The Arctic Observing Summit

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Outline

- Context
- Arctic Observing Summit
- AOS 2018 Recommendations
- Perspectives
Context

- We have entered the Anthropocene, i.e., a unique era with a cascade of fast accelerations …
- Virtually all physical, chemical, biological, socioeconomic, and sociocultural systems of our planet are on non-sustainable paths
- Some subsystems are close to or have exceeded critical thresholds (Planetary Boundaries/Constraints)
- We are experiencing changes of the Earth System on extremely short time scales
- This represents biggest challenge for humankind for foreseeable future
Context

- Next to the low Lying Island Nations (AOSIS), the Arctic Region is showing the strongest impacts of global change.
- Changes in the Arctic occur early and with amplified amplitudes.
- Even the best scenarios presently discussed (Paris Accord; IPCC SR 15) will lead to a temperature increase of ca. 3.5 to 5°C in the Arctic.
- As the Arctic system is already responding to the change in a mode of self-adaptation, strategic decision making informed by pan-Arctic observations is more urgent than ever.
- Responses to changes rely on complete picture of the evolution of the Arctic system.
- Such a picture relies heavily on a comprehensive Arctic Observing System.
Warming of the climate system is unequivocal, and since the 1950s, many of the observed changes are unprecedented over decades to millennia. The atmosphere and ocean have warmed, the amounts of snow and ice have diminished, sea level has risen, and the concentrations of greenhouse gases have increased (see Figures SPM.1, SPM.2, SPM.3 and SPM.4). {2.2, 2.4, 3.2, 3.7, 4.2–4.7, 5.2, 5.3, 5.5–5.6, 6.2, 13.2}

“Because of a variety of positive feedback mechanisms, the Arctic is likely to respond rapidly and more severely than any other area on Earth, with consequent effects on sea ice, permafrost, and hydrology.”

IPCC 2001 (Technical Basis p. 807)
Global Surface Temperature

NASA GISS
http://www.nasa.gov/topics/earth/features/2012-temps.html
Global Warming of 1.5°C

An IPCC special report on the impacts of global warming of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty.
Impacts and risks for selected natural, managed and human systems

Global mean surface temperature change relative to pre-industrial levels (°C)

- Warm water corals
- Mangroves
- Small scale low latitude fisheries
- Arctic Region
- Terrestrial Ecosystems
- Coastal flooding
- Fluvial Flooding
- Crop Yields
- Tourism
- Heat-related morbidity and mortality

Confidence level for transition: L=Low, M=Medium, H=High and VH=Very high

Level of additional impact/risk due to climate change
Time Scale for Response: Ca. 1 decade
Sea-ice trends: ice extent

2007: Minimum sea ice extent
2008: Record-low sea ice volume
2012: New sea ice extent minimum

Nature of Arctic Ocean is changing dramatically at present – changes will be more fundamental in a 2°C world.
Impacts

The observed changes have large impacts on Arctic:

• Fisheries
• Land cover
• Erosion
• Infrastructure
• Vegetation zones, forest fires
• Socioeconomic/Sociocultural systems

These impacts translate to more urgency in solving the scientific questions underlying the observed changes
Arctic Science Ministerial (ASM II)

- Strengthening, integrating and sustaining Arctic observations, facilitating access to Arctic data, and sharing Arctic research infrastructure;
- Understanding the regional and global dynamics of Arctic change;
- Assessing the vulnerability and building resilience of Arctic environments and societies.

- Arctic Observing Summit directly addresses topic 1 of Arctic Science Ministerial II
Arctic Observing Summit (AOS)

- SAON Task
- Biennial gathering, workspace and forum:
  - **GOAL**: Design, implementation, coordination & sustained operation of international, pan-Arctic observing system
    - Network: Arctic observing system of systems
    - Comprehensive: cross-disciplinary
    - Community-driven
    - Science-based guidance

- Planning and development led by **ISAC and partners (IASC, SAON, others)**

www.arcticobservingsummit.org
The Arctic Observing Summit (AOS)

- **PLATFORM:** address urgent & broadly recognized needs of Arctic observing across all components of the Arctic System

- **FORUM:** optimizing resource allocation, minimizing gaps; avoiding duplication.

- **WORKSPACE:** develop solutions, recommendations, and make tangible contributions for operation
Arctic Observing Summits

- 1\textsuperscript{st}: AOS \textbf{2013: Vancouver}, B. C. Canada
- 2\textsuperscript{nd}: AOS \textbf{2014: Helsinki}, Finland (with ASSW 2014)
- 3\textsuperscript{rd}: AOS \textbf{2016: Fairbanks}, USA (with ASSW 2016)
- 4\textsuperscript{th}: AOS \textbf{2018: Davos}, Switzerland (with POLAR 2018)

XXXV SCAR Biennial Meetings
Arctic Science Summit Week 2018 &
IASC Business Meetings
SCAR/IASC Open Science Conference
2018 Arctic Observing Summit
The Business Case for a pan-Arctic Observing System

- Propose to the highest levels of government, the business case for a comprehensive pan-Arctic observing system.” (AOS Conference Statement 2016)

- The AOS 2018 focused on pressing issues in the implementation and support of sustained observations that can be addressed through a business-case lens.
AOS 2018 Recommendations

- Since the AOS-2016 (Fairbanks, Alaska, USA), analytical advances, in a series of efforts that emerged from the first Arctic Science Ministerial (ASM1), have provided quantitative and qualitative valuation methods to support informed decisions drawing on the societal benefits of sustained observing systems and accessible data. **Case studies for selected Arctic challenges have shown positive return on investment, motivating our call for action to coordinate and extend sustained observations.**
Compared to other, more populated parts of the globe, Arctic observations rely heavily on research projects, rather than operational infrastructures and initiatives. There is an urgent need to progressively shift key observing system components – including community-based observations – from short-term research funding to sustained, operational infrastructure support. The operational infrastructure of the Arctic Observing System must target key variables that capture the Arctic system’s main features. It has to be augmented by observing a broader set of variables required for addressing topical problems through research projects. Such a system also serves a critical function as information infrastructure in support of global services derived from the Arctic system.
AOS 2018 Recommendations

- A properly resourced, comprehensive effort is needed to identify strengths and gaps in the current set of systems, sensors, networks, and surveys used to observe the Arctic. A knowledge map connecting these observations to societal benefits can then guide new observations, data management needs, and development of products and services, leading to a much-needed roadmap for Arctic system observing. Support for an international and local team of experts to complete these tasks under the auspices of SAON will greatly increase the benefits derived from Arctic observing activities and is deemed critical for successful deployment and sustained operation of an Arctic Observing System.
Observing and data systems, at different spatial and temporal scales, have to emerge from co-design, co-production, and co-management processes with relevant stakeholders and rights-holders embracing free, ethical, and open data sharing, adhering to the “FAIR” data principles (Findable, Accessible, Interoperable, Reusable) are essential.
To build an Arctic Observing System that is comprehensive, coordinated, sustainable, and fills current observational gaps, all existing assets and activities, including Indigenous knowledge, must be leveraged to the greatest extent. Such a system needs to span the full range of spatial and temporal observation scales. This is achievable by combining multiple observational methods and technologies, including Indigenous knowledge, community-based monitoring and citizen science, and by linking all relevant data systems.
Perspectives

- Need for Arctic Observing System has been firmly established
- Components of the system are being implemented in a network fashion
- Multi-Stakeholder nature of system well established
- International contributions are growing
- International collaboration is increasing
- Long-term support still a problem
- Danger of gaps in emerging time series
- ASM can play a critical role in securing implementation and operation of a comprehensive, long-term Arctic Observing System
Continued emissions of greenhouse gases will cause further warming and changes in all components of the climate system. Limiting climate change will require substantial and sustained reductions of greenhouse gas emissions. \{6, 11–14\}

Global surface temperature change for the end of the 21st century is likely to exceed 1.5°C relative to 1850 to 1900 for all RCP scenarios except RCP2.6. It is likely to exceed 2°C for RCP6.0 and RCP8.5, and more likely than not to exceed 2°C for RCP4.5. Warming will continue beyond 2100 under all RCP scenarios except RCP2.6. Warming will continue to exhibit interannual-to-decadal variability and will not be regionally uniform (see Figures SPM.7 and SPM.8). \{11.3, 12.3, 12.4, 14.8\}
IPCC 2013: Global Surface Temperature

Global ΔT: 0.85 [0.65 to 1.06] °C, over the period 1880 to 2012. ('It is virtually certain that globally the troposphere has warmed since the mid-20th century'.)
The Business Case for a pan-Arctic Observing System

1. The Need for the Observing System
2. Implementing and Optimizing a Pan Arctic Observing System
3. Leveraging Observing Systems and Networks
The Arctic in the Earth system: remote, pristine, exotic vs changing rapidly

- Gateway between Pacific and Atlantic
- Land-locked ocean, ice-covered
- Large ice masses on land
- Permafrost
- Vulnerable ecosystems
- Long and rich culture
Continued emissions of greenhouse gases will cause further warming and changes in all components of the climate system. Limiting climate change will require substantial and sustained reductions of greenhouse gas emissions. {6, 11–14}
Sea-ice trends: Simulations

Holland et al. 2006

(b) The Run 1 (black) and observed (red) 1990s averaged September ice edge (50% concentration) and Run 1 conditions averaged over 2010–2019 (blue) and 2040–2049 (green). The Arctic region used in our analysis is shown in grey.

Models simulate abrupt changes
AOS Goals

- To provide community-driven, science-based guidance for the design, implementation, coordination and sustained long-term (decades) operation of an International Network of Arctic Observing systems that serves a wide spectrum of needs.

- To create a forum for coordination and exchange between researchers, stakeholders, and funding agencies involved in long-term observing activities.
AOS Objectives, Products, Audience

- Engage academia, government agencies and other Arctic stakeholders (e.g. local communities, industry, non-governmental organizations).

- Assess the scientific basis for the Arctic observing activities.

- Synthesize network design options and observing priorities into recommendations for decision makers.

- Identify network issues that require SAON attention.
Academia’s New Challenge

- The industrial revolution can be seen as the starting point of a cascade of accelerations in human development and use of resources that push the planet towards the limits of its capacity.
- The Industrial Revolution changed Academia fundamentally.
- In order to respond to these challenges that are a real threat to global society, academia has to become more proactive and has to change its structures and pace of knowledge generation and translation into the solution and implementation domains.
- Earth Science has to position itself in this new context.
- Besides the curiosity-driven, ‘basic’ research, it has to accept new roles in ‘applied’, solution-oriented research that directly addresses societal challenges.
- This has to occur in close collaboration with other disciplines.
During the past three centuries the world population increased by a factor of about 10.

The energy use increased by a factor of ca. 16 in the 20th century causing increases of CO₂ and SO₂, among other effects.

The use of fossil fuels and agriculture led to increases in the concentration of the greenhouse gases CO₂ and Methane by ca. 40 and 100 %, respectively.

Crutzen, Nature, 2002
Earth System under Stress (2)

- Ca. 30–50% of the Earth surface is used anthropogenically
- More than half of Earth’s freshwater is used anthropogenically
- The amount of nitrogen fertilizer used in agriculture is larger than the nitrogen naturally fixed by all global ecosystems.
- ...

Crutzen, Nature, 2002
So far, these effects were caused by only ca. 25% of the world population. Consequences include global warming, acid rain, or smog. The role of humans in the Earth system is so large that a new geological unit of time, the ‘Anthropocene’ has been proposed (for example: Crutzen, Zalasiewicz).
Continued emissions of greenhouse gases will cause further warming and changes in all components of the climate system. Limiting climate change will require substantial and sustained reductions of greenhouse gas emissions. [6, 11–14]
Sea Ice Trends: Ice Extent

http://nsidc.org/arcticseaicenews/
Arctic System on Trajectory to New, Seasonally Ice-Free State

Big Sky meeting, 2003

20 plus scientists from diverse backgrounds

Need for Complex systems theory and modeling

Fig. 2. (a) Schematic of the essential components (or hubs) of the present Arctic system. The main interactions between hubs are denoted by arrows: Single or double arrowheads indicate one- or two-way interactions. Interaction strength is designated by arrow thickness, and the sign (plus or minus) indicates whether a change in one component produces a change in another of the same (plus) or opposite (minus) sign. Numbers in parentheses within each hub indicate the number of interactions going out of and coming into that hub. Driver hubs are blue; recipient hubs are yellow. (b) The Arctic system in the future after loss of substantial permanent ice.
Sea Ice Trends: Ice Extent

http://igloo.atmos.uiuc.edu/cgi-bin/test/testimage.2.sh?first=19790915.png&second=20120916.jpg
Global warming projections

Figure 2.3: Simulated year-to-year transport change of the Atlantic "conveyor belt" (Atlantic overturning) in a range of global warming scenarios computed by different climate research centres. Shown is the annual mean relative to the mean of the years 1991 to 1995 (1992, 1993, 1995). The past forcings are only due to greenhouse gases and aerosols. The future-forcing scenario is the IS92x scenario. See Table 9.1 for more information on the individual models used here.

Figure 2.4: Changes in surface air temperature caused by a shutdown of North Atlantic Deep Water (NADW) formation in a current ocean-atmosphere circulation model. Note the hemispheric seesaw (Northern Hemisphere cools while the Southern Hemisphere warms) and the maximum cooling over the northern Atlantic. In this particular model (HadCM3), the surface cooling resulting from switching off NADW formation is up to 6°C. It is further to the west compared to most models, which tend to put the maximum cooling near Scandinavia. This probably depends on the exact location of deep-water formation (an aspect not well represented in current coarse-resolution models) and on the sea-ice distribution in the models, as ice-margin shifts act to amplify the cooling. The largest air temperature cooling is thus greater than the largest sea surface temperature (SST) cooling. The latter is typically around 5°C and roughly corresponds to the observed SST difference between the northern Atlantic and Pacific at a given latitude. In most models, maximum air temperature cooling ranges from 6°C to 11°C in annual mean; the effect is generally stronger in winter.

Ocean circulation and climate during the past 120,000 years

Stefan Rahmstorf

Promotionsbeitrag für Umweltforschung, FU Berlin, 2001, Hrsg. o.D., Berlin, Germany

IPCC, TAR, 2001
Impacts: coastal erosion

http://cires.colorado.edu/science/features/thawingalaska/
1. **Supplying critical components for development of a pan-arctic Perspective**
   - *Plan, implement, and support an arctic observing network.*
   - *Facilitate access to distributed systems of hardware, software, information bases, and automated aids for data management, synthesis, interpretation, and modeling.*
   - *Improve communication and data transmission capabilities, remote field power options, and access to satellite observations.*

2. **Supporting the infrastructure for safe and efficient research**

3. **Maximizing resources and cooperation**
   - *Facilitate international coordination and cooperation.*
   - *Pursue interagency collaborations.*
   - *Enhance communication and partnerships with arctic communities.*
   - *Maintain and disseminate arctic expertise and train the next generation of arctic field experts.*

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**RSLWG report, 2003**

[http://www.arcus.org/Logistics/ArcticLogistics_10_03.pdf](http://www.arcus.org/Logistics/ArcticLogistics_10_03.pdf)
SEARCH

OBSERVATIONS
Long-term and Pan-Arctic

MODELING
Data Assimilation

Understanding and Prediction

PROCESS STUDIES
Understanding Processes

Understanding Specific Links

APPLICATION

Impact on Ecosystem and Society

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
Pan – Arctic observing systems

U.S. PRB: AON report; 2006

Local and traditional knowledge

International Partnerships; e.g.: SEARCH, DAMOCLES, ArcticNet, ISAC, SAON
Features of an Arctic Observing System/Network

- Pan-Arctic
- Multi-Domain
- Long-Term, Sustained
- Multi-Stakeholder (science and solution space)
- Network (System of Systems)
- Internationally coordinated
- Flexible Design
- Empirical Approach
- Optimization – OSSE
A Pan-Arctic Observing System must be:

- **integrated** one allowing for merging of data streams
- **focused** around central science questions and societal needs
- **relevant** to people’s lives, decision making and policy

Observing System Design:

- is **critical**
- the system should be **responsive** to arctic system change
- responsive to needs for improved **understanding** and **adaptation** to and **mitigation** of change.

The AOS must be **connected** with global observing systems.

(from: ISAC Science Plan 2010)
Scientific Challenges

IPY 2007-2008 is an opportunity to deepen our understanding of the physical, biological, and chemical processes in the polar regions and their global linkages and impacts, and to communicate these insights to the public. Five broad scientific challenges provide a framework for organizing IPY activities:

- Assessing large-scale environmental change in the polar regions, with questions looking at both the physical and human dimensions of change and its impacts.
- Conducting scientific exploration of “new” frontiers, whether these are once inaccessible places such as the seafloor, or areas of inquiry that are now open because of advances in technology, such as how the tools of genomics now allow exploration of previously unanswerable questions about biological adaptation.
- Observing the polar regions in depth, with adequate coverage of the vast and challenging landscape, to provide a description of current conditions and allow for better future understanding of variability and change.
- Understanding human-environmental dynamics in a region where the connections are intimate and where the impacts of change are clear.
- Creating new connections between science and the public, using these regions that are inherently intriguing.
Dickson et al., 2006

Figure 1. The elements of an integrated Arctic Ocean Observing System showing a) the ship-based Shelf Basin Exchange transects, b) the proposed mooring system for Shelf, Slope, Basin and Gateways c) grids of Ice-Tethered Platform and Tiltmeter Buoy (positions figurative) and d) the full combined deployment.
The integrated Arctic Ocean Observing System (iAOOS) in relation to ICARP, IPY and the multidecadal SEARCH and ISAC studies of Arctic change.

Dickson et al. 2006
Long-Term Stability

- DAMOCLES
- ACCESS
- INTERACT
- AOS
- ARCTIC NET
- SEARCH
- ISAC
- IPY
- ICARP II
- ICARP III

Global Float Array (ARGO)

3918 Floats
15-Mar-2016

[Map showing global float array with gridlines and distribution of float locations]
World Ocean Circulation Experiment
Global Repeat Hydrography
Remote Sensing

GPM Constellation Status

- MetOp B/C (EUMETSAT)
- Suomi NPP (NASA/NOAA)
- GPM Core Observatory (NASA/JAXA)
- TRMM (NASA/JAXA)
- Megha-Tropiques (CNES/ISRO)
- NOAA 18/19 (NOAA)
- JPSS-1 (NOAA)
- DMSP F17/F18/F19/F20 (DOD)
- GCOM-W1 (JAXA)

United States, Japan, France, India, European Union.
International Arctic Buoy Project
Ice Tethered Platforms
Hydrographic Sections

18 cruises
621 stations
Age Structure of AW

Pasqualini/Schlosser
Unpublished data

230 stations
c.a. 1300 data points

Apparent spreading rate = 0.82 cm/s
(95% confidence bounds: 0.778 0.867)
$R^2 = 0.8997$
Multi-Ship Operations

Canadian icebreaker Louis S. St.-Laurent

Russian icebreaker Kapitan Dranitsin

Norwegian RV LANCE

Moorings deployed in 2005
NABOS/CABOS moorings with multiyear records
Originally planned NABOS moorings

NABOS program, Polyakov et al.; IARC
Permafrost
Key role for new technology

- Reaching remote areas
- Operation under ice
- Continuous measurements
- Adjustable data collection patterns
- Real time data delivery
- Cost effective
- ...

![Image of gliders and related equipment]
Dickson et al. 2006
Circulation Patterns

FSBW - $^3$H/$^3$He Age

$\sigma_0 = 27.901$

$27.866 \leq \sigma_0 \leq 27.936$

stations with age data: 230

BSBW - $^3$H/$^3$He Age

$\sigma_0 = 27.9085$

$27.95 \leq \sigma_0 \leq 28.02$

stations with age data: 234
A 5°C Arctic in a 2°C World

CHALLENGES AND RECOMMENDATIONS FOR IMMEDIATE ACTION FROM THE JULY 21-22, 2016 WORKSHOP

Briefing Paper for Arctic Science Ministerial
September 20, 2016
(a) Enhance and support research in projecting which future states of the Arctic are possible in principle, under which conditions they can be reached, and which impact they would have.

(b) Design, initiate, and support a platform for a broad stakeholder dialogue on which future state of the Arctic we should strive for, drawing on existing local and regional platforms. The outcomes of the continuing dialogue have to inform decision-making processes in the context of the evolving Arctic trajectory.

(c) Expedite research on adaptation of the Arctic to ongoing and expected environmental changes and provide resources for implementation of science-based adaptation strategies.

(d) Ramp up technical and financial support for Arctic societies needing strategic adaptation solutions—including relocation and soft infrastructure support (building codes, zoning, and others).

(e) Complete and sustain the emerging Arctic Observing System, augmented by early warning components and enhanced Arctic system models to closely track key components of the changing Arctic.

(f) Unify the voices of the Arctic Nations and those global actors interested in the future of the Arctic in support of the science needed for immediate upscaling of efforts in global decarbonization and negative emissions schemes.

(g) Deploy measures for deep decarbonization of the global energy system and accelerate the upscaling and deployment of technologies for negative carbon emissions. Unify the efforts for allocating resources to master this historic challenge.