereby improving projections of, and adaptation to, anticipated future change has been broadly recognized (SEARCH, 2003, 2005; NRC, 2006; IARPC, 2007). In response to this critical need, the scientific community has identified a broad set of key scientific questions in the context of the Study of Environmental Arctic Change (SEARCH) Science Plan (2001) and Implementation Workshop Report (SEARCH, 2005). Building an effective, scientifically robust AON requires planning, coordination and analysis of data and model output over a range of disciplines and scales. The International Polar Year (IPY) has fostered a substantial push for intense observation campaigns and deployment of sensor networks, ushering in a phase of more coordinated observing efforts. Of these, three programs are of particular relevance: the SEARCH AON, the European DAMOCLES program (Developing Arctic Modeling and Observing Capabilities for Long-term Environmental Studies, winding down but spawning sustained observing efforts) and the Canadian ArcticNet Program. With U.S. agencies and others maintaining complementary observation efforts in the Arctic, there is now an urgent need for coordination, consolidation and optimization of the existing observing system elements, as well as for development of a broader strategy that includes more detailed design studies to enhance and sustain the observing system. There is also an unprecedented opportunity to use the wealth of available observations from the Arctic to exploit their synergies and assess their contributions to a holistic depiction of the state of the Arctic.

The AON Design and Implementation (ADI) project is a two-phase, 12-month process to explore and define different options and provide guidance to the National Science Foundation (NSF), the scientific community and others engaged in Arctic environmental observations on how to best achieve a well-designed, effective and robust U.S. Arctic observing effort in the context of ongoing efforts to optimize and implement an international Arctic observing system. A Task Force of experts in the Arctic and broader scientific community knowledgeable in observing system design and related fields will work with other key experts to achieve these goals. Activities will include a combination of virtual and in-person meetings, two workshops and a small array of proof-of-concept or exploratory studies overseen by the Task Force, culminating in a report and recommendations to NSF.

Arctic Observing System Design Considerations

The planned activities will need to consider the following issues that define the nascent U.S. AON. These traits distinguish the AON to some extent from previous efforts in other arenas, such as the Tropical Atmosphere Ocean/Triangle Trans-Ocean Buoy Network (TAO/TRITON, McPhaden et al., 2009), or the Long Term Ecological Research network (Hobbie et al., 2003), among others. This is an opportunity for truly transformative research but also poses a significant challenge that will likely guide the Task Force approach. From the perspective of SEARCH and its observing component, the U.S. AON, a number of issues arise that need to be considered by individual researchers, the community involved in the implementation of the observing system, and funding agencies that support the system.

(i) *Guidance by science questions*: The observing system has to be guided by the science questions that underpin the Arctic environmental change programs (SEARCH for the U.S. and the International Study of Arctic Change, ISAC, as the emerging international umbrella). These science questions have matured in recent years and are captured in the several science plans, most recently in the ISAC science plan (ISAC, 2009).

(ii) *Comprehensive nature of observing effort:* The broad range of questions and disciplines that are part of the observing system presents a challenge to traditional approaches in designing and maintaining an appropriately balanced observing system (e.g., remote sensing vs. ground-based, synoptic surveys vs. point-based measurements, broad regions of interest).

(iii) *Coordination of measurement activities:* Individual projects derive guidance on specifics of measurement activities from broader program plans and project goals, but intercomparability and thematic compatibility of data sets require additional efforts in determining sampling rates, spatial resolution of measurements, site selection, and variables to be measured. International coordination, for example through initiatives such as ISAC, can help maximize synergy, e.g., through joint workshops or meetings on a regular schedule.

(iv) *Need for observing system to be highly adaptive:* The rate of change in the Arctic, in particular in relation to standard funding cycles or the response times of international research organizations and programs, requires new approaches in the design and optimization of an observing system. The complexity of the problem, the fast pace of change, and the importance of observing the anthroposphere in the context of SEARCH require that the observing system be highly adaptive, allowing for the system to evolve on the timescales required to track rapid change and plan for effective response. Abrupt changes that have to be expected in the transition of the Arctic into a new state pose challenges for the observing system, specifically concerning its capacity for high sampling rates.

(v) *Dual purpose of AON:* SEARCH explicitly identified the need for an Arctic observing system to serve the scientific community as well as serving information needs of key stakeholder groups. This duality of purpose requires novel approaches with respect to the design of an observing network, but will likely result in transformative research on the coupling between human activities and environmental change.

(vi) *Interdisciplinary nature of an observing system:* The interdisciplinary nature of many of the pressing SEARCH science questions and societal needs require a multi-disciplinary observing network with a degree of disciplinary intertwining and topical breadth that is pioneering at this scale. At present, funded AON projects (from CADIS web site, retrieved 24 April 2009) comprise the following topical areas: atmosphere (7), ocean and sea ice (18), hydrology and cryosphere (6), terrestrial ecosystems (3), human dimensions (1), data management and coordination (2). The current portfolio may change as the program evolves, and may require guidance to ensure the disciplinary balance needed to meet the overarching scientific goals of the program. At the same time, the concentration of atmosphere-ocean-sea ice projects reflects critical information needs and scientific opportunities.

Ideally, one would like to base the design and implementation of a complex observing system on a comprehensive theoretical framework with the following attributes:

(a) Capability to optimize distribution and mix of sensors for the set of variables that are identified by interpretation of existing data through synthesis, modeling and scale analyses.

(b) Exploration of tradeoffs between deployment of sensors for different variables and data streams that primarily satisfy scientific needs vs. those that satisfy primarily stakeholder information.

(c) Examination of irreversible loss of information on the Arctic system dynamics through termination or re-location of time series measurements.

(d) Determination of accuracy at which variables have to be measured to yield the information needed for answering the science questions underpinning the observing system.

Unfortunately, such theoretical frameworks are currently not available and will not be available for the foreseeable future because they depend on the capability to describe the dynamics of the integrated Arctic system in a 4-dimensional fashion. De facto, a fully coupled, multi-domain Arctic system model is needed as the starting point for such a theoretical approach to an observing system design. While steps toward the development of such a model are underway, there will continue to be a need for a more pragmatic and empirically based approach to ensure expedience in maximizing the return from investments into system-scale, integrated, long-term observing systems.

Empirical Approach to Arctic Observing System Design

The implementation of a sustained, pan-Arctic observing system can be considered as a hierarchy of sub-problems (Fig. 1). However, since implementation has progressed and continues to evolve at all levels of this hierarchy, questions of observing system design cannot be addressed in isolation (bottom-up or top-down) but need to be considered in the context of existing efforts. This process is naturally challenging but it allows continuation of the implementation of an increasingly complex and optimized observing system. Significant benefits can be derived from the synergistic implementation of different studies, initiatives and programs already underway. One promising strategy to draw on such benefits is to anchor the design and planning of the observing system in the context of the hierarchy shown in Fig. 1. The science questions that drive the observing system are well established and already guide the implementation of individual projects as well as that of the integrated system. The linkages between individual projects in the context of overarching trans-disciplinary programs such as SEARCH or ISAC is emerging but presently not fully developed. Similarly, there are emerging benefits from international coordination and implementation although this process is still in an exploratory stage (e.g., SEARCH for DAMOCLES).

It should be emphasized that although lacking a theoretically based approach, observing system design is already actively underway on a scientifically informed basis. For example, individual projects use information on the dynamics of the system including spatial and temporal scales of movement of air, water and ice for system design (Rigor et al., 2002; Lindsay and Zhang, 2006; Lee et al., 2009). They also make use of existing data sets by artificially reducing the data density in sections until some of the prominent features can no longer be resolved. Terrestrial observations utilize information on typical vegetation migration rates from modern or paleo-observations to design an observing program that would capture future northward migration of specific species (Jia et al., 2003). Modeling studies are increasingly analyzed for information on critical time scales, particle tracking to simulate Lagrangian experiments, or Eulerian type time series sampling to infer expected frequencies and amplitudes of perturbations at fixed points (Maslowski et al., 2000). These empirical designs are becoming more sophisticated as the data sets increase and the models are able to more realistically simulate processes in nature. Stakeholder information needs that inform an observing system can be assessed and prioritized through an analysis of services provided by the system and the institutions that govern use of these services (Eicken et al., 2009).

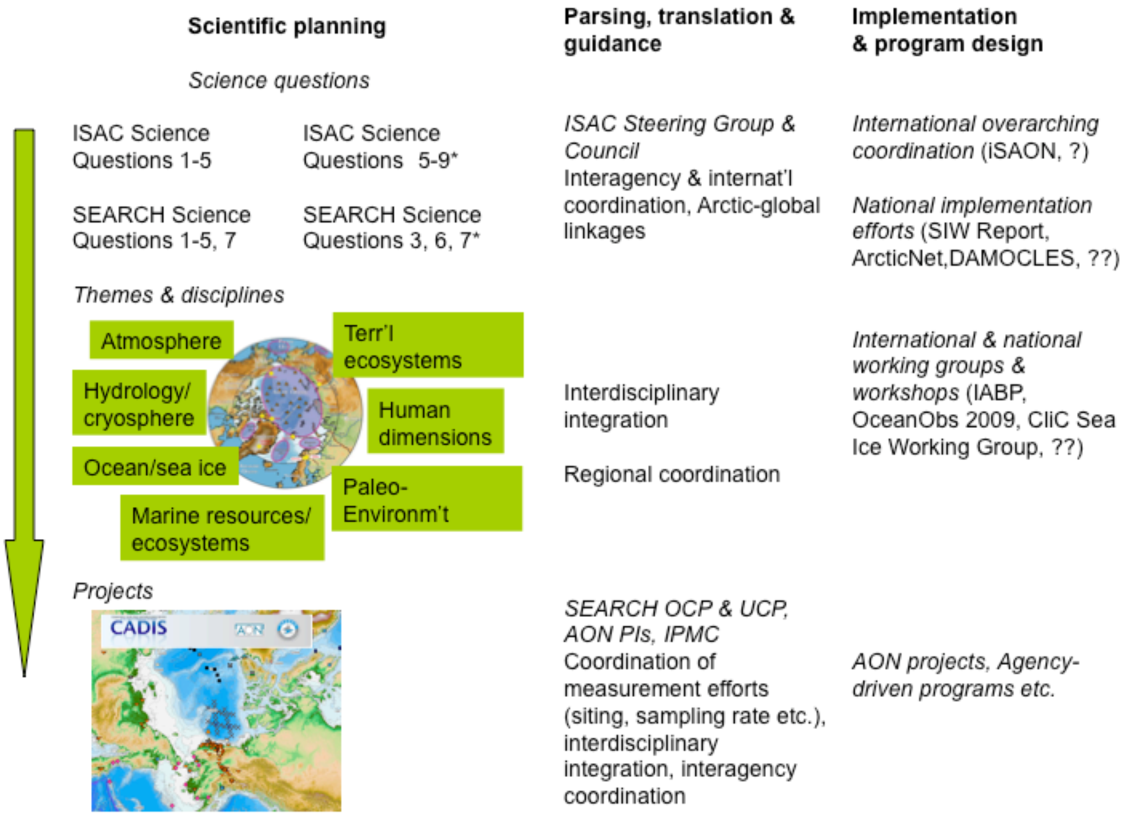

Figure 1: *Schematic of a hierarchy of approaches and activities governing design and implementation of an Arctic observing system. Note that the science questions in the left column have been separated into those primarily driven by fundamental research questions (left) and those that include specific information needs by different stakeholders (right, marked with asterisk). While this division is artificial (ultimately, all science questions meet societal information needs) it is helpful in organizing and prioritizing different research efforts.*

Most of the methods described above are applied to design observing activities on the scale that can be handled by single PI's or by PI groups. The design of system-scale, single-domain observing systems is still lagging behind the design of individual, geographically limited components, in terms of sophistication and optimization. Even more work has to be done to optimize observing system components that cross domains although these are exactly the type of observing systems that are needed for modern, theme-driven, system-based studies. Tackling these tasks has to be given immediate attention and high priority for effective observing system design and implementation and will be a key concern to the AON Design and Implementation (ADI) Task Force.

A significant challenge remains in particular for those components of an observing system that focus on the upper trophic levels of ecosystems and human activities. Time-space grids may work well for relatively static landscapes (such as in agricultural applications), but do not fit the dynamic and patchy distribution of animals and people in the Arctic. The observing system must be able to track specific populations that are present in discrete locations over space and time and be able to adapt observation efforts to best match the dynamics of these communities.

2. Objectives and Scope of ADI Task Force Activities and Related Efforts

The following objectives can guide the ADI Task Force activities and supporting efforts by the SEARCH panels and Science Steering Committee (SSC) and other relevant steering groups towards improvement of observing system design:

a. evaluate the current implementation status of the Arctic Observing System vis-à-vis the key science questions identified by the Arctic research community;

b. improve design and adaptation of observing system components through observing system simulation experiments and similar approaches;

c. synthesize information arriving from the existing observing system components and quantitative design studies to guide its design and refinement;

d. coordinate between individual national and international efforts. Here, ISAC can help with international aspects of coordination.

The process to advance these goals and the urgent need for guidance on AON design and implementation identified above includes the following tasks:

(1) Assessment of the present state and near-term implementation plans of the AON and related efforts

Under the leadership of Understanding Change Panel Chair John Walsh, SEARCH representatives (mainly members of its SSC, Observing Change and Understanding Change Panels [OCP, UCP]) with key contributors from the Arctic System Science Program (ARCSS) and the broader Arctic community are preparing an assessment of the AON in its current form. This review will examine how well the AON addresses the major Arctic Change science questions, identify newly emergent, high-priority science questions or drivers that should augment those in the SEARCH plan, as well as identify critical gaps or needs and make recommendations for the next steps in the integration of observing system efforts. A starting point for this activity is the Report from the 2008 Arctic Observations Integration Workshop (http://www.arcus.org/search/meetings/2008/aow/report.php). This activity will produce a brief report that the ADI Task Force can draw on to allow for more effective and rapid progress.

(2) Identifying and assessing effective, promising approaches and tools for observing system design and optimization

This objective is at the core of the ADI Task Force's charge. Given the lack of a comprehensive theoretical framework for observing system design and optimization applicable to the AON, the Task Force will consider a broad array of methods that provide information on the performance and options for future enhancement of the observing system. These methods include observing system simulation experiments (OSSE), evaluation of the information coming from the data assimilation community (e.g., reanalysis and forecasting projects, Bromwich et al., 2008) or tools such as manipulation of data sets to examine the data density required to capture the processes that determine the characteristic features of the observed system components. This process needs coordination, an interface with the AON data management system (such as the Cooperative Arctic Data and Information System, CADIS) and the involvement of the modeling community.

To initiate this process, a Task Force with relevant expertise has been convened, including experts from outside the Arctic research community. The composition and specific tasks of this group are outlined in more detail in Sections 3 and 4. Building on initial exchange through e-meetings and other communications, the first ADI workshop will be held December 2-4, 2009, in conjunction with the AON Principal Investigators' meeting November 30-December 2 in Boulder, CO, to lay out a strategy for choosing the most promising approaches and methods for Arctic observing system design and optimization. These activities constitute Phase I of the ADI process. The group will define a set of specific tasks, such as proof-of-concept activities, that will be taken up by individual PI's or small PI groups in Phase II of the ADI process. These tasks will need to be performed in a short period of time so that their results can inform the next steps in the development of the Arctic observing system as well as a second workshop in spring 2010 that will evaluate these and other relevant efforts. Phase II of the ADI process will conclude with completion of a report summarizing findings and recommendations for further future efforts and providing guidance to NSF on the design, implementation and longer-term perspective of an Arctic observing system. The observing system design would not only be informed by data from instrumental records and models, but would also utilize paleo-data to place the present changes into the proper historical context and strengthen the attribution studies.

(3) Synthesis and discussion of design options and approaches as part of the AON PI Meeting, fall 2009

Holding the first ADI Task Force Workshop in conjunction with the AON PI Meeting will ensure effective meeting flow, introduce and inform Task Force members of ongoing activities, and offer an opportunity to synthesize ongoing activities reported at the level of themes or disciplines rather than individual projects, with invitees from within and outside of SEARCH to provide broader-scale evaluations. The participation of AON PIs who have spent significant time and effort on the (mostly) disciplinary and region-specific aspects of an AON will allow for productive discussion of these synthesis talks. Participating members from the AON program, the SEARCH SSC, OCP and UCP will provide perspectives on system design approaches in the context of SEARCH. Personnel involved in observation programs supported by other nations and agencies will provide input on pan-Arctic and interagency coordination aspects where needed.

(4) White paper on Arctic observing system design

A more fundamental examination of the design philosophies, options and challenges for a comprehensive AON may require the form of a white paper that draws on, but goes well beyond efforts currently underway at the disciplinary or project-level (Fig. 1). Such a white paper may draw on existing efforts at identifying needs and approaches towards observing system implementation, such as the white paper prepared for the OceanObs 2009 Symposium or the reports put together for the Arctic Council's Snow, Water, Ice and Permafrost in the Arctic Assessment. The group working on such a white paper would comprise a small but balanced mix of Arctic experts and potential contributors from outside of the polar community. The paper would address in particular those aspects unique to the AON and try to map out the fundamental aspects of a design and implementation strategy that successfully addresses the challenges outlined above. The paper would serve as a discussion item and potential contribution to the deliberations by the Task Force.

Additional considerations: Interagency coordination and guidance on societal information needs

An AON that is embedded in SEARCH as an interagency effort will require effective and far-reaching coordination among different agencies involved in Arctic observation programs. Some agencies also have resources and expertise pertaining to design of observing systems at lower latitudes that may be of relevance. Identifying and cultivating effective means of coordination will require a dedicated effort, including key contacts for AON design and implementation discussions within different agencies and—to ensure resources for coordination efforts—involvement of agency representatives at higher levels. The Interagency Program Management Committee (IPMC) and the Interagency Arctic Research Policy Committee (IARPC) can provide crucial guidance and help facilitate such efforts and will be kept apprised of ADI Task Force activities.

A key aspect of the SEARCH program is the integration of activities that address the observation, understanding and response to Arctic environmental change. Hence, even in a quantitative, scientifically driven effort at observatory system design, guidance on the societal information needs component of an observing system will be critical. In order to help with this task, key experts should contribute to the different activities outlined above. In particular, stakeholders and governments have needs for data at unique spatial and temporal scales relevant to human activities.

3. Members of the Arctic Observing Network (AON) Design and Implementation (ADI) Task Force September 2009

The membership of the ADI Task Force seeks to represent a good balance between Arctic researchers and observing system design experts from other fields outside of the Arctic, as well as expertise on observing system design covering a broad range of approaches. While representation of key disciplines is important, it is also recognized that the currently funded AON projects reflect the broadly recognized notion that changes in the Arctic Ocean–sea ice–atmosphere system are of particular importance and urgency in understanding and responding to Arctic change (Serreze et al., 2007; Brigham, 2007; Jia et al., 2003; Overland et al., 2008; Burn and Zhang, 2009).

The following individuals are members of the ADI Task Force. Members of the Executive Committee are indicated with an asterisk, and each member's relevant expertise is listed in italics:

Sandy Andelman
Conservation International
Phone: 703-341-2690
E-Mail: s.andelman@conservation.org
Terrestrial ecology and sensor network design

*Hajo Eicken
Geophysical Institute (GI)
University of Alaska Fairbanks
Phone: 907-474-7280
E-Mail: hajo.eicken@gi.alaska.edu
Sea ice geophysics,
Incoming Chair, SEARCH SSC,
Outgoing Chair SEARCH OCP

Lawrence C. Hamilton
Department of Sociology
University of New Hampshire
Phone: 603-862-1859
E-Mail: lawrence.hamilton@unh.edu
Arctic human dimensions studies

Marika Holland
Climate and Global Dynamics Division
National Center for Atmospheric Research
Phone: 303-497-1734
E-Mail: mholland@ucar.edu
General circulation models and atmosphere-ice-ocean interaction

Craig M. Lee
Applied Physics Laboratory (APL)
University of Washington
Phone: 206-685-7656
E-Mail: craig@apl.washington.edu
Autonomous underwater vehicles and sensor networks, physical oceanography
Incoming SEARCH OCP Co-Chair

Breck Owens
Physical Oceanography
Woods Hole Oceanographic Institution
Phone: 508-289-2811
E-Mail: bowens@whoi.edu
Argo Program and autonomous ocean observation network design

Mohan Ramamurthy
Unidata Program Center
University Corporation for Atmospheric Research
Phone: 303-497-8661
E-Mail: mohan@ucar.edu
Data assimilation, cyberinfrastructure and related tools

*Peter Schlosser
Lamont-Doherty Earth Observatory
Columbia University
Phone: 845-365-8707
E-Mail: schlosser@ldeo.columbia.edu
Global tracer oceanography
Outgoing Chair, SEARCH SSC

Mark C. Serreze
Cooperative Institute for Research in Environmental Sciences
National Snow and Ice Data Center
Phone: 303-492-2963
E-Mail: serreze@kryos.colorado.edu
Arctic climate, data management and dissemination
ARCSS Committee and UCP member

John R. Vande Castle
LTER Network Office
University of New Mexico
Phone: 505-277-2634
E-Mail: jvc@unm.edu
Technology and remote sensing in terrestrial ecology

Charles Vörösmarty
NOAA-CREST Center
City College of New York
Phone: 212-650-8099
E-Mail: charles.vorosmarty@unh.edu
Hydrology and water use
Director of Environmental Crossroads Initiative

*John E. Walsh
International Arctic Research Center (IARC)
University of Alaska Fairbanks
Phone: 907-474-2677
E-Mail: jwalsh@iarc.uaf.edu
Arctic atmosphere, ocean and sea-ice climatology and dynamics
SEARCH UCP Chair

Alison York
Arctic Research Consortium of the U.S. (ARCUS)
Phone: 907-474-1600
E-mail: york@arcus.org
SEARCH Project Office staff

4. ADI Phase I: Fall ADI Workshop, Scope and Planning of Activities

While some of the Task Force activities can be accomplished outside of in-person meetings, there is an urgent need for the workshop outlined in Section 2 (# 2) above. There have been meetings in the past discussing the broader implementation and general design of the AON, notably the SEARCH Implementation Workshop in 2005 and the Arctic Observation Integrations Workshops in 2008. However, at this point there has not been a meeting (or other activity) discussing design and implementation of an AON at the level of specificity outlined above. Moreover, so far the discourse has mostly been within the Arctic research community; this meeting would be the first to have dedicated involvement from experts outside of the Arctic, with significant benefits to be derived for the broader Arctic research community and strengthening of those aspects of SEARCH focusing on low-high latitude linkages.

A rough outline of a potential agenda for the first ADI Workshop, planned for 2-4 December 2009, in conjunction with the AON Principal Investigators' meeting November 30-December 2 in Boulder, CO, includes the following:

- Introduction to SEARCH/AON, expectations from NSF, overview of the Task Force charge
- Brief review of SEARCH science questions (as updated by UCP, see Section 2, #1 above) and AON implementation status (summarizing results from AON PI meeting, see Section 2, #3 above)
- Definition of the problem and task at hand
- Examples of successfully implemented observation networks, lessons learned as applicable to AON: LTER, TAO, etc.
- Review of challenges specific to AON
- Review of principal approaches, methods and tools relevant for observing system design and implementation
- Discussion of next steps: Proof-of-concept, exploratory studies
- Discussion of next steps: Other activities and planning of report
- Workshop conclusions and recommendations

In addition to the members of the Task Force (section 3, above), workshop participants will include another 15 to 25 individuals representing key areas of expertise and backgrounds. The Organizing Committee for the workshop will be constituted of the ADI Task Force Executive Committee and a few other key Task Force Members/Participants.

Once the Task Force with input from workshop participants has determined a plan of action, and following consultations with NSF and other key partners, then Phase II of the ADI process will go forward, and a proposal detailing the next steps and seeking support for them will be submitted.

5. Timeline of Task Force Activities and Management Plan

Table 1 provides a list, associated timeline and responsibilities for activities that are part of the *ADI Task Force's* portfolio or that are relevant for their work. An *Executive Committee* for the ADI Task Force will assure that milestones and deadlines (Table 1) are met, communication with NSF is maintained, and to oversee SEARCH Project Office (SPO) support of the ADI process. The broader group of participants in the two ADI workshops will inform and directly contribute to the deliberations and recommendations that will culminate in the report to be completed by late spring/early summer 2010.

A key aspect of the ADI process will be the completion of small-scale proof-of-concept or *exploratory studies* that will help the ADI Task Force evaluate the potential value of different approaches and methodologies. The ADI Task Force will work with Fall ADI workshop participants in identifying promising approaches and target PIs for involvement. While it is anticipated that NSF will have resources available allowing such studies recommended by the ADI Task Force to go ahead (likely at the level of c. $20k each for between five and ten projects), it will be up to the PIs to seek funding support in a manner that would allow completion for the April 2010 deadline.

Table 1: Timeline of ADI process and Task Force activities. Phase I activities are indicated in green. ADI organizers will seek support for Phase II activities (in yellow) after the task force develops a specific plan of action for their completion.

Activity	***Lead***	***Time period***
Assess state of AON implementation relative to SEARCH/ISAC questions (incl. critical updates to SEARCH science questions)	UCP et al. (Walsh)	June-October 2009
Planning of AON PI Mtg	OCP (Lee & Eicken)	June-October 2009
Identify potential members of ADI Task Force	Eicken, Schlosser, Walsh	July-August 2009
Task Force initiates ADI process, plans ADI Fall workshop	Eicken, Schlosser, Walsh	August-October 2009
Assemble small team for observing system white paper	Eicken, Schlosser	August 2009
ADI Task Force reviews UCP AON status document	ADI	October 2009
AON PI Meeting	OCP & JOSS/NCAR & SPO	November 30-December 2, 2009
Fall ADI Workshop	ADI & JOSS/NCAR & SPO	December 2-4, 2009
ADI Task Force identifies key proof-of-concept and exploratory design exercises	ADI	November/December 2009
ADI Task Force Executive Group to visit with NSF and other programs in DC	ADI Executive Group	December 2009/ January 2010
Small ADI Task Force follow up and planning meeting	ADI	January-February 2010
Exploratory studies underway	Indiv. PIs	January-April 2010
White paper on observing system due to ADI	Eicken, Schlosser	April 2010
ADI Task Force reviews results from exploratory studies	ADI	April/May 2010
Spring 2010 ADI Workshop	ADI & SPO & TBD	May 2010
ADI Task Forces prepares first draft of report	ADI	June 2010
Final report due at NSF	ADI	July 2010

References Cited

Bromwich, D. H. and others, 2008: A multi-year Arctic system reanalysis. *9th WRF Users' Workshop,* http://www.mmm.ucar.edu/wrf/users/workshops/WS2008/abstracts/P6-07.pdf.

Burn, C. R. and Zhang, Y., 2009: Permafrost and clinmate change at Herschel Island (Qikiqtaruq). *J. Geophys. Res.,* 114: F02001, doi: 02010.01029/02008JF001087.

Committee on Designing an Arctic Observing Network, N. R. C., 2006: *Toward an integrated Arctic Observing Network*. Washington: National Academies Press, 1-182 pp.

Eicken, H., Lovecraft, A. L., and Druckenmiller, M., 2009: Sea-ice system services: A framework to help identify and meet information needs relevant for Arctic observing networks. *Arctic*: 62(2), 119-136.

Hobbie, J. E., Carpenter, S. R., Grimm, N. B., Gosz, J. R., and Seastedt, T. R., 2003: The U.S. Long Term Ecological Research Program. *Bioscience,* 53: 21-32.

Interagency Arctic Research Policy Committee, IARPC, 2007: Arctic Observing Network: Toward a U.S. contribution to pan-Arctic observing. *Arctic Res. U.S.,* 21: 1-94.

ISAC, 2009: *International Study of Arctic Change - Science Plan*. Stockholm: ISAC Program Office.

Jia, G. S. J., Epstein, H. E., and Walker, D. A., 2003: Greening of arctic Alaska, 1981-2001. *Geophys. Res. Lett.,* 30: -.

Lee, C. M. and others, 2009: Autonomous platforms in the Arctic Observing Network. *OceanObs 2009*.

Lindsay, R. W. and Zhang, J., 2006: Arctic Ocean ice thickness: Modes of variability and the best locations from which to monitor them. *J. Phys. Oceanogr.,* 36: 496-506.

Maslowski, W., Newton, B., Schlosser, P., Semtner, A., and Martinson, D., 2000: Modeling recent climate variability in the Arctic ocean. *Geophys. Res. Lett.,* 27: 3743-3746.

McPhaden, M. J. and others, 2009: The global tropical moored buoy array. *OceanObs 2009*.

Overland, J., 2008: The Arctic and Antarctic: Two faces of climate change. *Eos, Trans. Am. Geophys. Un.,* 89: 177-178.

Rigor, I. G., Wallace, J. M., and Colony, R. L., 2002: Response of sea ice to the Arctic Oscillation. *J. Climate,* 15: 2648-2663.

SEARCH, 2005: *Study of Environmental Arctic Change: Plans for implementation during the International Polar Year and beyond. Report of the SEARCH Implementation Workshop, May 23-25, 2005*. Fairbanks: Arctic Research Consortium of the United States.

SEARCH SSC and IWG, 2003: *SEARCH: Study of Environmental Arctic Change, Implementation strategy, revision 1.0*. Polar Science Center, Applied Physics Laboratory, University of Washington, Seattle.