Arctic Forum 2007

Abstracts

Water in the Arctic:
International Collaborations and Understanding Environmental Change

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Cover Photo: Ice pillars caused by water eroding the ice near Barrow, Alaska, observed by Teachers and Researchers Exploring and Collaborating (TREC) teacher Misty Nikula-Ohlsen (2004). Photo by Misty Nikula-Ohlsen.

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Foreword

Each year the Arctic Research Consortium of the U.S. (ARCUS) hosts the Arctic Forum in conjunction with the ARCUS annual meeting. The goal of the Arctic Forum is for arctic researchers in all disciplines to interact with colleagues and agency representatives. This collection of abstracts showcases the oral presentations and poster session at the Arctic Forum held 24–25 May 2007, in Washington, D.C.

The ARCUS annual meeting and Arctic Forum are the culmination of our efforts each year to represent the arctic research community on behalf of ARCUS' 49 voting and associated member institutions. ARCUS serves its member institutions by acting as a communication channel, providing information about current research activities and arctic science issues to the research community, and informing agencies and the public about arctic research. This work is done at many levels, including newsletters and other publications, electronic communications, K–12 education projects, workshops, and symposia like the Arctic Forum. The Arctic Forum provides access for individual researchers to information on research, education, and facilities outside of their fields, which has led to many successful collaborations. Since its inception in 1994, the Arctic Forum remains one of only a few interdisciplinary arctic science meetings. The Arctic Forum abstract series begins with *Arctic Forum 1998*.

This abstract volume illustrates the diversity and interdisciplinary nature of arctic research today. The theme for the 2007 Arctic Forum was "Water in the Arctic: International Collaborations and Understanding Environmental Change." The keynote speakers were Helena Ödmark of the Ministry for Foreign Affairs, Sweden, and John Walsh of the International Arctic Research Center, Alaska.

As executive director of ARCUS, I appreciate the efforts of the many researchers who shared their results with the community through the Arctic Forum. We thank Gunhild Rosqvist and Larry Hinzman for chairing the Forum and the National Science Foundation for supporting this opportunity. Alysa Loring and Jamie Mohatt of ARCUS were the managing editors for this abstract volume. We invite you to join us at the Arctic Forum in 2008.

Wendy K. Warnick
Executive Director

Introduction
Water in the Arctic: International Collaborations and Understanding Environmental Change

Larry Hinzman, University of Alaska Fairbanks; and
Gunhild (Ninis) Rosqvist, Stockholm University (Arctic Forum Co-Chairs)

Changes occurring in the arctic water cycle impact not only the circumpolar arctic, but also the global community. Forum sessions included a diverse and international range of perspectives on the state of knowledge of the hydrological cycle in the circumpolar Arctic, gaps in our knowledge, and research and policy opportunities and priorities. The Arctic Forum sessions highlighted international collaborations for the International Polar Year and beyond. The 2007 Arctic Forum was timed to coincide with a special program at the Embassy of Sweden on "Water and Environment," which offered reflections on global, national, regional, and local perspectives regarding water.

Presentations and discussions focused on three thematic questions:

- What are the changes being witnessed in the water cycle and how will these changes impact the physical, biological, and social environments of the Arctic?
- How does the science of water and the arctic environment relate to public policy, and how can information be translated to decision makers?
- How can we forge international collaborations during IPY and beyond to address these exciting scientific challenges and opportunities?

Participants addressed these questions in a combination of plenary and poster presentations as well as moderated panel discussions. This volume of abstracts illustrates the diversity and interconnected nature of changes in the arctic water cycle and underscores the importance of strengthened international and interdisciplinary collaboration.

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Presentation Abstracts

Opportunities for Arctic Circumpolar Cooperation

Helena Ödmark, Ministry of Foreign Affairs, Sweden

In recent years, the global community has witnessed spectacular changes in the Arctic. These changes have received good media coverage, sparking public interest and concern. As a result, climate change and energy issues have recently moved to the forefront of many countries' political agendas. However, these countries and their scientists cannot solve these issues alone. The global community needs a comprehensive regime to reduce emissions and greenhouse gasses. Several current and upcoming events provide worthwhile opportunities for arctic researchers to bring together valuable data, information, and technology, and to influence legally binding global legislation.

Changes in the Arctic have the potential to affect a variety of economic processes: infrastructure, industry, energy exploration, commercial shipping, tourism, as well as health and education services. Changes in any of these sectors affect employment and will impact local communities. As the public learns more about the effects of climate change in the Arctic, governments are expected to prevent negative influences on sensitive ecosystems and cultural traditions. In determining how best to move forward, countries must make use of new opportunities and share in technology, information, and resources. Intergovernmental cooperation is required to achieve energy savings, improve forestry management, and develop alternative fuel and transportation systems to prevent further climate change.

Although international conflicts may arise that result from disagreements in continental shelf claims and international waters regulations, ample conditions exist for international cooperation. Upcoming United Nations conventions on climate change and biodiversity will provide arctic states an excellent occasion to strengthen the legal framework for advancing economic, political, and educational concerns in the Arctic. Arctic Council forums involving permanent member indigenous groups and observer states offer venues for raising key issues in circumpolar cooperation. Finally, scientists have a unique opportunity to leave an arctic legacy with events and research opportunities during the International Polar Year.

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The Arctic Ocean Carbon Cycle in a Changing Environment

Leif G. Anderson, Göteborg University

Seawater enters the Arctic Ocean from both the Atlantic and Pacific Oceans with much of the surface water passing over the very large Barents and Bering-Chukchi shelf seas. On its way north the surface water cools, which increases the solubility of gases, and in summer significant primary production occurs that lowers pCO_2. Both cooling and primary production promote a flux of CO_2 from the atmosphere to the surface ocean. However, as much of the sea surface is covered by sea ice, at least during the winter season, gas exchange is hampered. One consequence of the seasonal ice cover is that the surface waters of the central Arctic Ocean are under-saturated with respect to CO_2.

The Arctic Ocean is small compared to the global oceans and thus the carbon fluxes are also comparatively small. However, in the inflowing shelf seas like the Barents Sea and Bering-Chukchi Seas primary production and air-sea fluxes of CO_2 are many times the global average per unit area. The Pacific waters flowing into the Arctic Ocean through Bering Strait enter the North Atlantic through varying routes, making the Arctic an important transport path between these two major global oceans. Another specific condition of the Arctic Ocean is the deep water formation that both transports dissolved organic and inorganic carbon from the surface ocean to the intermediate and deep waters and is an essential part in the sequestration of anthropogenic CO_2. The formed subsurface waters constitute the headwaters of the Meridional Overturning Circulation, spreading water to all global oceans.

At present the Arctic Ocean is undergoing rapid changes, e.g., decreasing sea ice coverage and increasing temperatures of the inflowing Atlantic Water, both impacting processes of importance for C-fluxes. Furthermore, the processes behind the deep water formation are sensitive to environmental change, which potentially could considerably alter these sinks, especially since the formation of sea ice has been postulated to promote uptake of CO_2 from the atmosphere when the surface water is under-saturated.

Furthermore, vast amounts of gas hydrates have been documented in association with thick arctic permafrost occurrences found beneath land areas and some shallow water areas of the continental shelf, as well as beneath deeper water areas of the Arctic Ocean. Because gas hydrates dissociate in response to warming temperature it has been speculated that methane from dissociating gas hydrate deposits could be released in a warming arctic climate.

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Circumpolar Arctic Mammals and Consequences of Climate Change

Anders Angerbjörn, Stockholm University; Love Dalén

Species respond to an increased availability of habitat by increasing their distribution, for example, at the end of the last glaciation. However, little is known about the opposite process, when the amount of habitat decreases. The hypothesis of habitat tracking predicts that species should be able to discern both increases and decreases in habitat availability. The alternative hypothesis is that populations outside refugia become extinct during periods of unsuitable climate. To test this we used ancient DNA techniques to examine genetic variation in the arctic fox (*Alopex lagopus*) whose geographic distribution was expanded during the last glaciation and subsequently decreased during the Holocene. The southern Late Pleistocene populations have not, however, contributed genetically to present day populations and went extinct when the habitat shifted to the north. We do not know anything about the mechanisms. Today, the Scandinavian arctic fox population is threatened to go extinct due to decreasing amounts of habitat, a decrease in food availability, e.g., lemming, and an increase in a temperate competitor, e.g., the red fox. These results provide new insights into how arctic species respond to climate change and the mechanisms behind extinction.

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Arctic Atmospheric Hydrologic Cycle from Reanalyses and Climate Change

David Bromwich, The Ohio State University; Sheng-Hung Wang

The atmospheric hydrologic cycle over the Arctic Basin has a significant impact on the mass balance of the sea ice cover. North Atlantic conditions are intimately related to the discharge of sea ice and freshwater from the Arctic Ocean through Fram Strait. The resulting variability in the North Atlantic thermohaline circulation can potentially impact global climate. However, the presence of a floating ice field prevents the collection of reliable measurements of atmospheric moisture and precipitation in the arctic region. In particular, measurements of solid precipitation are highly inaccurate when winds are strong, although statistical correction methods have been developed. Gauge-based measurements are also subject to blowing snow around the measurement sites. These limitations have led the exploration of the atmospheric moisture budget to derive estimates of precipitation minus evaporation/sublimation (P-E) from reanalysis data.

The two most widely used global reanalysis data sets are the collaborative effort of the National Centers for Environmental Prediction (NCEP) and the National Center for Atmospheric Research (NCAR) Reanalysis (NNR, 1948–present) and the European Centre for Medium-Range Weather Forecasts (ECMWF) 40-year Reanalysis (ERA-40, 1957–2002). A new global reanalysis data set from the Japan Meteorological Agency (JMA) and the Central Research Institute of Electric Power Industry (CRIEPI), and the Japanese 25-year Reanalysis (JRA-25, 1979–present), is also available. These data sources are used to explore the long-term (1960–present) characteristics of the atmospheric moisture transport into the Arctic as a function of climate variability and change. In particular, an atmospheric contribution to the ongoing retreat of the arctic sea ice cover is sought.

The current shortcomings of global reanalyses in this data-sparse region are discussed and a proposal is advanced to greatly improve our monitoring and understanding of this key climatic component.

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The Roles of Arctic Observatory Networks in Environmental Change Research and Monitoring

Terry V. Callaghan, University of Sheffield; Margareta Johansson; Torbjörn Johansson; Craig E. Tweedie; Mads C. Forchhammer

Recent assessments of the accelerated global warming being experienced in the Arctic have highlighted uncertainties in our knowledge base while the U.S. National Academies of Sciences and the Arctic Council Ministers have independently identified the need for sustained and coordinated monitoring of the Arctic's environment. A workshop in 2004 identified the great potential that networks of Flagship Observatories could achieve by combining observation with research and outreach. SCANNET (Scandinavian and North European Network of Terrestrial Field Bases) is an example of an extensive network that combines both flagship sites and small field bases within wide climate, environmental, and land use envelopes. Participating sites in SCANNET cover a range of mean annual temperatures from -10 °C to +8 °C, total annual precipitation from 200 to 2000 mm, vegetation zones from polar desert to grassland, and land use from occasional past hunting to sheep farming. The geographical area also covers great variability in recent climate change from cooling to warming, and the North Atlantic sites surround a region of potential profound importance to the world's ocean circulation and climate systems.

In this presentation, the diversity of contributions of SCANNET members to understanding environmental change will be demonstrated by using examples of two flagship observatories: the Abisko Research Station in the northern Swedish sub-arctic and the Zackenberg Research Station in the high Arctic of northeast Greenland. Long-term data series will be presented for the former showing complex 100-year changes in climate, environment, and biota, whereas comprehensive and integrated whole-ecosystem research and monitoring will be demonstrated for the latter. An example will be given of how a flagship observatory works with local stakeholders, the Sami, to enrich science and indigenous knowledge bases. Recently, SCANNET joined the U.S.-led Circumarctic Environmental Observatories Network (CEON) that will unite North American, European, and Russian networks and which is focusing initially on building web-based map servers for research and monitoring activities for observatories throughout the Arctic.

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Consequences of Permafrost Thawing and Hydrological Changes for Landscape Scale Greenhouse Gas Exchange

Torben R. Christensen, Lund University

Northern wetlands are the largest single source of atmospheric methane. High northern latitudes host a large proportion of these wetlands often appearing as hot spots for atmospheric exchanges of both carbon dioxide and methane in composite landscapes. According to recent major international assessments, such as the Arctic Climate Impact Assessment, the high northern latitudes will see significant climate change within coming decades. In addition to emissions of methane and potential substantial CO_2 releases from stored soil organic carbon, arctic land and permafrost areas are influencing and interacting in other ways with the climate system. Snow cover changes, permafrost thawing, and the associated effects changing energy exchange are obvious components of these interactions where also the vegetation composition and the position of the tree-line play an important role. Studies of interactions between the terrestrial biosphere and climate must pay attention to all these different and often interlinked processes. However, particular emphasis in studies of northern land-atmosphere interactions has been on measuring exchanges of carbon dioxide and methane. These greenhouse gases, in particular the latter, have the potential for strongly influencing the further development of climate. However, if the carbon budget of a northern landscape as a whole is to be studied, the immediate atmospheric exchanges of trace gases are only one part of the story. Lateral transport of dissolved organic carbon and lake fluxes/sedimentation are factors that also are important for true catchment scale carbon and methane emission budgets and these are strongly influenced by permafrost dynamics. Here an attempt is made to evaluate the information available on all components of the carbon cycling including methane emissions in examples of composite northern landscapes: the Torneträsk region in northern Sweden and the Zackenberg valley in northeast Greenland. Many components of the carbon cycling and methane emissions are associated with huge uncertainties, and the budgets presented will merely be pointing these out as subjects of further studies rather than arguing final budgets for the landscapes that are presented.

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West Greenland Wildlife: Recent Caribou and Muskox Observations and Future Plans

Christine Cuyler, Greenland Institute of Natural Resources

Greenland is geographically isolated from North America and has limited diversity of terrestrial mammals. These few species will be subject to climate change without interference from invasive wild mammals moving north.

Models predict that by the end of the 21st century average temperature will rise 6–8 °C in northeast Greenland, following the expected retreat and reduction in sea ice cover, and 2–5 °C in West Greenland. Furthermore, precipitation specifically in winter is predicted to increase 20–30%, with south and west Greenland experiencing greater precipitation changes than the rest of Greenland.

Today, most Greenlanders live a modern city life far removed from that of their parents or grandparents. The recreational hunting of large herbivores, specifically caribou, provides an important bond to cultural traditions of the past, and income for commercial hunters. No holiday or special event would be complete without roast caribou on the menu, and although a relative newcomer to west Greenland, muskox has been steadily gaining favour. Recently, despite large herds, harvesting has been difficult. Local knowledge indicates that recent warmer temperatures have made access to hunting areas difficult or impossible, affected insect abundance, and appear to have changed the amount of surface water when it occurs. In addition, some caribou populations have changed their August-September distribution, and parasitic infestation appears to be increasing. To date documentation is lacking but this is about to change.

NuukBasic is a new long-term study located around the nation's capital city, Nuuk, in subarctic west Greenland. There are four research programs: MarineBasic, BioBasic, GeoBasic, and ClimaBasic. Together they will produce knowledge about short- and long-range variations in these arctic ecosystems. Understanding how climate change affects low and high arctic ecosystem structure and processes will better define their relative vulnerability to expected changes.

BioBasic-Nuuk is an ecosystem-monitoring program starting this summer. The first full field season will be 2008. The project will be conducted in coordination with similar work already established at Zackenberg, which is the high Arctic station in northeast Greenland (www.zackenberg.dk). Simultaneous observations of several terrestrial components (e.g., vegetation, soil fauna, birds, lake ecology, plant gas-flux [methane, CO_2] and herbivores) will be related to local, regional, and global climate change. Parameters will include: reproduction, distribution, phenology, species occurrence (plankton, arthropods, fish, birds, plants), and water and soil chemistry. The focus will be on a small fjord close to Nuuk, with a larger area to the north

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added to include caribou ecology. The Danish National Environmental Research Institute (DMU), Department of Arctic Environment is responsible for the project with financing from the Danish Ministry of the Environment (MST).

Long-term monitoring in west Greenland's highly populated sub-arctic region will increase understanding of the connection between human use of the animals and climate change's influence on these and their environment.

Changing Arctic Rivers

Stephen Déry, University of Northern British Columbia

This talk will present an overview of documented changes in arctic rivers during the 20th century, their implications, and projections for future changes. To begin, a brief description of the pan-arctic hydrological cycle and its climatology will be presented. Challenges of collecting hydrological data in harsh arctic conditions as well as other data issues will then be discussed. Changes in arctic rivers, both in Eurasia and North America, will then be presented, including observational evidence and attributions for change. Some implications of changing arctic rivers will follow, and changes in arctic rivers projected for the 21st century will then be discussed. The talk will end with a summary and a list of research priorities concerning the impacts of climate change on arctic rivers.

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Glacier Change in the Arctic: Important Consequences for Near Future Sea Level Rise

Andrew G. Fountain, Portland State University

Glaciers in the Arctic and sub-Arctic are rapidly changing in response to global warming. Although the spatial pattern of change varies around the hemisphere, over the past century the glaciers have been shrinking. The dominant influence on the glaciers is from rising air temperatures, but local to regional variations in winter snowfall can buffer this influence. It appears that in recent years we have entered a new phase of glacier change. Not only have many alpine glaciers accelerated their shrinkage, but the Greenland Ice Sheet is now experiencing increased melt. In addition, the Greenland Ice Sheet appears to be dynamically responding to climate warming and is increasing ice flow into the ocean. The sum of ice melt and ice flow to the ocean is an important factor in current sea level rise and may accelerate in the near future further increasing sea level rise.

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A Seasonally Ice-Free Arctic?

Marika Holland, National Center for Atmospheric Research

Large and coordinated changes are occurring in the arctic climate system, including a significant retreat of the arctic summer sea ice. Climate models project that decreasing ice cover will continue into the foreseeable future and suggest that a seasonally ice-free Arctic could be realized within the next century. However, these models differ considerably in the rate and character of projected sea ice change. For example, a number of models exhibit abrupt retreat of the summer ice cover while others show more gradual change. Here the mechanisms that drive rapid ice retreat are explored, and a number of factors that influence whether climate models simulate rapid reductions in ice cover are addressed. This includes an analysis of simulated changes in arctic heat budgets and the role of forced versus natural variability in simulated sea ice change. To the extent possible, we discuss what this analysis suggests about how and when a seasonally ice-free Arctic might be realized.

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The Narwhal Tusk, Potential as an Arctic Water Probe and Weather Station: Collaborative and Integrative Studies of Science and Inuit Traditional Knowledge

Martin T. Nweeia, Harvard School of Dental Medicine

Biological and behavioral studies of the narwhal may contribute valuable insights and information to the understanding of a changing arctic environment. Broad-based collaborations with the integration of myriad disciplines has enabled this work to comment on osteocranial structures and teeth, as well as narwhal behavioral modifications in response to ocean and climate change.

Studies of narwhal tusk microanatomy reveal structural components with hydrodynamic sensory capabilities. A network of microtubules connects the inner nerve and blood supply of this tooth to its external environment. Collaborating scientists at the Paffenbarger Research Center (PRC) at the National Institute of Standards and Technology examined two freshly harvested tusks and discovered millions of such connective, fluid-filled pathways that are capable of detecting changes in water and air temperature and pressure and osmotic gradients. The tusk surface is also capable of sensing tactile stimuli. Using the theorized model of tubule fluid detection discovered by Swedish scientist Martin Brannstrom, narwhal are capable of detecting changes in their water and air environments that most mammals can only sense in pathologic conditions. PRC investigators also examined position-resolved sections of narwhal tusk with Fournier transform infrared fluorescence microspectroscopy, which revealed an opposite structural modeling to normal mammalian teeth. Narwhal tusks have lower mineral to collagen (m/c) ratios in their outer dentin circumference and the inner core has a high m/c ratio giving it a rigid core surrounded by a flexible outer covering. Analysis of tissue hardness and flexibility reveal bending properties that enable an eight foot tusk to flex approximately one foot in all directions.

These microanatomical tusk characteristics generate thought about function as it relates to evolutionary adaptation. The existence of dentin dates to the late Cambrian period, approximately 510 million years ago, at that time expressing a biodiversity that greatly exceeded the subsequent 450 million years and present day variation. Ordovician jawless fish had exoskeletons derived from dentin material that had the ability to detect temperature, osmotic gradients, and tactile sensation. Though the teeth of mammals have this tissue and the associated capability for sensory perception, the narwhal exhibits an unusual expression and configuration of these tubules.

Embryologic studies, cited in the literature, describe tooth buds for six pairs of teeth, four that are somehow switched off genetically and one that is minimal in adult development. Despite a diet of larger fish like Greenland halibut

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and Arctic cod, the narwhal has no erupted teeth in its mouth for chewing. Its adaptation of turning on a single growth center producing such a disproportionate size tusk with no intraoral function and having such an unusual microanatomy and expression is explored in this investigation of narwhal tusk function.

Collection of Inuit Traditional Knowledge, from ten communities in northeastern Baffin Island and northwestern Greenland that have a strong association with narwhal, parallels the scientific investigations. Traditional Knowledge has guided, confirmed, and challenged the findings of this study in many and varied disciplines of scientific pursuit. Inuit descriptions of anatomic variation, observations of behavior, and the effects of migration patterns and timing are noteworthy in the discussion of tusk function and narwhal behavior and add to the overall knowledge and understanding for this arctic marine mammal. Findings from this investigation demonstrate the value of integrating science and social science and combining the analytic mind of a trained scientist with the perception, observation, and experience of Inuit on the land.

A Virtual Expedition to Swedish Arctic Research Platforms

Gunhild (Ninis) Rosqvist, Stockholm University

This expedition will take us to the two research stations located in arctic Sweden: Tarfala Research Station and Abisko Scientific Research Station. The glaciological, hydrological, meteorological, and biological research and long-term monitoring carried out at these stations will be introduced briefly. During the International Polar Year (IPY), data showing the dynamic response of Swedish glaciers will feed into international projects, and new studies of the effect of climate change on reindeer herding have recently started. During the IPY, the Kinnvika station located on Nordaustlandet, Svalbard, will be reactivated for research in different disciplines. One project, for example, will focus on the coupling between present climate change and the Vestfonna ice cap. The Swedish icebreaker *Oden* will travel along the Lomonosov Ridge in the Arctic Ocean to map the bathymetry in detail using a multi-beam echosounder during the summer of 2007. The ocean circulation and the sea ice extent will also be studied. *Oden* will be used for studies of processes forming summer clouds in the Arctic in the summer of 2008.

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Rivers, Lakes, Tundra, and Taiga: A Journey Across Alaska and Northern Canada

Matthew Sturm - Cold Regions Research and Engineering Laboratory, Alaska

U.S. and Canadian International Polar Year (IPY) scientists drove snowmobiles from Fairbanks, Alaska, to Baker Lake, Nunavut, during March and April of 2007, traveling 4,300 km. Their route lay along the Yukon, MacKenzie, and Thelon Rivers, as well as many lesser rivers. It included a traverse of Great Bear Lake, the 8th largest lake in the world. It wound in and out of the taiga and tundra, and it took them through 11 arctic communities, most of which subsist off the land. Along the way, past, present, and future sites of mining, oil, and gas extraction were examined. Across this vast area, historically the waterways were, and they still remain, crucial to the transportation system. Water, in the form of snow and rain, is one of the primary agents in landscape evolution, and alterations in water regimes, due to climate change, are likely to have a more profound impact on ecosystems and humans than any change in temperature. Vignettes from the journey will be used to illustrate these points.

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Arctic Atmospheric Modeling: Should We Believe the Models?

Michael Tjernström, Stockholm University

Climate models form the backbone for climate research. Not only are they the only way by which we can say something about the future, but they are also fundamental tools for understanding the climate system. The climate system is so complex and non-linear that it is basically impossible for the human mind to comprehend without the aid of models describing of all the processes and their interactions within the system.

But what is a climate model, and why should we believe in them? From a philosophical point, a climate model is the aggregate of our understanding of how the system and the parts thereof work. It is the sum of all hypotheses about the processes we understand, refined to the furthest point possible given the uncertainty of our current knowledge, and the extent to which current computing power allows implementation of this understanding into computer code. Climate models thus contain all the things we are pretty sure about, quite a few things we have a fair but not complete understanding about, but also processes where we know we could do a lot better but are hindered by the practicalities of current modeling techniques. There are also the things we sense might be important, but do not know how to formalize into equations the way a model must be designed, and—of course—all the processes that we don't know that we don't know about; these could be important or not and since we don't know, how can we make an informed judgment?

In practice, we thus tend to believe in climate models for two reasons: 1) They are capable of reconstructing present climate, given the climate forcing of today; 2) They (are supposed to) take into account all the processes we think are important, including their interactions. At the heart of this problem lies the scale separation between resolved and unresolved scales. As computing power increases, the resolved scales become finer and finer and today's models properly resolve the "synoptic scale," or what we commonly refer to as the "weather systems." But a paradox in climate modeling is that the processes that drives the climate—and climate change—will likely "forever" remain unresolved in these models. In the atmosphere this is the case for radiation, cloud and aerosols, precipitation, boundary-layer turbulence, energy balance, and the exchange processes at the surface. These are all processes that have to be parameterized—described as functions of the resolved scale variables—applying some understanding that ultimately always relies on empirical evidence. This implies a fundamental uncertainty, and the Intergovernmental Panel on Climate Change (IPCC) AR4 report also points to the cloud processes as a fundamental reason for different models having

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different climate sensitivity. For the Arctic, this is a particular problem since the body of empirical evidence for any process is small, certainly smaller than for other regions—or climate regimes—on Earth.

In this presentation I aim to show that both the fundamental cornerstones for believing in climate models may in fact be rather shaky at best. Current global climate models do not necessarily do a very good job of reconstructing the current arctic climate. And while the relevant processes are there, they are parameterized based on empirical evidence that does not come from the Arctic and thus, due to aspects of some climate processes that are unique to the Arctic, they don't always work very well. On top of these issues is, of course, the large inherent climate variability of the entire arctic climate system. Thus, the paradox that although climate change is the fastest in the Arctic, the tools we use to understand this change are at the same time the poorest. The challenge therefore becomes to improve the representation of arctic climate in global climate models, while at the same time preserving or improving their overall performance. This can only happen if we learn more about climate processes in the Arctic, which implies in situ process studies in the Arctic. This is what IPY is—or should be—all about.

The ARCSS Freshater Integration Study: A Synthesis of Changes in the Arctic Hydrologic System

Charles J Vörösmarty, University of New Hampshire; Larry Hinzman; Jonathan Pundsack; FWI Research Community

The NSF-ARCSS program is undergoing a purposeful move toward system-wide and synthetic thinking. As part of this broader agenda, the NSF-ARCSS Freshwater Initiative (FWI) was established in 2002, to study the multiple roles of water in the arctic system and as a key element of arctic change. Three overarching science questions have guided the effort.

The first is devoted to determining whether or not the arctic hydrologic cycle is intensifying, which requires establishing benchmarks and documenting patterns of change. Pursuit of this question also demands careful analysis of observational records and a search for coherence with arctic system model outputs.

The second question explores the sources of such change. Here, literature-based synthesis and simulated states of the pan-arctic hydrologic cycle demonstrate limits on the potential sources of an acceleration from the continental land mass of the Arctic. FWI researchers also demonstrated the potential for a hemisphere-scale redistribution of fresh water from lower to higher latitudes, in tandem with diversified local-scale changes.

The third question focuses on the implications of arctic hydrologic change on the broader Earth system and human society. A heuristic feedback model has been formulated to uncover possible pathways and sensitivities of these changes. An additional series of model-based results have explored the sea ice albedo feedback as it links to broader global ocean circulation issues. Social systems across the Arctic are also the subject of study, and there is growing evidence of water stress similar to that found across the arid and semi-arid zones of the lower latitudes.

Under the FWI umbrella, synthesis studies were facilitated by working groups. One such group produced the first comprehensive arctic water budget, quantifying both stocks and fluxes over atmospheric, oceanic, and terrestrial domains. Other groups are providing a systematic accounting of observed changes, initial articulation of feedbacks operating through the arctic system as mediated by water,

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and a combined modeling and data assimilation approach to uncover a possible acceleration of the hydrologic cycle across the Arctic. These efforts represent both inductive and deductive approaches, and the FWI uses an operational definition of synthesis as a coordination of thought to discover emergent system properties to detect and understand arctic water cycle change.

This discussion will focus on recent results of analysis with acknowledgement of input from a broad set of FWI researchers. It also highlights remaining challenges to our capacity to fully understand the role of water in the arctic system, brought on by the loss of hydrometeorological monitoring capacity, incomplete model formulations and parameterizations, an absence of approaches for reconciling observations with models, and impediments to crossing space and time scales. The talk concludes with some *lessons learned* on executing community-based synthesis efforts.

The Arctic in the Intergovernmental Panel on Climate Change (IPCC) Fourth Assessment Report

John Walsh, University of Alaska Fairbanks

The Arctic, especially its hydrology, is more prominent in the 2007 report of the Intergovernmental Panel on Climate Change (IPCC) than in previous IPCC reports. While some of the IPCC's findings about the Arctic draw upon the Arctic Climate Impact Assessment, there are notable additions and updates. Key arctic-related findings are an accelerated rate of decrease of summer sea ice (-7.4% +/- 2.4% per decade), an acceleration of the total cryospheric contribution to sea level change from 0.2–0.4 mm/year to about 1 mm/yr in the past 5–10 years, warming of the upper permafrost layers by up to 3 °C since the 1980s, a reduction in the maximum area of seasonally frozen ground by 7% (15% in spring), and a recent freshening of subarctic seas.

Among the impacts that have been identified (with "high confidence" or better) are changes in species' ranges and abundances, and in the positions of some tree lines in the Arctic, improved marine access, increased coastal wave action, changes in coastal ecology (including adverse impacts on ice-dependent marine wildlife), and indications that arctic indigenous peoples are already adapting to climate change but facing a combination of stressors that are severely testing their resiliency.

Projected changes for the 21st century include a warming of 4–5 °C, largest in the autumn and winter and over the polar oceans, increases of precipitation and especially the rain-to-snow ratio, increases of river discharge by 10–30%, thawing of some areas of discontinuous permafrost, and a general thickening of the active layer by 30–50% by 2100, leading to destabilization of river banks and slopes, increased erosion and sediment supply, and increased discharge from glaciers and ice sheets. Positive impacts of the projected climate change include reduced heating costs, increased agricultural and forestry opportunities, and improved marine access to the Arctic. Major uncertainties are the future rates of ice mass loss from Greenland and the rates of permafrost degradation.

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Vulnerability to Changing Conditions in the Canadian Arctic: The Case of Arctic Bay, Nunavut

Johanna Wandel, University of Guelph

This paper outlines a methodological framework employed in a number of empirical analyses aimed at identifying vulnerability to changing environmental conditions in human communities. The approach involves categorizing current and past exposure sensitivities and adaptive strategies from a variety of sources to identify implications and possible adaptive strategies related to anticipated changes in environmental conditions relevant to the community. The approach is illustrated with a case study from the community of Arctic Bay in Canada's High Arctic. The framework forms the basis for comparison and integration among a number of case studies currently being undertaken as part of International Polar Year.

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Effects of Changes in Water Resources on Northern Societies

Daniel M. White, University of Alaska Fairbanks; Larry D. Hinzman; Lilian Alessa; Andrew Kliskey; Peter P. Schweitzer

Freshwater is critical to the sustainability of people and their activities in the Arctic. The availability and status of water resources may promote good health or propagate disease, support the distribution and quality of plants and animals used for subsistence, and promote or impede transportation and resource development. Water is integral to the culture of arctic people. In the past thirty years, the climate in the Arctic has warmed appreciably, and there is evidence for a significant polar amplification of global warming in the future. Recent studies suggest that climate change is having and will continue to have a significant impact on arctic hydrology and northern societies. For example, of concern to people in the Arctic are lakes disappearing with the loss of permafrost, low river stage limiting access to subsistence resources, and the availability of water for construction of ice roads. This presentation will discuss how humans depend on freshwater at local scales in the Arctic and how climate change is affecting this dependency.

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Panel Discussion: Water in the Arctic and International Collaborations: Opportunities During IPY and Beyond

Moderator: Maribeth Murray, University of Alaska Fairbanks

Panel Members: Sara Bowden; Katey Walter; Inger Marie Gaup Eira; Volker Rachold; Daniel White

Maribeth Murray, of the University of Alaska Fairbanks, moderated this panel discussion, which centered on three key focus questions:

- What are the critical scientific and policy issues with regard to “Water in the Arctic,” particularly those related to international collaboration?
- What is the relationship between water and security, including national political security issues, access to food and natural resources, and cultural sustainability?
- What is the most important result, scientific or otherwise, that could come out of IPY? What is the single most important factor to ensure a successful IPY?

Panelists were each given 2–3 minutes to present key issues and considerations relevant to international collaborations in arctic science. Presentation topics varied from ocean sciences, methane emissions from thermokarst lakes, snow conditions for Sami reindeer herders, changes in the arctic cryosphere, risks for global coastal regions, and water policy issues. All panelists presented a similar vision for IPY legacy—the need for strengthened and sustained international collaboration.

The resulting discussion with Arctic Forum participants centered on a variety of crucial water issues in the Arctic, including: capitalizing on the energy of early career scientists and encouraging them to think and work globally, energy concerns, the urgent need for long-term observing stations, how scientists can be active in shaping policy, and how to help the public recognize the value of limited resources like fresh water. Panel members and participants outlined several important results that should come out of IPY:

- IPY should be seen as a starting point of international collaboration in science, rather than a small window of opportunity;

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- IPY should forge international treaties and commitments for future collaborations;
- The IPY legacy is dependent on global commitment; and
- Scientists are in a unique position to help shape future policy, international relations, and discussions with policy makers.

Poster Abstracts

The Arctic Water Resources Vulnerability Index (AWRVI): A New Tool for Assessing Resilience to Change

Lilian Alessa, University of Alaska Anchorage; Andrew Kliskey; Richard Lammers; Christopher D. Arp; Daniel M. White; Larry D. Hinzman

To date, no water vulnerability index exists for the Arctic, despite rapid changes in both climate and ecosystems. Several water indices have been developed in other parts of the world, but none has been developed until now, to assess the resilience and vulnerability of freshwater resources in the Arctic.

The Arctic Water Resources Vulnerability Index (AWRVI) is a new and powerful on-the-ground tool for decision making, which identifies where resilience and vulnerabilities exist in freshwater resources and how an action, such as development, may affect those resources. It works at the watershed scale, which is most relevant to the daily lives of arctic residents, and is based on the interactions of cumulative factors. Its indicators include biophysical, sociocultural, economic, and institutional components and it can be used by communities without extensive specialized training. Once AWRVI has been applied, a Resilience Score is determined for a community's water resources.

Using AWRVI, a community can assess the effects of environmental change on their social health and well-being. It combines both western and indigenous knowledge systems using the Internet, oral traditions, and existing data. It rapidly indicates where gaps in knowledge exist and how urgent the need is to fill those gaps. The authors designed AWRVI to compile diverse information in a context that is relevant to a community's desires such that they can make informed decisions and adapt to change on their own terms.

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Wetland Carbon Stocks in Arctic Watersheds: We Might Know About How Much, But Where Is It?

David W. Beilman, Queen's University Belfast

The organic carbon (C) stocks contained in peat-accumulating wetland ecosystems were estimated for a southern region of the Mackenzie River Basin using high-resolution wetland map data, available soil C characteristics, and peat depth datasets and geostatistics. Peatlands cover 32% of the 25,119 km^2 study area. The thickness of peat deposits measured at 203 sites was 2.5 m on average, but as deep as 6 m and highly variable between sites. Peat depths showed little relationship to terrain data within 1 to 5 km, but were spatially autocorrelated and were generalized using Ordinary Kriging. Polygon-scale calculations and Monte Carlo simulations yielded a total peat C stock of 998–1010 Tg C that varied in mean C density (C mass per unit area) between 53 and 165 kg m^{-2}. This geostatistical approach showed as much as 10% more C than calculations using mean depths. This estimate was compared to an overlapping 7,868 km^2 portion of the best independent peat C stock estimate for western continental North America, which revealed similar values for total peatland area, total C stock, and total C density. However, agreement was poor within ~875 km^2 grids owing to inconsistencies in wetland cover and little relationship in peat depth between estimates. The greatest disagreement in mean C density occurred in grids with the largest peatland cover, owing to the spatial coincidence of large cover and thick deposits in the high-resolution assessment. Existing peat C stock estimates in the southern Mackenzie Basin are likely of reasonable accuracy, but owing to uncertainties particularly in peat depth, we presently have limited information regarding the actual location of large stocks at scales as wide as several hundreds of square kilometers.

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PolarTREC-Teachers and Researchers Exploring and Collaborating: Innovative Science Education from the Poles to the World

Katie J. Breen, Arctic Research Consortium of the U.S.; Janet Warburton

PolarTREC—Teachers and Researchers Exploring and Collaborating is a three-year (2007–2009) teacher professional development program celebrating the International Polar Year (IPY) that will advance polar science education by bringing K–12 educators and polar researchers together in hands-on field experiences in the Arctic and Antarctic. PolarTREC builds on the strengths of the existing TREC program in the Arctic, an NSF-supported program managed by the Arctic Research Consortium of the U.S. (ARCUS), to embrace a wide range of activities occurring at both poles during and after IPY. PolarTREC will foster the integration of research and education to produce a legacy of long-term teacher-researcher collaborations, improved teacher content knowledge through experiences in scientific inquiry, and broad public interest and engagement in polar science and IPY.

PolarTREC will enable over 40 teachers to spend 2–6 weeks in the Arctic or Antarctic, working closely with researchers investigating a wide range of IPY science themed topics such as sea ice dynamics, terrestrial ecology, marine biology, atmospheric chemistry, and long-term climate change. While in the field, teachers and researchers will communicate extensively with their colleagues, communities, and hundreds of students of all ages across the globe, using a variety of tools including satellite phones, online journals, podcasts and interactive "Live from IPY" calls and web-based seminars. The online outreach elements of the project convey these experiences to a broad audience far beyond the classrooms of the PolarTREC teachers. In addition to field research experiences, PolarTREC will support teacher professional development and a sustained community of teachers, scientists, and the public through workshops, Internet seminars, an e-mail listserve, and teacher peer groups.

To join the discovery, make global connections, and be part of the International Polar Year or, for more information, visit the PolarTREC website at: http://www.polartrec.com.

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PolarTREC-Teachers and Researchers Exploring and Collaborating: Classroom Activities and Learning Resources

Katie J. Breen, Arctic Research Consortium of the U.S.; Janet Warburton

This display highlights a variety of classroom activities that students completed in conjunction with various PolarTREC and TREC expeditions. Projects include artwork, songs, movies, research posters, and research papers. Contributions come from:

- Hanna High School, Brownsville, Texas
- Barrett Elementary School, Arlington, Virginia
- Concord High School, Concord, New Hampshire
- Horace Greeley High School, Chappaqua, New York
- Renfroe Middle School, Decatur, Georgia

For more information about PolarTREC see the PolarTREC abstract (previous page) or visit the website at:

http://www.polartrec.com.

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Pan-Arctic Drainage Basin Monitoring: Current Status and Potential Significance for Assessment of Climate Change Impacts and Feedbacks

Arvid Bring, Stockholm University (student scholarship recipient); Georgia Destouni; Fredrik Hannerz

Access to reliable hydrologic data is of paramount importance for the accurate understanding of changes in the arctic hydrologic cycle and is also vital to policymakers as a base for sound environmental decisions. Accessibility to such data is limited and continues to decline for some arctic areas, while little information exists on which data gaps are most critical. This study presents a quantitative assessment of openly available monitoring data for water discharge and chemistry in the pan-arctic drainage basin. Results indicate that there is significant disparity in the spatial and temporal distribution of accessible monitoring data, in particular for water chemistry monitoring. Additionally, there are systematic differences between the characteristics of monitored and unmonitored areas. These differences may limit the reliability of assessments of arctic water and solute flux changes under a warming climate. Arctic monitoring needs to be extended in certain areas and data needs to be disseminated more efficiently to fully enable characterization of the hydrologic variability and change in the region.

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ARCUS Internet Media Archive (IMA): A Resource for Outreach and Education

Tina M. Buxbaum, Arctic Research Consortium of the U.S.; Wendy K. Warnick

The ARCUS Internet Media Archive (IMA) is a collection of photos, graphics, videos, and presentations that are shared through the Internet. It provides the arctic research community with a centralized location where images and video pertaining to polar research can be browsed and retrieved for a variety of uses. The IMA currently contains almost 5,000 publicly accessible photos, along with 360 video files, 260 audio files, and approximately 8,000 additional resources that are being prepared for public access.

The contents of this archive are organized by file type, photographer's name, event, or by organization, with each photo or file accompanied by information on content, contributor source, and usage requirements. All the files are keyworded, and all information, including file name and description, is completely searchable.

ARCUS plans to continue to improve and expand the IMA with a particular focus on providing graphics depicting key arctic research results and findings as well as edited video archives of relevant scientific community meetings. To submit files or for more information and to view the ARCUS Internet Media Archive, please go to: http://media.arcus.org or E-mail photo@arcus.org.

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Development of the Pan-Arctic Snowfall Reconstruction: New Land-Based Solid Precipitation Estimates for 1940–1999

Jessie Cherry, University of Alaska Fairbanks; Bruno Tremblay; Marc Stieglitz; Stephen Déry; Gavin Gong

A new product, the Pan-Arctic Snowfall Reconstruction (PASR) was developed to address the problem of cold season precipitation gauge biases for the 1940–1999 period. The method used to create the PASR is different from methods used in other large-scale precipitation data products and has not previously been employed for estimating pan-arctic snowfall. The NASA Interannual-to-Seasonal Prediction Project Catchment Land Surface Model is used to reconstruct solid precipitation from observed snow depth and surface air temperatures. The method is tested at 4 stations in the United States and Canada where results are examined in depth. Reconstructed snowfall at Dease Lake, British Columbia, and Barrow, Alaska, is higher than gauge observations. Reconstructed snowfall at Regina, Saskatchewan, and Minot, North Dakota, is lower than gauge observations, probably because snow is transported by wind out of the prairie region and enters the hydrometeorological cycle elsewhere. These results are similar to gauge biases estimated by a water budget approach. Reconstructed snowfall is consistently higher than snowfall from ECMWF Reanalysis-40, but does not have a consistent relationship with snowfall derived from the WMO Solid Precipitation Intercomparison Project correction algorithms. Advantages of the PASR approach include: 1) the assimilation of snow depth observations captures blowing snow where it is deposited, and 2) the modeling approach takes into account physical snowpack evolution. These advantages suggest the PASR product could be a valuable alternative to statistical gauge corrections, and that arctic ground-based solid precipitation observing networks might emphasize snow depth measurements over gauges.

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Intensification of the Arctic Hydrologic Cycle: Evidence from the Lena Basin, Siberia

Jessie Cherry, University of Alaska Fairbanks; Vladimir A. Alexeev; Beate Liepert; Pavel Groisman; Vladimir Romanovsky

Strong positive climate feedbacks cause much of the Arctic to warm faster than the global average (IPCC, 2001; ACIA, 2004). The global hydrologic cycle is expected to accelerate in a warmer world because a warmer atmosphere can hold more water vapor. However, an important question that has not been adequately addressed is whether thawing of permafrost and deepening of the soil's active layer, which pulls moisture away from the surface into deeper reservoirs, will lead to a wetter or dryer arctic climate (Vörösmarty et al., 2001). There is an apparent paradox in the Arctic between increasing annual precipitation trends (ACIA, 2004), increasing occurrence of forest fires (Kasischke et al., 1999; Korovin and Zukkert, 2003), and the drying of surface lakes (Smith et al., 2005). Our investigation of hydroclimatological change in the Lena Basin, Russia, points to an increasingly wet Arctic. Though much of the near-surface air temperature (SAT) warming is occurring when the ground is covered by snow, increases in frozen precipitation are also contributing to warmer soil temperatures by increasing soil insulation. A deeper active layer caused by spring and summer warming holds more soil moisture and is leading to increasing potential evapotranspiration (shown in the model), increasing hydrologic baseflow (modeled and observed), and increasing summer nighttime cloudiness (observed). Changes in summer cloud types are suppressing warming during the days, but warming the nights significantly even during the polar day (Groisman et al., 1996). Earlier onset of snow cover in autumn traps the spring and summer warming, a trend that leads to further deepening of the active layer. These observed and modeled feedbacks describe an arctic hydroclimatological regime in which water storage and flow has increased and moved from the surface to the subsurface.

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Migration in the Arctic: Subsistence, Jobs, and Well-Being in Urban and Rural Communities

Lee Huskey, University of Alaska Anchorage; Matt D. Berman; Lance Howe; Stephanie L. Martin; Wayne Edwards

Migration of the indigenous population of the Arctic is an important but little understood phenomenon. Migration affects the size and demographic structure of arctic communities. It is also an indicator of both community and individual well-being. Migration behavior is influenced by and also affects the outcome of policy decisions at all levels of government.

The first step in understanding arctic migration is to describe its historic pattern. Relatively little is published about this pattern because access to much of the data that have been collected is legally restricted or difficult for researchers to obtain. Through support from the National Science Foundation and cooperation of the U.S. Census Center for Economic Studies, North Slope Borough, and other organizations and individuals, we have gained access to much of these data.

This poster summarizes the patterns of movement of Alaska Natives in Alaska's arctic regions. Migration into and out of the region is described. Movement is traced both over time and along a hierarchy of places from village to regional center, to the state's urban regions. Variation in migration rates across age, gender, and education groups is also examined. We compare migration rates for people with different characteristics and in different time periods since 1980, and summarize survey results of questions that provide insights into motivations for migration decisions. We evaluate our findings in light of arctic migration hypotheses discussed in previous literature, and we generate new research questions and hypotheses about the determinants of migration patterns among the indigenous residents of arctic Alaska.

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Hydrocarbons Biodegradation Potential In the Kola Bay (Barentz Sea) Littoral Area During Year In Relation with Macrophytes Growth

Vladimir V. Ilinskiy, Moscow State Lomonosov University; Inga V. Peretruchina; Michail N. Semenenko

Macrophytes usually produce some small amounts of hydrocarbons together with other organic substances during their life cycle, and algae leaves (talloms) can usually support a high microbial number and diversity. For these reasons, it might be possible to suggest a higher hydrocarbon-oxidizing bacteria activity near macrophytes growth than far from it. Hydrocarbon biodegradation potential (HBP) was investigated in Kola Bay littoral water near macrophytes growth formed by the *Fucus* and *Laminaria* species. Samples were taken monthly during the year. HBP was measured as a sum of mineralization and biodegradation microbial processes using ^{14}C-octadecane (80 mcl/100 ml) water samples spiked with labeled hydrocarbon were then incubated for four hours at in situ temperature. A strong positive correlation ($R = 0.86$; $a < 0,001$) was observed between HBP and Kola Bay littoral water temperature with minimal HBP values (lower than 200 ng l^{-1} h^{-1}) during winter months December and January, and maximal HBP values (near 300 ng l^{-1} h^{-1}) during summer in June and August. Kola Bay littoral water temperature during the year varied from 1 to 10°C. Summer and winter HBP values observed in Kola Bay were near the same as maximal HBP values, which we observed early in Kandalaksha Bay (White Sea) near shore water during summer and winter periods. Water samples taken from macrophytes growth consistently demonstrated higher (up to 20%) HBP values than samples taken far off macrophytes.

Our results show that macrophytes can stimulate microbial activities in relation to oil hydrocarbons during a full year. We saw no great differences between summer and winter HBP values, and it is possible to suggest that mesophilic hydrocarbon-oxidizing bacteria population, which were presented in Kola Bay during summer, were replaced by psychrophilic bacteria population during the winter period. As far as octadecane belonging to n-alkanes, which is most easily degraded by microorganisms, HBP values observed in Kola Bay during the year may be near the maximum possible for oil hydrocarbons in this area.

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Interannual Variability in the Arctic Ocean Freshwater Balance

Alexandra Jahn, McGill University (student scholarship recipient); Bruno Tremblay; Lawrence A. Mysak

The Arctic Ocean has relatively low salinity compared to other oceans, due to the large amount of runoff it receives. Hence, the export of large quantities of fresh arctic surface water and sea ice are a source of freshwater (water with salinity of less than 34.8) for the northern North Atlantic. Because the thermal expansion coefficient for sea water at low temperatures is very small, salinity plays a more important role than temperature for the stratification of the water column in the high latitude oceans. As a consequence, large variations in the freshwater export from the Arctic Ocean can lead to decreased deep water formation and a weaker meridional overturning circulation. As changes in the meridional overturning circulation can affect the climate worldwide, a better understanding of the mechanisms which cause these variations in freshwater export is important.

We present a detailed characterization of the freshwater budget of the Arctic Ocean and exchanges with the northern North Atlantic as simulated by a high resolution version of the University of Victoria Earth System Climate model (UVic-ESCM). This analysis includes a 50-year average present-day freshwater budget for the Arctic Ocean as well as a thorough analysis of the interannual variability of the different terms of the Arctic Ocean freshwater balance (i.e., runoff, net precipitation, Bering Strait inflow, sea ice export, and liquid freshwater export) over the period 1950–2005. We show how this variability is related to atmospheric modes and how atmospheric modes influence different components of the freshwater balance in the Arctic Ocean.

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Arctic Research Mapping Application (ARMAP)

George W. Johnson, University of Texas El Paso; Joaquin A. Aguilar; Allison G. Gaylord; Karla Martinez; Raed Aldouri; Mike Dover; Diana Garcia-Lavigne; William F. Manley; Robbie Score; Craig E. Tweedie

The Arctic Research Mapping Application (ARMAP) is an interactive, online mapping program for field-based scientific research in the Arctic. The gateway website can be found at: http://armap.org.

Users can navigate to areas of interest and explore research projects by location, year, funding program, investigator, discipline, keywords, and other variables. ARMAP is dynamically linked to the Arctic Research Logistics Support Service (ARLSS) database from VECO Polar Resources, which contains over 5,000 research sites, is regularly updated, and is expanding to include projects funded by a variety of agencies. Project information is displayed within the mapping application itself, with links to web pages for additional details. Users can also view a variety of base maps (satellite imagery, topography, bathymetry, and shaded relief), framework layers (cities, roads, lakes, place-name gazetteer, etc.), and scientific data (sea ice extent, treeline, arctic vegetation, etc.). The 2D mapping application is capable of complex search queries to combine parameters. Users can copy selected data, print or export maps for presentations or publications, and choose from a "map gallery" of predefined images of interest. An online help system, a narrated tour, and Federal Geographic Data Committee (FGDC) metadata are provided. ARMAP will continue to improve and evolve; the 2D interface is being refined, the adoption of "best practices" will

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make the data widely available through additional web services, and users will soon be able to navigate in three dimensions (using Google Earth as well as ArcGIS Explorer).

With special emphasis on the International Polar Year (IPY), this service is targeted to science planners, research scientists, educators, and the general public. In sum, ARMAP goes beyond map display to analysis, synthesis, and coordination of arctic research.

Late-glacial and Holocene Biogeochemical Response to Hydrologic Changes in an Alaskan Peatland

Miriam Jones, Lamont-Doherty Earth Observatory; Dorothy M. Peteet; Raymond Sambrotto; Tom Guilderson; Dorothy Kurdyla

Boreal peatlands have been shown to store large quantities of carbon, but climate change is threatening carbon uptake by altering atmospheric temperatures, peatland hydrology, and biogeochemical cycles. Climate change influences vegetation patterns, as plant species have different temperature and moisture thresholds. Certain plant types can also influence carbon and nutrient cycling, depending on substrate quality, oxidation availability, temperature, moisture, pH, palatability, and regrowth potential. Stable carbon and nitrogen isotopic signals preserved in peat cores have the potential to provide insight on the global carbon and nitrogen cycles and how these have varied through time. A late-glacial and Holocene stable isotope record of carbon and nitrogen isotopes from a peatland on the Kenai Peninsula, Alaska, was taken to document shifts in nutrients and moisture availability. Paired with a detailed record of bryophyte species change through time, estimates of pH, methane flux, and mineral availability were made. Both the carbon and nitrogen isotopes initially are depleted in the late-glacial and early Holocene, when brown mosses dominated the fen and the water table was higher. A shift to more atmospheric nitrogen isotopic values (~0%) and less negative carbon isotopic values (~5% shift) occurred when the fen became *Sphagnum*-dominated at ~8,800 cal BP. This shift reflects a change in nitrogen sources from combined pools to atmospheric nitrogen. The shift in moss species reflects a change in dominant water source. Early Holocene rich fen conditions prevailed when the fen was fed primarily by groundwater. *Sphagnum* build up above the water table caused a change in dominant water source location from groundwater to atmospheric, decreased the pH, induced a change in dominant vascular plant types, and altered biogeochemistry.

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Polar Bears on Bering Sea Islands

David R. Klein, University of Alaska Fairbanks

Explorers first visiting the St. Matthew Island group in the northern Bering Sea reported seeing numerous polar bears present during summer when sea ice is not present in the Bering Sea. H.W. Elliott, a government scientist based at the Pribilof Islands, visited St. Matthew and Hall islands in 1874 and estimated 250 to 300 polar bears present, including young animals. Elliot reported that many of the bears were observed to be feeding on vegetation as is common for brown bears in early summer throughout mainland Alaska. During Russian ownership of Alaska, parties of Russians were occasionally put ashore to hunt the bears for their skins. During the intensive whaling of the latter half of the 19th Century, whaling ships on their way to and from the whaling grounds were known to have stopped at St. Matthew and Hall Islands to hunt walrus and polar bears. When the Harriman Expedition visited these islands in 1899, no polar bears were found. These polar bears, the only resident population present in the United States, had apparently been hunted to extinction. Fossil polar bear bones found on the Pribilof Islands indicate that there may also have been a population of polar bears resident there about 4,000-years ago (Yesner et al. 2005). Current research at the University of Alaska Fairbanks is seeking answers to the following questions relating to the history, ecology, and genetic relationships of the St. Matthew Island polar bears:

1. Was plant material important nutritionally in the diet of the polar bears?
2. Are these bears genetically similar to modern polar bears?
3. Were whalers responsible for the demise of the St. Matthew bears?
4. What was the paleohistory of the St. Matthew and Pribilof Island polar bears?
5. Is re-establishment of a resident population of polar bears on St. Matthew and Hall islands a feasible conservation strategy?

St. Matthew and Hall islands are uninhabited and protected as part of the Alaska Maritime National Wildlife Refuge.

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Modeling Soil Moisture Distribution in Northern Alaska: Today ± 100-Years

Anna K. Liljedahl, University of Alaska Fairbanks

A warming of the arctic region with thawing of carbon-rich soils will have global implications. By exerting a major control on the form of carbon (CO_2 or CH_4) released to the atmosphere, the soils' moisture condition will affect the strength of a positive climate feedback. At present, annual precipitation is about the same as in a desert. However, the amount of available energy limits evaporation and the annual water storage capacity in the soil, maintaining moist soil conditions throughout the summer. Climate warming can result in a drastically altered ecosystem through additional supply of energy into the system. How will the near-surface soil moisture respond to warmer soils and a longer and/or warmer thaw season? The question requires spatially distributed, high-resolution modeling, integrating processes occurring in the physical and biological systems. TopoFlow, a physically based hydrological model, will serve as the major tool to simulate past and future soil moisture distribution in a watershed at the northern Alaskan coast. The complex biosphere-atmosphere interactions will be evaluated by examining the interdependence between climate, ecosystem, hydrology, snow distribution, and active layer models. The research project is a collaborative effort under the NSF-funded project Study of Northern Alaska Coastal System (SNACS).

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Carbon Flux from Melted Permafrost Cores

Lorene Lynn, University of Alaska Fairbanks (student scholarship recipient)

A decrease in extent and duration of the polar ice cap coupled with increased storm intensity is causing a decline in protection to the vulnerable Beaufort Sea coast, especially in the spring and fall when the ice barrier is no longer present. The Beaufort Sea coast is eroding at a rate of 1–6 m/year, washing massive quantities of carbon-rich peat soils into the sea. After a section of coastline erodes, the newly exposed ice wedges melt and the soil drains, lowering the water table and increasing the depth of the active layer. Carbon-rich peat soils extend deep into the permafrost. As these soils melt, the organic material becomes available to decomposers, which can metabolize the carbon into methane and carbon dioxide. In order to understand the fate of the stored organic carbon, permafrost cores were collected at three sites: Barrow, Prudhoe Bay, and Barter Island. The cores were melted over a 24 hour period, and released methane and carbon dioxide were measured. At maximum values, carbon dioxide was 100 times greater than methane. Melt water from the cores was tested for dissolved organic carbon (DOC) concentrations. Values for DOC ranged from 0.1–450.0 mg/l, the range being highly dependent on the total ice content present in each sample. Total carbon was also measured in order to calculate the complete carbon balance in the permafrost cores. In order to better understand what portion of the permafrost cores exists as ice and will drain from the soil when melted, soil moisture was calculated. This research project is a collaborative effort under the NSF-funded project Flux and Transformation of Organic Carbon across the Eroding Coastline of Northern Alaska.

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International Polar Year Data and Information Services

Mark S. McCaffrey, University of Colorado Boulder; Mark A. Parsons

The International Polar Year Data and Information Service (IPYDIS) is an international federation of data centers, archives, and networks working to ensure proper stewardship of IPY and related data. The National Snow and Ice Data Center seeks to act as a coordination office for IPYDIS to ensure the long-term preservation of and broad, interdisciplinary, and non-expert access to IPY data. IPYDIS is guided by the IPY Data Policy and Management Subcommittee, which is presently developing an overall IPY data strategy. The IPYDIS, through its Data Coordination Office, plans to visibly track the data flow for IPY. In collaboration with the IPY International Programme office, it will develop a data registry that will continue throughout the IPY. Ultimately, this site may provide a portal to IPY and related data. In addition, IPYDIS will coordinate the development of a template for narrative educational metadata, or Data Stories, with IPY project leads in support of goals of the IPY Education, Outreach and Communications (EOC) Subcommittee, which seeks to demystify how data are collected and research is conducted. The initial Data Stories will focus on sea ice research and data.

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Facilitating Collaborative Scientific and Technical Research in the Arctic Sciences and Geosciences

Laura M. Meany, U.S. Civilian Research and Development Foundation; Erik A. Edlund

The U.S. Civilian Research and Development Foundation (CRDF) is a private, nonprofit, grant-making organization created in 1995 by the U.S. government through the National Science Foundation (NSF). CRDF promotes international scientific and technical collaboration primarily between the United States and Eurasia through grants, technical resources, and training.

The Foundation's goals are to support exceptional research, offer scientists alternatives to emigration, and strengthen the scientific and technological infrastructure in Eurasia. CRDF achieves these goals by advancing the transition of foreign weapons scientists to civilian work, moving applied research to the marketplace, and strengthening research and education in universities abroad.

CRDF offers two unique services and a program that provide support to U.S. and Russian scientists engaged in collaborative arctic and geoscience related research:

- Under a contract with NSF, CRDF assists Office of Polar Programs (OPP) and Geosciences Directorate (GEO) grantees and collaborators by providing an office and personnel in Moscow. Using this staff and in-country resources, NSF grantees receive help in identifying and communicating with individual and institutional partners, navigating government agencies, facilitating travel and visas, and providing on-site office support to visiting U.S. travelers.
- CRDF's Grant Assistance Program Services (GAP) enable U.S. government agencies, universities, and other organizations to utilize CRDF's financial and administrative infrastructure to transfer payments, purchase and deliver equipment and supplies, and carry out other project management services to collaborators in Russia and elsewhere in Eurasia.
- The Cooperative Grants Program (CGP) allows U.S.-Russian collaborators in arctic sciences and geosciences to apply for two-year R&D grants.

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Influx of Freshwater Runoff to the Northern Atlantic Ocean from East Greenland

Sebastian H. Mernild, University of Alaska Fairbanks

The arctic climate is changing. Hydrological processes are changing and evolving in response to these changing conditions. In the Arctic the rough terrain and harsh climatic conditions yield a lack of cryospheric and hydrological knowledge. The limited data of such key components is a serious impediment to the hydrological research at east Greenland, (e.g., the amount and variation in cryosphere storage change and in influx of freshwater runoff to the North Atlantic Ocean). In arctic Greenland, the terrestrial cryosphere storage (snow, ice, and permafrost) does have an important influence in the high-latitude freshwater runoff contribution to the ocean.

Analyses of freshwater runoff from the only two east Greenland catchments have been done by glacier and snow observations, water flow observations, and experiments through the glaciers and the landscape, indicating glacier recession in both places. Total freshwater runoff from the southern catchment (the Mittivakkat catchment) was ~$3.7*10^{-2}$ km^3 y^{-1} and from the northern catchment (the Zackenberg catchment) was ~$21.9*10^{-2}$ km^3 y^{-1}, highly dominated by the percentage of glacier cover. The glacier recession dominates the mean annual catchment runoff by 30–90%. The total freshwater input up-scaled to the North Atlantic Ocean is ~450 km^3 y^{-1} (1999–2004). The future (2071–2100) climate impact assessment based on the IPCC A2 and B2 scenarios modeled in HIRHAM indicates an increasing mean annual east Greenland air temperature by 2.7 ° C. The 2071–2100 mean annual freshwater input to the North Atlantic Ocean is assessed to ~670 km^3 y^{-1}, an increase of approximately 50% from today's values, highly based on changes in air temperature rather than in precipitation and evapotranspiration.

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Arctic Science Discoveries

National Science Foundation

The past five decades of intense research have increased our understanding of the Arctic, but much remains to be learned. The Arctic Sciences Section of the National Science Foundation (NSF) funds basic research of the Arctic through the Arctic Natural Sciences, Arctic Social Sciences, and Arctic System Science programs, with field research support from the Research Support and Logistics program. Some recent research results are presented both as answers to important questions and leads to future research directions.

Studying Arctic Change: The Study of Environmental Arctic Change (SEARCH) is an interagency, interdisciplinary, multiscale program to study changes occurring in the Arctic and their potential impacts.

A Look at Ringed Seal Migration: Working with Alaska Native hunters, researchers attached a satellite tracking device to follow a ringed seal as it migrated northward with the melting ice of the Chukchi Sea.

Photochemistry in Greenland Snow: Light-mediated chemical reactions (photochemistry) occur at the air-snow interface and significantly impact the chemical composition of air trapped in ice and of the air overlying the snow.

Small Streams on the Move: Small streams contribute more to removing nutrients such as nitrogen from water than do their larger counterparts. Based on data collected initially from streams in NSF's Arctic Tundra Long-Term Ecological Research site in Alaska, the findings were confirmed by data from 12 sites across the country.

Living Conditions in the Arctic: An international effort involving a partnership of researchers and indigenous organizations across the Arctic to advance our understanding of changing living conditions among Inuit and Saami peoples and the indigenous peoples of Chukotka.

Life on the Gakkel Ridge: The Gakkel Ridge is the slowest spreading center in the world, giving scientists the opportunity to explore Earth's inner layers as the mantle spreads at about 1 cm per year onto the ocean floor near the North Pole.

Understanding the Arctic Ocean: The Western Arctic Shelf Basin Interactions (SBI) project is investigating the impact of global change on physical, biological, and geochemical processes over the Chukchi and Beaufort Sea shelf basin in the western Arctic Ocean. The closely affiliated Chukchi Borderlands project studies the region where relatively cold, fresh, and nutrient-rich water from the Pacific Ocean meets warmer, saltier, and deeper water from the Atlantic Ocean over a bottom tortuously rife with slopes, ridges, and deep-sea plateaus.

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The International Polar Year

National Science Foundation

The International Polar Year 2007–2008 is envisioned to be an intense, coordinated field campaign of polar observations, research, and analysis that will be multidisciplinary in scope and international in participation. IPY 2007–2008 will provide a framework and impetus to undertake projects that normally could not be achieved by any single nation. The National Science Foundation (NSF) was designated by the President's Office of Science and Technology Policy to be the lead U.S. agency in organizing IPY activities.

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The Circumpolar Active Layer Monitoring (CALM) Network

Frederick E. Nelson, University of Delaware; Nikolay I. Shiklomanov; Kenneth M. Hinkel; Jerry Brown; Galina Mazhitova

The Circumpolar Active Layer Monitoring (CALM) program is one of several global-change programs affiliated with the International Permafrost Association (IPA). CALM was initiated in the early 1990s to track possible changes and trends in the seasonally frozen ("active") layer in the permafrost regions. Widespread, large-magnitude increases in the thickness of the active layer induced by climatic warming could liberate carbon sequestered in near-surface permafrost, create irregular topography ("thermokarst terrain") in areas of ice-rich permafrost, damage human infrastructure on the surface, and induce pronounced ecological changes.

CALM is a hypothesis-driven program that monitors active-layer thickness and shallow ground temperature, coordinates field experiments, and provides data for use by investigators involved in a wide-range of cold-environment research and modeling activities. The CALM network is currently comprised of more than 150 sites distributed throughout the Arctic, parts of Antarctica, and several mountain ranges of the mid-latitudes. Efforts to expand the number and capabilities of sites in the Southern Hemisphere (CALM-S) are underway. Instrumentation and data-acquisition methods include monitoring the soil thermal and moisture regimes with automatic data loggers, mechanical probing of the seasonally thawed layer at specified spatial and temporal intervals, frost/thaw tubes, and a variety of instruments for measuring frost heave and thaw subsidence. Several groups of sites have been used to create maps of active-layer thickness and estimates of the volume of thawed soil at regional scales. The CALM network has also provided a large amount of data pertaining to cryostratigraphy, cryoturbation, and soil carbon. Data obtained from the network have been used in validation procedures for hydrological, ecological, and climatic models at a variety of geographic scales. Data are archived at the Frozen Ground Data Center (http://nsidc.org/fgdc/) in Boulder, Colorado.

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CALM is sponsored by the U.S. National Science Foundation's Office of Polar Programs. CALM is linked with many other global-change programs through the network of observatories known collectively as the Global Terrestrial Network for Permafrost (GTN-P), a network under the World Meterological Organization (WMO) Global Climate Observing Network (GCOS). With its sister programs, Thermal State of Permafrost (TSP), Antarctic Permafrost, Periglacial, and Soil Environments (ANTPAS), Carbon Pools in Permafrost Regions (CAPP), and Arctic Coastal Dynamics (ACD), CALM forms a comprehensive effort on the part of the IPA to monitor, understand, and predict the effects of environmental change in the world's permafrost regions. CALM is a major component of the IPA's coordinated program for the International Polar Year. Detailed information about the CALM program can be found at http://www.udel.edu/Geography/calm.

Hunting Bowhead in Northern Alaska 1980–2005: Iñupiat Adaptation and Resilience to Climatic Variability

Craig Nicolson, University of Massachusetts; Stephen Braund; Craig George; Jack Kruse; Sue Moore; Carin Ashjian

Bowhead whales are a vitally important cultural and subsistence resource in the Alaskan communities of Barrow and Kaktovik. In the light of current projections of a warming Arctic, we have been examining how whale migration, regional climate change, variability in local weather conditions, and policy are likely to affect the success of whale hunting in these two communities.

Although in the central Beaufort Sea the offshore distance of the whales' migration path is influenced by summer sea ice extent, at Barrow and Kaktovik whales are close to shore irrespective of the regional sea ice extent. We found that in the spring whale hunting season at Barrow (April 20–May 31), wind speed and direction both have an important influence on hunting success. However, in fall the data indicated (a) that wind direction is not strongly linked to hunting success, and (b) even though at a daily scale the average wind speed does influence the probability that hunters will land a whale, the overall success of the Barrow fall hunting season (as measured in total number of whales landed) during 1980–2005 was much more strongly affected by International Whaling Commission policy (especially from 1980–1992), by the community's need for whales after the spring hunt, and by the timing of the hunt than by wind speed. Finally, we show that whale hunting is a strongly adaptive system, responding to feedbacks from science and from hunters' experience in previous years. We conclude that whale hunting in Barrow and Kaktovik seems remarkably resilient to climate variability and change.

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Narratives of Environmental Change from Wetland, River, and Lake Communities in Iceland and Norway

Astrid E. Ogilvie, University of Colorado; Oyvind Nordli; Gisli Palsson; Thomas H. McGovern; Arni Einarsson; Orri Vesteinsson; Trausti Jonsson; Ian A. Simpson; Jennifer Brown

Records of increasing temperatures, melting glaciers, reductions in the extent and thickness of sea ice, thawing permafrost, and rising sea level all highlight the recent warming in the Arctic and sub-Arctic. Evidence for these changes has now become overwhelming (as documented in the recent Intergovermental Panel on Climate Change [IPCC] Working Group I report). The changes are not limited to polar ocean and coastal regions, but also affect other areas currently covered by ice and snow. Thus, for example, rivers fed by mountain glaciers could run dry or change their course. Social change is intertwined with environmental change and human and animal populations are impacted across the Arctic and sub-Arctic. This poster highlights work drawn from several research projects, which have an international, multidisciplinary approach to understanding environmental change in wetland, river, and lake communities in Iceland and Norway. These projects cover many scientific disciplines, including historical climatology, meteorology, archaeology, anthropology, biology, ecology, soil science, and tephrochronology. Information is also provided by Traditional Ecological Knowledge. Areas of focus are the Myvatn wetland area in Iceland and lake/wetland communities in the Oppland district of Norway.

Myvatnssveit (the "Myvatn district") lies on the western border of the volcanic zone, which cuts across northeastern Iceland from north to south and is an extension of the mid-Atlantic Ridge. The district takes its name from the lake Myvatn (literally "midge water"). Myvatn is a large shallow lake of about 37 km^2 with about 50 islands and islets in the lake. The surrounding landscape is shaped by volcanism, and

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lake Myvatn itself was created c. 2,000 years ago by a volcanic eruption, which poured large volumes of lava over the district. The lake and its outflowing river, the Laxá, are renowned as a breeding and moulting ground for a large number of species of duck and other water birds. Lake Myvatn and the Laxá River were protected by law in 1974 and in 1978 placed on the Ramsar List of Wetlands of International Importance (http://www.ramsar.org). The area seems to have been one of the first to be settled in Iceland's "landnám" (early settlement period). The district is relatively isolated. In 1984 the population numbered 590, but by 1996 it had dropped to 470. Approximately 200 people live in the village of Reykjahlí∂. Until the early part of the 20th century, the inhabitants lived almost entirely on the proceeds of the land by farming and fishing for trout (Myvatnsilungur) in Lake Myvatn. However, life has changed radically in recent times. Because of its volcanic nature, Iceland is well suited to the use of geothermal energy, and geothermal power plants have been established at Krafla and Bjarnarflagi. The Krafla station in particular was a topic of debate from the outset and its construction provoked a major public controversy. The plant started operations early in 1977. Landsvirkjun, the Icelandic Power Company, bought the plant from the Icelandic state in 1985. These plants provide employment for about 20 people. Very few plants use fossil fuels such as coal or oil as their energy source. In this way, Iceland obtains almost its entire power supply from clean energy resources. Not surprisingly, there has been concern about the possible effect of increased geothermal development and effluents on the natural environment in and around Lake Myvatn only 2 km away, and potential effects are monitored carefully (see e.g., Thorbergsdóttir et al., 2004). With Myvatn's scenically beautiful and geologically interesting landscapes, coupled with the outstanding bird life, it is not surprising that tourism is a steadily growing business. There are several hotels and guest houses as well as restaurants, camping sites, and other small companies connected to tourism. This area has been chosen for study because the changes occurring there are currently rapid and far-reaching—agricultural practices that have changed little from settlement times are in sharp contrast to the recently established generation of geothermal power.

The district of Oppland (meaning "highland") in southeastern Norway stretches from broad farmlands in the south to the Rondane, Dovre, and Jotunheimen mountain ranges in the north. It is one of only two districts in Norway that do not have a sea coastline. The total population of Oppland is 184,000 (compare with Iceland's total population of approximately 300,000). The area includes high mountain terrain as well as tracts of forests and also agricultural landscapes with a focus on sheep and cattle as the main farming activity. It has some 48 lakes of which one, Randsfjord, will receive special attention here (Nordli et al., 2007). The area has a rich cultural heritage, and archaeological findings show a large and well-organized community in existence 3,000 years ago. It thus forms a long-established farming community where many traditional practices are maintained. Thus, for example, seterbruk (transhumance) still exists—that is, bringing livestock up to the lush mountain pastures for the summer months. Indeed, it is the Oppland region of Norway where transhumance is most common. However, this practice is rapidly dying out. About one-third of the populace still derive their livelihood from farming, primarily meat and milk production. Other important economic practices are forestry, tourism, and the production of rakfisk, preserved trout. Fish in lakes and streams provided an important supplement to the diet in the past and continue to do so today. Trout and perch are the main species found. Another fish, the so-called “common whitefish” (*Coregonus lavaretus*, Norwegian name Sik), found in certain waters in the region is on the World Conservation Union’s list of threatened species. Fishing is also a recreational activity and is part of the attraction of the area for tourists. As in Iceland, tourism is becoming a booming industry and is taking the place of many traditional economic practices. Also, as in Iceland, the use of hydroelectric power is being developed fast in the larger watercourses of Oppland.

Information regarding environmental and social change for the Oppland and Myvatn areas will be highlighted here. Data sources include documentary historical evidence such as weather diaries and letters, as well as environmental and climate data from systematic modern observations. Other sources of information range from zooarchaeological data in the form of well-dated animal bone collections, to present-day agronomic, socioeconomic, and population data, as well as local knowledge from key informants.

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Precipitation Changes, Uncertainties, and Associated Impacts to the Arctic Environment

Michael A. Rawlins, University of New Hampshire

Recent assessments of the arctic environment suggest that significant changes have occurred, due primarily to an increase in air temperature almost twice the global average rate over the past century. Analysis of records from meteorological stations and from model simulations show a positive trend in annual precipitation across much of the Arctic, with the strongest increases evident over the winter months. A trend toward more extreme precipitation events is also noted in the historical station record. Uncertainties in arctic precipitation estimates are attributable to both the sparse nature of meteorological station networks and rain-gauge undercatch of solid precipitation in windy environments.

Changes anticipated to occur over the next century follow the trajectory of past trends. Although model spread is relatively high, increases in annual precipitation of 10–30% are suggested based on the Special Report of Emissions Scenarios (SRES) A1B storyline of future greenhouse gas emissions. Projected arctic precipitation increases will likely exceed global trends due to enhanced storminess at high latitudes. This presentation describes precipitation changes that have occurred over the past century, the challenges in characterizing arctic precipitation variability and change, and projections for future trends. Changes in precipitation seasonality and the impact on river discharge and water resource availability are also explored.

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Identification of Dominant Patterns in Pan-Arctic River Discharge Trends

Asa K. Rennermalm, Princeton University (student scholarship recipient); Eric F. Wood

In the 21st century, climate change due to anthropogenic release of greenhouse gases is expected to be most pronounced in the arctic region. That arctic climate change already might be underway is indicated by 20th century increase of Eurasian river discharge into the Arctic Ocean. However, there is a spatial variability in arctic discharge trends exemplified by the late 20th century decreased river discharge into Hudson Bay. The causes for the spatially varying arctic discharge trends are largely unknown. Finding explanations for 20th century discharge trends have been difficult because of the sparse temporal and spatial coverage of arctic environmental and hydrological data.

We propose that trend attribution can be aided by the identification of regions within the arctic drainage basin that have similar trend characteristics. Here, we present a framework to seek for dominant patterns in arctic river discharge trends. The framework combines a simple description of trends in station discharge measurements with a clustering and classification technique to reduce the complexity of arctic discharge data. Indeed, with this method we are able to identify dominant trend patterns of pan-arctic discharge trends that also show some spatial patterns. Thus, the presented framework has the potential to significantly simplify the trend attribution process by reducing the problem from finding the cause of the trends in every single river basin to only finding the cause to a few dominant trend patterns. The limitations to trend attribution set by data gaps in time and space may be solved for by using environmental and hydrological data from all regions where a dominant trend pattern appears.

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High Resolution Analysis of Laminated Lacustrine and Marine Sediments in Cape Hurd Lake, Devon Island, Nunavut, Canada: A Contribution to the ARCSS 2,000-Year Synthesis of Climate Variability from Arctic Lakes

Mike Retelle, Bates College

A fundamental task of the NSF-ARCSS sponsored initiative, "A Synthesis of the Last 2,000 Years of Climatic Variability from Arctic Lakes" is to reconstruct series of high-resolution records of arctic temperature using various physical, biological, and biogeochemical proxies for the past 2,000-years. In this fashion, the present warming trend and its predicted impacts (ACIA, 2004) can be assessed in the context of past cold and warm events (i.e., the Little Ice Age and Medieval Warm Period) and a more clear understanding of temporal and spatial climatic variability in the arctic system can be attained. In the 2K initiative, 14 Principal Investigators and 11 collaborators focus their efforts on approximately 30 lake sites spanning from Beringia across the North American Arctic to Svalbard. The detailed lacustrine records will provide new and detailed paleoclimate data to assist climate modeling experiments that will explore climate forcing mechanisms and controls such as volcanism, solar irradiance, and inherent modes of climate variability to explain significant temporal and spatial patterns in the proxy records.

This poster presents results of geochemical and sedimentological analysis of sediments from Cape Hurd Lake, Devon Island (74°37'N 90°15'W), in the Canadian High Arctic. Results from the first phase of this study focused on the analysis of several short cores recovered in spring 2003. The short core record extends back to about ca. 600 BP (Putnam, 2004; Retelle et al., 2006) and was presented at the Arctic Workshop in Boulder in 2006. In this poster, we present a composite record using detailed analyses from both the short core and the upper meter of a 6 m-long vibracore, to extend our series to span the last 2,000-years.

Cape Hurd Lake is a relatively small (~2.0 km^2) density-stratified coastal isolation basin situated at sea level adjacent to Lancaster Sound, the eastern arm of the Northwest Passage on southwestern Devon Island. The basin is separated from the sea by a narrow bedrock sill mantled by shingle beach deposits that rise from west to east from sea level to approximately 70 m asl. The basin is connected by a tidal inlet to Lancaster Sound during the summer melt season, allowing tidal circulation into the basin when sea ice melts and retreats from the channel mouth. Two inlet streams feed the lake. The main inlet on the north shore drains from a plateau ice cap while a minor snowmelt-fed inlet enters along the west shore of the lake.

The basin has evolved through the Holocene from an open glacial-marine inlet to a density-stratified isolation basin (Saenger, 2002). Today, salinity in the epilimnion varies

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seasonally due to input of glacial meltwater from the plateau ice cap. Prior to initiation of seasonal runoff in 2003, a cap of oxygenated saline water (32 ppt) lay over anoxic and more saline (40 ppt) bottom water, which was found to a depth of 55 m.

In spring 2003, three short cores were recovered using Glew and Aquatic Research Gravity Coring Systems from the 50 m deep central basin site, where a 6 m long Rossvelder vibracore had been recovered in 2001 (Saenger 2002). One short core provided thin sections and preliminary lower resolution down-core analysis of grain size, %LOI, and biogenic silica as described by Putnam (2004). One of the additional adjacent surface cores was recovered within several meters of Putnam's core and was subsampled in detail (0.5 cm interval) for the 2K project. Both surface cores contain approximately 35 cm of finely laminated clayey silt overlying a 10 cm-thick massive layer. Analysis of the long core was undertaken on the uppermost meter of the vibracore and on a 1 m u-channel sample taken from the core for paleomagnetic studies (Stoner et al., 2004).

Multiproxy analyses of the sediments include grain size, magnetic susceptibility, biogenic silica (BiSi), %LOI, %OC, C/N, ^{13}C, and ^{15}N of organic matter. Non-destructive high-resolution elemental analysis (10 micron stratigraphic sampling) was also undertaken on the u-channel samples from both the surface and vibra cores using an Itrax XRF Core Scanner, housed in the Geographic Information Retrieval and Analysis System (GIRAS) laboratory at the Centre Eau, Terre and Environnement, Quebec, courtesy of Dr. Pierre Francus.

Preliminary results are outlined below:

Lithostratigraphy and geochronological control:

- The sediments in the cores are mostly finely laminated couplets of terrigenous carbonate mud and diatomaceous layers separated by occasional thicker turbidites and massive layers. Lamination counts and thickness were initially done for this core site by Putnam (2004) and recounted using various sets of criteria. A varve count of approximately 300 years for the surface core recognized multiple intra-annual pulses within varves as events within a melt season and best matches the ^{210}Pb results.
- The age model for the core constructed using varve count for the upper 30 cm is approximately 300-years, while the lower portion of the stratigraphy below the laminated zone to 100 cm was constrained using an ^{14}C AMS age on fish bone in sediments at 135 cm depth in the long core yielding an age of 3,310 +/- 40 (3055+11 calendar years). Several other macrofossils including plant debris and fishbone have been removed from the cores and have been submitted for AMS ^{14}C analysis.
- Detailed XRF multi-element scanning provides a wealth of data on major cations and trace elements. Our first focus is an attempt to utilize Ca as a proxy for rock flour flux due to the predominance of limestone bedrock in the Cape Hurd watershed. In both the long and short cores, Ca levels are out of phase with biogenic silica and ^{13}C, indicating the predominance of marine phytoplankton as the major sediment component, overwhelming terrestrial sediment from the ice cap during these phases.

Geochemistry:

- C/N values of the organic matter in the short core ranges between 9 and 14, representing a predominantly aquatic source (i.e., phytoplankton or sea ice algae) with periods of higher terrestrial input possibly corresponding to depths with higher C/N values. In the long core C/N shows a prominent shift at 35 cm depth from values from 8 to 10 to values averaging 12 to 13, perhaps indicative of increased terrestrial input.

- ^{13}C values of organic matter from the short core sediments range between -28 and 24 per mil with more enriched values in the upper third of the core. In the long core, the upper and lower core sections are more enriched than the middle zone. In general, the values ranging from -26 to -28 are consistent with marine phytoplankton, and would be more enriched in ^{13}C if ice algae was a major component to the organic matter preserved in the sediment cores. The measured carbon isotope shifts may represent changes in water temperature with an overall increase in temperature over the last ~400 years. Conversely, the ^{13}C, may also be reflecting changes in rates of primary productivity with higher rates corresponding to higher ^{13}C values.
- BiSi values range from 0.5 to 7% with the highest levels peaking in the upper third of the short core and in the upper 20 cm of the meter-long vibracore with minimal values in the central section, and more moderate values at depth. Elevated BiSi values likely result from enhanced periods of primary productivity in the lake basin brought about by either an increase in temperature, or an increase in ice-free days.
- A preliminary interpretation is that varve thickness, ^{13}C and biogenic silica records indicate that Cape Hurd Lake has experienced the highest rates of primary productivity and perhaps warmest temperatures over the last 300 years. Two periods of lower productivity and colder temperatures are indicated by thinner varves, low BiSi, and low ^{13}C occurred prior to this period, i.e., during the early phases of the Little Ice Age. Slightly higher values in the proxies for the period from ca. 1100 BP to 2200 BP indicate more moderate conditions.

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Monitoring Frost Heave and Thaw Subsidence at CALM Sites in Northern Alaska with Differential GPS

Dmitry A. Streletskiy, University of Delaware; Jonathon D. Little; Nikolay I. Shiklomanov; Frederick E. Nelson

Vertical movement of the ground surface due to frost heave and thaw subsidence is a common phenomenon in permafrost regions. The magnitude of this movement varies both temporally and spatially, owing to interannual climatic variability at the ground surface and to local variations of soil moisture. Traditional survey methods for measuring vertical surface movement have some disadvantages. Geodetic surveys have good spatial coverage, but are limited to small numbers of survey benchmarks in the Arctic. Frost tubes and heavometers allow precise measurements of heave/subsidence, but are usually limited to point locations or very small areas. Differential Global Positioning System (DGPS) provide an alternative approach for measuring ground heave/subsidence that can fill the gap between spatial coverage and precision. DGPS technology, in conjunction with survey targets designed specifically for this study, was employed at 3 sites in the northern Brooks Range Foothills and the Arctic Coastal Plain of northern Alaska. Beginning in 2001, vertical movement of the ground surface was measured twice per year (June and August). The resulting 5-year heave/subsidence record, in conjunction with temperature and active-layer measurements, was used to evaluate regional and site-specific factors affecting the spatial and temporal variability of frost heave and subsidence. Results indicate that heave and settlement show patterns of spatial variation similar to those of active-layer thickness, but that progressive penetration of thaw into the ice-rich transient layer occurred between 2001 and 2006. Comparison of GPS-measured ground surface elevations with historic data reveals significant long-term ground subsidence at several sites near Barrow. DGPS methodology is useful for measuring frost heave and thaw settlement over relatively large areas with very fine resolution.

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Arctic Sea Ice is Disappearing Faster than Forecast

Julienne C. Stroeve, University of Colorado Boulder; Mark C. Serreze; Marika Holland; Walter Meier

From 1953 to 2006, arctic sea ice extent at the end of the melt season in September has declined sharply. All models participating in the Intergovernmental Panel on Climate Change Fourth Assessment Report (IPCC AR4) show declining arctic ice cover over this period. However, depending on the time window for analysis, none or very few individual model simulations show trends comparable to observations. Current arctic summer sea ice conditions are on average 30 years ahead of where the models say we should be. Since the IPCC models suggest summer ice free conditions as early as 2050, this state to a seasonally ice free Arctic may occur sooner than projected.

Results from the study also suggest greenhouse gases are playing a significant role in the observed decline. If the multi-model ensemble mean time series provides a true representation of forced change by greenhouse gas (GHG) loading, 33–38% of the observed September trend from 1953 to 2006 is externally forced, growing to 47–57% from 1979 to 2006. Given evidence that as a group, the models underestimate the GHG response, the externally forced component may be larger.

Although it remains a mystery as to the exact date when the Arctic may become ice free in summer and how rapid this transition may be, this new state would have profound implications for climate around the globe. A warmer Arctic will result in altered atmospheric and oceanic circulation patterns that will affect weather worldwide. Studies have already linked arctic sea ice loss to changes in atmospheric patterns that cause reduced rainfall in the American West and increased precipitation over western and southern Europe.

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Melting Over the Greenland Ice Sheet in 2006 and the 2003–2006 Melting Anomaly from Space-Borne Microwave Data

Marco Tedesco, University of Maryland

Greenland is the world's largest island, containing the second largest glacier on Earth (the Inland Ice) with a surface extent of approximately 1.75 million km^2. It is also the largest relic of the Ice Age in the Northern Hemisphere, containing enough ice to raise the sea level by around 7 m. Recently, the Intergovernmental Panel on Climate Change (IPCC, available at http://www.ipcc.ch/SPM2feb07.pdf) estimated contribution to the sea level rise from the Greenland Ice Sheet at 0.21 mm/year, representing 7.5% of the sum of individual climate contributions to sea level rise (2.8 mm/year) and 6.7% of the observed total sea level rise.

Wet and dry snow have different physical properties, although they appear to be very similar at first look. Scientists agree that the presence of liquid water within the snowpack causes more incoming solar radiation to be absorbed than dry snow. Hence, as Greenland is very sensitive to changes in climatic forcing, a rise in temperature will increase the areal extent of surface snowmelt. This decreases the amount of solar energy reflected back to space, which, in turn, will increase the energy absorbed by the Earth. Also, recent studies show that melting snow enhances sliding of glaciers as surface meltwater seeps down to the ice-bedrock interface. Furthermore, increased melting liberates water that can freely evaporate; this may increase cloud cover, which is associated with its own complex set of climate feedbacks.

In this poster, I will show maps of melt extent and duration in 2006 over the Greenland Ice Sheet derived from space-borne microwave brightness temperatures measured by the Special Sensor Microwave Imaging radiometer (SSM/I). I will also show temporal trends of daily melting areas from which distinct events regarding the onset melting and freezing can be identified. A long-term analysis for the period 1988–2006 shows that 2006 ranked 7th or 5th, depending on the frequency, within the study period. Lastly, melting anomalies for the period 2003–2006 will be displayed, showing consistent results with those regarding mass loss, altitude, or surface temperature changes from other satellite missions, such as GRACE, ICESat, and MODIS.

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ISAC - International Study of Arctic Change

Michael Tjernström, Stockholm University; Grete K. Hovelsrud

The International Study of Arctic Change (ISAC) is a science program jointly launched by the International Arctic Science Committee (IASC) and the Arctic Ocean Sciences Board (AOSB). It is designed as a long-term, international, cross-disciplinary, and pan-arctic program to document arctic environmental changes. ISAC will take a system approach to facilitate expansion and deepening of our knowledge of the arctic system and to document changes in the Arctic. ISAC is motivated by already documented changes large enough to affect the lives of native populations, other residents in the arctic realm, as well as the ecosystem. Climate models suggest substantial future changes; these will have a profound impact on humankind not only at high latitudes but potentially also at lower latitudes through climatic teleconnections. It is obvious that the distribution of sustainable marine resources will change, but to what degree and in what patterns is not possible to answer with certainty before reliable climate forecasting can be performed. It cannot be disregarded that poorly understood feedback mechanisms might alter the system resulting in abrupt changes in climate. Whereas dealing with changes is challenging enough, the lack of predictability compounds the problem because it does not allow development of strategies to deal with the changed environment. Among the major products of ISAC will be contributions to scientific assessments that address present and future needs of impact assessments. Toward this end, ISAC will engage in multidisciplinary observational, synthesis, and modelling activities responding to societal needs, science plans, and priorities established by the scientific community.

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Synoptic Influences on the Arctic's Freshwater Budget: Case Studies From the Northern North Atlantic

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The freshwater budget of the Arctic has drawn scientific attention for several decades. The shrinkage of sea ice observed in recent decades together with the increased high latitude storm activity and precipitation has a potential to alter the rate of thermohaline circulation in the North Atlantic and thus influence the global climate. The majority of research devoted to this problem has focused on a monthly and/or annual timescale. We complement current research by looking at the key variables of the arctic freshwater budget on a synoptic timescale.

In addition to its significance in the global climate system, the northern North Atlantic region is one of the most synoptically active and variable regions of the planet, especially during the winter season. Through impacts on net precipitation and wind driven export of sea ice via Fram Strait, these cyclones can modulate the arctic freshwater budget.

National Centers for Environmental Prediction (NCEP)/National Center for Atmospheric Research (NCAR) reanalysis data are used to examine winter synoptic activity in the North Atlantic. The cyclone identification algorithm is based on the sea level pressure (SLP) pressure field. We use ERA-40 6-hourly fields to assess precipitation, evaporation and moisture flux, and daily sea ice concentration from Nimbus-7 Scanning Multichannel Microwave Radiometer (SMMR) and Defense Meteorological Satellite (DMSP) Special Sensor Microwave/Imager (SSM/I) passive microwave and daily Polar Pathfinder Ease-Grid sea ice motion vectors to investigate sea ice; the latter two are distributed at the National Snow and Ice Data Center (NSIDC). We identify several typical cases and analyze their regional precipitation and sea ice input.

Precipitation follows the cyclone activity closely. Generally, the more intense the synoptic system is, the more precipitation is associated with it. However, since cyclones vary in size and developmental patterns, a case study approach proves to be the most valuable tool to assess precipitation. Cyclones generating low level wind have a huge effect on sea ice motion when the storm is fairly deep and fairly close to the sea ice margin. Using several case studies we illustrate these associations in greater detail.

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IPY: Impacts of Permafrost Degradation on Methane Emissions from Arctic Lakes

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A recent first-order estimate suggests that arctic lakes are significant emitters of methane (CH_4) contributing as much as ~6% of global atmospheric CH_4 sources annually. Emissions from arctic lakes are projected to increase as permafrost thaws in the Arctic, releasing tens of thousands of teragrams to the atmosphere in the form of bubbles. Emissions are particularly high from lakes influenced by permafrost degradation, a process that discharges labile organic matter to anaerobic lake bottoms, fueling biological methane production and emissions. Complete thaw of permafrost beneath lakes may destabilize deeper methane sources such as hydrate methane and provide pathways for the release of sub-permafrost methane from biogenic or thermogenic sources. Despite the potential for catastrophic release of deep methane pools to the atmosphere, little is known about the occurrence, extent, and vulnerability of these methane sources. Quantifying, mapping, and projecting biological and geological methane emissions from arctic lakes in Alaska and Siberia in conjunction with permafrost degradation are the goals of our research group during the IPY. By pioneering new methods of measuring methane bubbling (dominant mode of emissions) from lakes using geophysical measurements, isotope geochemistry, remote sensing, and the establishment of a Pan-Arctic Lake Ice Methane Monitoring Network (PALIMMN), we aim to link paleo-records of thaw lake emissions to Earth-system modeling to improve understanding of the role of thaw lakes in climate change over millennial time scales, and to project emissions from arctic lakes in the future as permafrost continues to warm and thaw. This collaborative effort

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involves a highly interdisciplinary and international team of researchers from the United States, Canada, United Kingdom, India, Russia, Germany, Sweden, and Romania as well as integration with IPY-certified projects including SEARCH, AON: Collaborative Research on Carbon, Water, and Energy Balance of the Arctic Landscape at Flagship Observatories and in a Pan-Arctic Network, Permafrost Observatories: Thermal State of Permafrost, Arctic Circum-Polar Coastal Observatory Network, and Carbon Pools in Permafrost Regions.

The Arctic Research Consortium of the U.S.

Wendy K. Warnick, Arctic Research Consortium of the U.S.

The Arctic Research Consortium of the United States (ARCUS) is a nonprofit membership organization, composed of universities and institutions that have a substantial commitment to research in the Arctic. ARCUS promotes arctic research by improving communication among the arctic research community, by organizing workshops, and by publishing scientific research plans. ARCUS was formed in 1988 to serve as a forum for planning, facilitating, coordinating, and implementing interdisciplinary studies of the Arctic; to act as a synthesizer and disseminator of scientific information on arctic research; and to educate scientists and the general public about the needs and opportunities for research in the Arctic.

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Community Needs Assessment and Portal Prototype Development for an Arctic Spatial Data Infrastructure (ASDI)

Helen V. Wiggins, Arctic Research Consortium of the U.S.; Wendy K. Warnick; Lamont C. Hempel; Jordan Henk; Mark Sorensen; Craig E. Tweedie; Allison Graves Gaylord

As the creation and use of geospatial data in research, management, logistics, and education applications has proliferated, there is now tremendous potential for advancing science through a variety of cyberinfrastructure applications, including Spatial Data Infrastructure (SDI) and related technologies. SDIs provide a necessary and common framework of standards, securities, policies, procedures, and technology to support the effective acquisition, coordination, dissemination and use of geospatial data by multiple and distributed stakeholder and user groups. Despite the numerous research activities in the Arctic, there is no established SDI, and because of this lack of a coordinated infrastructure, there is inefficiency, duplication of effort, and reduced data quality and searchability of arctic geospatial data. The urgency for establishing this framework is significant considering the myriad of data that is likely to be collected in celebration of the International Polar Year (IPY) in 2007–2008 and the current international momentum for an improved and integrated circumarctic terrestrial-marine-atmospheric environmental observatories network. The key objective of this project is to lay the foundation for full implementation of an Arctic Spatial Data Infrastructure (ASDI) through an assessment of community needs, readiness, and resources and through the development of a prototype web mapping portal.

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Arctic Forum Agenda

2007 Arctic Forum | Meeting Agenda

Water in the Arctic: International Collaborations and Understanding Environmental Change
Focus questions:

- What are the changes being witnessed in the water cycle and how will these changes impact the physical, biological, and social environments of the Arctic?
- How does the science of water and the arctic environment relate to public policy, and how can information be translated to decision makers?
- How can we forge international collaborations during IPY and beyond to address these exciting scientific challenges and opportunities?

Wednesday, 23 May 2007 **House of Sweden**

1:00 p.m. Welcome and Introductions *Arctic Forum Co-Chairs:*
Gunhild Rosqvist, Tarfala Research Station
Larry Hinzman, International Arctic Research Center

1:10 p.m. Opportunities for Arctic Circumpolar Cooperation *Ambassador Helena Ödmark*
Ministry for Foreign Affairs, Sweden
Swedish Senior Arctic Official

1:40 p.m. A Virtual Expedition to Swedish Arctic Research Platforms *Gunhild Rosqvist*
Tarfala Research Station and Stockholm University

TERRESTRIAL ENVIRONMENT

2:10 p.m. Rivers, Lakes, Tundra, and Taiga: A Journey Across Alaska and Northern Canada
Matthew Sturm
Cold Regions Research and Engineering Laboratory

2:40 p.m. Consequences of Permafrost Thawing and Hydrological Changes for Landscape Scale Greenhouse Gas Exchange *Torben Christensen*
Lund University

3:10 p.m. The Roles of Arctic Observatory Networks in Environmental Change Research and Monitoring *Terry Callaghan*
Abisko Research Station and University of Sheffield

3:40 p.m. Break

4:00 p.m. Changing Arctic Rivers *Stephen Déry*
University of Northern British Columbia

4:30 p.m. Glacier Change in the Arctic: Important Consequences for Near-Future Sea Level Rise *Andrew Fountain*
Portland State University

5:00 p.m. Circumpolar Arctic Mammals and Consequences of Climate Change
Anders Angerbjörn
Stockholm University

5:30 p.m. Summary Remarks *Arctic Forum Co-Chairs*

6:00 p.m. Reception (House of Sweden Anna Lindh Hall)

Thursday, 24 May 2007 **National Association of Home Builders**

8:00 a.m. Continental Breakfast

8:30 a.m. Welcome and Introductions *Arctic Forum Co-Chairs*

8:40 a.m. The Arctic in the Intergovernmental Panel on Climate Change Fourth Assessment Report *John Walsh*
International Arctic Research Center

SYNTHESIS OF CHANGES IN THE HYDROLOGICAL CYCLE

9:10 a.m. Synthesis of Changes in the Freshwater Cycle *Charles Vörösmarty*
University of New Hampshire

MARINE ENVIRONMENT

9:35 a.m. The Arctic Ocean Carbon Cycle in a Changing Environment *Leif Anderson*
Göteborg University

10:00 a.m. A Seasonally Ice Free Arctic? *Marika Holland*
National Center for Atmospheric Research

10:25 a.m. Break

ATMOSPHERE

10:45 a.m. Arctic Atmospheric Modeling: Should We Believe the Models?
Michael Tjernström
Stockholm University

11:10 a.m. Precipitation Changes, Uncertainties, and Associated Impacts to the Arctic Environment *Michael Rawlins*
University of New Hampshire

WATER IN THE ARCTIC: PAST AND FUTURE

11:35 a.m. Arctic Atmospheric Hydrologic Cycle from Reanalyses and Climate Change
David Bromwich
Ohio State University

12:00 p.m. Lunch Buffet

1:00 p.m. Poster Session: Highlights of Arctic Research and Education

HUMAN ENVIRONMENT AND NATURAL RESOURCES

2:00 p.m. Vulnerability to Changing Conditions in the Canadian Arctic: The Case of Arctic Bay, Nunavut *Johanna Wandel*
University of Guelph

2:25 p.m. Effects of Changes in Water Resources on Northern Societies *Dan White*
University of Alaska Fairbanks

2:50 p.m. West Greenland Wildlife: Recent Caribou and Muskox Observations and Future Plans *Christine Cuyler*
Greenland Institute of Natural Resources

3:15 p.m. The Narwhal Tusk, Potential as an Arctic Water Probe and Weather Station: Collaborative and Integrative Studies of Science and Inuit Traditional Knowledge
Martin Nweeia
Harvard University and Smithsonian Institution

3:40 p.m. Break

4:00 p.m. *Panel Discussion*: Water in the Arctic and International Collaborations: Opportunities During IPY and Beyond

Panel Focus Questions:

1. What are the critical scientific and policy issues with regard to “Water in the Arctic,” particularly those related to international collaboration?
2. What is the relationship between water and security, including national/political security issues, access to food and natural resources, and cultural sustainability?
3. What is the most important result, scientific or otherwise, that could come out of IPY? What is the single most important foactor to ensure a successful IPY?

Moderator: Maribeth Murray, University of Alaska Fairbanks
Panelists:
Sara Bowden, Arctic Ocean Sciences Board
Katey Walter, University of Alaska Fairbanks
Inger Marie Gaup Eira, Sami University College
Volker Rachold, International Arctic Science Committee

5:30 p.m. Summary Remarks *Arctic Forum Co-Chairs*

6:00 p.m. Adjourn

6:30 p.m. *Open Meeting: Human Dimensions of the Arctic System (HARC) - Human Dimensions Research in the Context of IPY.*

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Water in the Arctic

INTERNATIONAL COLLABORATIONS AND UNDERSTANDING ENVIRONMENTAL CHANGE

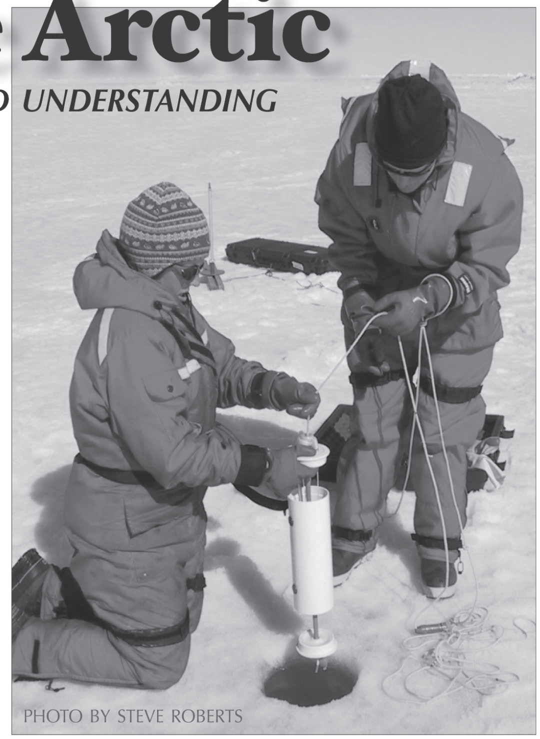

PHOTO BY STEVE ROBERTS

23-24 May 2007
Washington, D.C.

Wednesday, 23 May 2007
House of Sweden
Arctic Forum: 1:00 - 6:00 p.m.
Reception (Anna Lindh Hall): 6:00 - 10:00 p.m.

Thursday, 24 May 2007
National Association of Home Builders
Conference Center
Arctic Forum: 8:00 a.m. - 6:00 p.m.

HOSTED by the Arctic Research Consortium of the U.S. (ARCUS) and the Embassy of Sweden, *Arctic Forum 2007* will include diverse presentations focusing on "Water in the Arctic: International Collaborations and Understanding Environmental Change."

The keynote speakers are Helena Ödmark of the Ministry for Foreign Affairs, Sweden, and John Walsh of the International Arctic Research Center, Alaska.

ARCUS

The annual reception will include appetizers, a hosted bar, exhibits on the Arctic & Antarctica, as well as nature photography and paintings. The public is welcome and there is no charge for attending.

For more information on *Arctic Forum 2007* and the reception, go to www.arcus.org.