Abstracts from the

Arctic Forum

2000

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May 2000

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This report is published by ARCUS with funding provided by the National Science Foundation (NSF) under Cooperative Agreement OPP-9727899. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the authors and do not necessarily reflect the views of the NSF.

This publication may be cited as:
Arctic Forum 2000. The Arctic Research Consortium of the U.S. (ARCUS), Fairbanks, AK. 2000. 97 pp.

Cover Photo: Noctilucent clouds occur in the mesosphere over the polar regions. Increases in noctilucent cloud formations in the last century may have been the first harbinger of rising concentrations of greenhouse gasses in the atmosphere. (Photo by Peter Dalin, Space Research Institute, Moscow, Russia)

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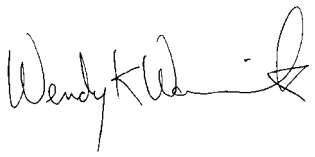
Foreword

The Arctic Research Consortium of the U.S. (ARCUS) hosts the *Arctic Forum* annually in conjunction with the ARCUS annual meeting to provide an opportunity for arctic researchers in all disciplines to interact with colleagues and agency representatives during oral presentations, a poster session, and informal gatherings. This collection of abstracts represents presentations at the *Arctic Forum* held 16–19 May 2000, in Washington, D.C.

The ARCUS annual meeting and *Arctic Forum* are the culmination of each year's efforts to represent the arctic research community on behalf of ARCUS' 41 U.S. and international 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, as well as 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 projects outside of their field, which has lead to many successful collaborations. Since its inception in October 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. Dr. Warren M. Washington of the National Science Board gave the keynote address about current NSF research initiatives and Mr. George Harper of the Blacks in Alaska History Project gave a special presentation about Captain Michael Healy, for whom the USCGC Healy is named. The *Arctic Forum* also provides student winners of the annual ARCUS Award for Arctic Research Excellence with the chance to present their research to a diverse audience of experts in arctic research.

As executive director of ARCUS, I appreciate the efforts of the many researchers who share their results with the community through the *Arctic Forum*. We thank Wieslaw Maslowski for chairing the Forum and the National Science Foundation for supporting this opportunity. Renée Crain of ARCUS edited this abstract volume; Diane Wallace, Sue Mitchell, Alison York, and Alison Carter provided editorial and technical assistance. We invite you to join us at the *Arctic Forum* in 2001.



Wendy K. Warnick
Executive Director

Introduction to the session: Environmental changes in the Arctic and their interactions with people and the global climate

Wieslaw Maslowski, Naval Postgraduate School

Scientific research in recent decades has dramatically increased our awareness of environmental changes in the polar regions and their potentially important effects on global climate. Concerns of indigenous peoples of the high North and residents in the mid-latitudes of Europe, Russia, Canada, and the U.S. have led to increased national and international support for polar sciences. In the U.S., the National Science Foundation (NSF), Departments of Defense, Energy, and Commerce, and the National Aeronautics and Space Administration (NASA) have increased support of arctic research.

Recent critical findings include evidence that the Arctic Ocean might be a center of hemisphere-wide, long-term variability affecting the land, atmosphere, sea ice, and ocean. Thompson and Wallace (1998) show that the leading mode of sea level pressure (SLP) anomalies, which they defined as the Arctic Oscillation, describes a significant portion of the northern hemisphere SLP anomalies and is most pronounced in the central Arctic. The arctic ice pack, a critical component of global climate, has decreased in thickness by about 40% in many regions of the central Arctic (Rothrock *et al.*, 1999). Some regional (Maslowski *et al.*, 2000) and global climate models (Walsh, this volume) predict qualitatively similar changes in the Arctic Ocean.

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The Forum's keynote speaker Warren M. Washington described many of the interagency and interdisciplinary efforts underway to improve our understanding of the arctic system. Interagency initiatives such as the Study of Environmental Arctic Change (SEARCH) promote interdisciplinary studies of arctic environmental change. The NSF Arctic System Science (ARCSS) Program seeks to improve our understanding of the arctic system as a whole. Other countries, including Russia and Canada, also are vigorously developing plans for focused studies of arctic change and biodiversity.

This volume of abstracts from the *Arctic Forum* demonstrates the diversity of current research to develop a better understanding of the Arctic as a system and to describe its affects on the global system. Individual and collaborative efforts presented at the *Arctic Forum* represent the cutting edge of national and international efforts to unravel the driving forces and direction of environmental changes in the arctic system and their interactions with people and the global system.

References:

Thompson, D.W.J. and J.M. Wallace. 1998. Arctic Oscillation signature in the wintertime geopotential height and temperature fields. *Geophys. Res. Lett.* 25, 1297-1300.

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

Rothrock, D.A., Y. Yu, G.A. Maykut. 1999. Thinning of the arctic sea-ice cover. *Geophys. Res. Lett.* 26, 3469-72.

A new environmental initiative for NSF and advances in climate modeling of the Arctic

Warren M. Washington, The National Center for Atmospheric Research

The National Science Board (NSB) and NSF staff have developed a new environmental initiative. After reviewing many previous reports, holding public hearings and symposia, obtaining input from professional societies, and hearing from many individuals on the web, the NSB Environmental Task Force issued an interim report. The interim report drew many additional comments and suggestions. Finally, the final report has been issued. The NSB heard that human-caused environmental changes are producing new scientific challenges and that understanding environmental systems requires more than the standard disciplinary approach. These issues are even more critical in the Polar Regions where it is expected the changes will be among the largest. For this portion of the talk, the principal findings and recommendations will be discussed. In the second part of the talk a very brief history of climate models of the Arctic will be given with a glimpse into the future when global climate models will become global environmental models. The two aspects of the talk are connected in that 21st century environmental research will become more holistic and interdisciplinary.

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The Arctic Oscillation: Implications for arctic research

John Mike Wallace, University of Washington

The Arctic Oscillation (AO) is a term coined by Thompson and Wallace (GRL 1998) for a mode of atmospheric variability defined by the leading (SLP) field. Virtually identical to the "North Atlantic Oscillation" of Sir Gilbert Walker in the 1920s and the "zonal index cycle," as interpreted by J. Namias and his M.I.T. colleagues E. N. Lorenz and L. W. Gates ca. 1950, the AO is characterized by SLP anomalies of opposing sign over the polar cap region and the surrounding zonal ring centered near 45° N. The 'high index state' with below normal pressure over the polar cap region is distinguished by westerly wind anomalies at subpolar latitudes and enhanced subtropical trade winds, and vice versa. The wind anomalies associated with the AO intensify with height all the way up to the tropopause, and during wintertime the subpolar wind anomalies extend upward into the stratosphere where they modulate the intensity of the polar night jet.

Though the AO is truly hemispheric in scale, its impacts are particularly pronounced in high latitudes. During wintertime, the high index polarity of the AO tends to be characterized by mild weather over Eurasia and colder than normal conditions over Labrador and southern Greenland. The snow line tends to lie north of its climatological-mean position over much of Eurasia (Anjuli Bamzai, Rutgers University, personal communication). Arctic melt ponds tend to form earlier than normal in spring (Sheldon Drobot, Iowa State University, personal communication) and the drift of sea ice over the Arctic is modified in such a way as to reduce the recirculation in the Beaufort Gyre and enhance the outflow through the Fram Strait, thereby thinning the ice pack (Ignatius Rigor, University of Washington, personal communication).

Over the past 30 years the AO has experienced a pronounced drift toward the high-index state, particularly during the months of January, February, and March when it is strongly coupled with the lower stratosphere. This drift accounts for most of the SLP trends observed during this period, as well as much of the observed trends in surface air temperature, wind, and quantities such as snow cover, precipitation, and total column ozone. In diagnosing the long-term changes in such quantities, the month-to-month and season-to-season variations in the AO can serve as a surrogate for the trends.

Additional information on the AO and its implications for recent climate change (including many of the diagrams shown in this talk) can be downloaded from David Thompson's web site <http://tao.atmos.washington.edu/ao/index.html>.

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Are recent arctic climate variations consistent with greenhouse projections?

John Walsh, University of Illinois

Control runs and greenhouse simulations from a suite of nine global climate models have provided the basis for an assessment of the climate changes projected for the Arctic as trace gas concentrations increase. Common features of most of the model projections for the late 21st century are a strong but highly seasonal warming over the Arctic Ocean, a more modest (3–6°C) but less seasonal warming over the subarctic land areas, and a summertime increase in subarctic terrestrial precipitation. The models also project a general decrease of sea level pressure over the Arctic and enhanced wind forcing of ice/ocean outflow to the North Atlantic. The warming is associated with a retreat of sea ice. Observational data for the past half-century show a seasonal warming and an increase of precipitation over the subarctic land areas. However, the observed warming appears to be largest in late winter and spring, while the model-projected warming is largest in autumn and early winter (in response to the enhanced summertime heating of the Arctic Ocean as sea ice thins). A major discrepancy in the model results and observational data is that the models' ice extent decreases most strongly in winter, while the data show a larger retreat in summer than in winter. Changes in the atmospheric circulation pattern are consistent with the observed pattern of sea ice retreat.

Composite, model-derived scenarios of 21st-century change for specific locations, including the Alaskan interior, the central Arctic Ocean, and the subpolar North Atlantic, illustrate the strong seasonality of the signal and its increase over time. The composite scenarios shown for the specific locations include ranges of uncertainty based on the scatter among the different models.

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The summer arctic frontal zone as seen in the NCEP/NCAR reanalysis

Mark C. Serreze, University of Colorado; Amanda H. Lynch; Martyn P. Clark

Calculations of a thermal front parameter (TFP) using NCEP/NCAR reanalysis data over the period 1979–1998 reveal a relative maximum in frontal frequencies during summer along northern Eurasia from about 60–70° N, best expressed over the eastern half of the continent. A similar relative maximum is found over Alaska, which although best expressed in summer is present year-round. These high-latitude features can be clearly distinguished from the polar frontal zone in the middle latitudes of the Pacific basin and collectively resemble the summertime "Arctic frontal zone" discussed in several early studies. While some separation between high- and middle-latitude frontal activity is observed in all seasons, the summer season is distinguished by the development of an attendant mean baroclinic zone aligned roughly along the Arctic Ocean coastline and associated wind maxima in the upper troposphere. The regions of maximum summer frontal frequency correspond to preferred areas of cyclogenesis and to where annual precipitation is dominated by summertime contributions. Cyclones generated in association with the Eurasian frontal zone often track into the central Arctic Ocean, where they may impact on the sea-ice circulation.

Development of the summer Eurasian frontal zone occurs in conjunction with a seasonal change in the large-scale circulation characterized by a zonal orientation of the isotherms. Over both Eurasia and Alaska, baroclinicity appears to be enhanced by differential heating between the Arctic Ocean and snow-free land. Frontal activity also shows an association with orography, which may help to focus the baroclinicity. Several studies have argued that the location of the summer arctic frontal zone may be in part determined by discontinuities in energy exchange along the tundra/boreal forest boundary. However, a vegetation forcing is not required in our conceptual model.

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Why is the arctic ice cover so thin?

Drew Rothrock, University of Washington; Yanling Yu; Gary A. Maykut; Jinlun Zhang

The sea-ice cover in the Arctic Ocean observed at the end of summer has declined by 1.3 m in draft—from a draft of about 3.1 m in the period 1958–1976 to a draft of 1.8 m in the period 1993–1997. This represents a loss of the ice volume of about 40%. The decrease is larger in the central and eastern Arctic than in the Beaufort and Chukchi seas. This result mirrors the decline in northern hemisphere sea-ice extent reported by Walsh and Chapman (2000).

The ice draft observations come from upward-looking sonars aboard U.S. Navy submarines. The data set includes three cruises in the 1990s from the SCICEX (Scientific Ice Expeditions), and 5 cruises from the period 1958–1976. The large decrease is observed when comparing the data from these two time periods. There is also a measurable downward trend of 0.1 m per year during the three cruises in the 1990s (1993, 1996, and 1997). These are changes in mean draft defined to include all portions of a transect including open water. If open water segments of the transects are omitted from the means, a similar decrease in the "ice-only" means is seen.

To try to elucidate the causes of this thinning we have examined results from an ice-ocean model that includes a 12-category, ice-thickness distribution. When forced with 48 years of NCEP reanalysis winds and downwelling radiation, the model shows a September ice thickness (1.12 x draft) that declines (very irregularly) from a peak of 3.5 m in 1966 to a minimum of 1.3 m in 1998. Of this change, about three quarters is attributable to a shift in ice circulation, associated with a rising North Atlantic Oscillation index, that evacuates ice from the Arctic Ocean rapidly. About a quarter of the change can be attributed to increased heating from the atmosphere and ocean.

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Towards prediction of arctic climate change

Wieslaw Maslowski, Naval Postgraduate School

Analysis of atmospheric sea level pressure (SLP) fields in the Northern Hemisphere (NH) for this century indicates an increased variability since the mid-1960s. In an attempt to explain the Arctic Ocean response to such changes, results are presented from a high-resolution, regional, coupled ice-ocean model, forced with realistic atmospheric data derived from the European Centre for Medium-range Weather Forecasts (ECMWF) for 1979–1998. The model resolution is 18 km and 30 levels and its rotated numerical grid includes the Arctic Ocean, Nordic seas, Canadian Archipelago, and sub-polar North Atlantic. The model consists of an ocean general circulation model (OGCM) adapted to the Pan-Arctic region, coupled to a viscous-plastic, dynamic-thermodynamic sea-ice model. The primary integration uses daily-averaged 1979 atmospheric data repeated for 20 years and then continues with interannual forcing for 1979–1998. Analysis of model output allows for improved understanding of the ice-ocean system response to the atmospheric circulation and its variability over the Arctic Ocean.

The cyclonic (or eastward) shift in ice and ocean circulation, distribution of fresh water and extent of Atlantic Water has been determined when comparing conditions between the early 1980s and 1990s. A new opposite trend is modeled during the late 1990s. It appears to have a tendency to reverse large-scale conditions of the ice-ocean system to its state known from the 1970s and 1980s, implying an oscillatory behavior of the system. Both sea ice and the upper ocean circulation as well as fresh water export from the Russian shelves and the intensified re-circulation of Atlantic Water within the Eurasian Basin indicate that the Arctic Ocean climate is undergoing another shift. Interannual variability of the atmospheric conditions appears to be the main and sufficient driver of modeled changes in the sea ice and ocean below during the last two decades. Additional data for the late 1990s, especially from the Eurasian Basin, is needed in order to verify the model prediction of the latest climate change in the Arctic.

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A perspective on present and future oceanographic studies in the Canadian Arctic: Change and biodiversity

Eddy Carmack, Department of Fisheries and Oceans (Canada)

Conservation of biodiversity, especially those components upon which humans depend for survival, is the most pressing challenge facing earth and environmental scientists today. Much of the current oceanographic research conducted in Arctic Canada is focused on climate change and living resources. It is thus natural to combine the two issues and ask: "What is the role of a changing physical environment in biodiversity?" In fact, the Arctic is in many ways the ideal place to address such a question. First, both observational and modeling studies warn that climate change will occur first and most intensely in high-latitude regions. Second, because of habitat considerations, climate change in the Arctic will impact biota from both bottom-up (*e.g.*, changes in light regime or nutrient delivery) and top-down (*e.g.*, by disturbing predator-prey relations) effects. This duality of bottom-up and top-down effects will be felt in both the seasonal ice zone (SIZ) and in the riverine coastal domain (RCD). The former SIZ affects not only light and nutrients, but also comprises an important habitat for marine fish and mammals. The latter RCD represents not only a supply of nutrients, but also a transport corridor for larvae and anadromous fish. To link biodiversity to a changing physical environment requires that we accommodate all scales, from the molecular to that of climate.

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Update on the Study of Environmental Arctic Change (SEARCH)

James Morison, University of Washington

The Study of Environmental Arctic Change is being developed to understand the present and future course of the changes that have occurred in the Arctic over the last 10–20 years. These include a change in atmospheric circulation, ice conditions, and ocean circulation. The program has been developed over the last 2–3 years with the support of the Arctic Program of the NSF Office of Polar Programs. However, in recent developments SEARCH has taken on an increasingly interagency character. In addition to NSF, NOAA, ONR, NASA, and DOE began developing an interagency SEARCH program. SEARCH has been made an integral part of the Interagency Arctic Policy Committee (IARPC) 5-year plan. The IARPC met recently and formed an official Interagency Working Group for SEARCH with the mandate of developing intermediate and long-range plans for an interagency SEARCH effort. Such a program will take advantage of the special strengths of each agency to develop a broad yet coherent effort. In other developments SEARCH has been adopted as a third element of the US-CLIVAR program. This gives SEARCH a connection to the international climate research effort that it needs.

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Circulation of Atlantic-derived intermediate water in the Arctic Ocean

William M. Smethie, Jr., Lamont-Doherty Earth Observatory of Columbia University; Peter Schlosser; Manfred Mensch; Gerhard Bönisch; Reinhold Bayer; Markus Frank; Brenda Ekwurzel; Samar Khatiwala

Near surface water from the Atlantic Ocean enters the Arctic Ocean through Fram Strait and the Barents Sea. The Fram Strait Branch Water (FSBW) is clearly identified as a warm, salty subsurface water mass beneath the cold halocline within a depth range of about 200–600 m. The Barents Sea Branch Water (BSBW) is modified by air-sea interaction and mixing with river water and sea-ice melt during its transit across the Barents Shelf. This results in it being colder and fresher, and having higher CFC and tritium concentrations than FSWB. It enters the Arctic Basin from the Kara Sea, but is slightly denser than FSBW. Although it mixes with FSBW as it enters the basin, it sinks to a deeper level and is generally found between about 600 and 1500 m depth. During the 1990s a large suite of hydrographic and tracer data have been collected throughout the Arctic Ocean from a combination of icebreaker and submarine cruises which allow basin scale mapping of the spreading pathways of both of these water masses using a combination of temperature, salinity, CFC, and tritium data. The time scale for this spreading and the extent of mixing that occurs along the spreading pathways can be estimated using the tracer data. Both water masses circulate around the Eurasian Basin in a cyclonic direction. The flow splits at the eastern end of the Eurasian Basin with flow paths extending across the Lomonosov Ridge along the East Siberian slope and along the Lomonosov Ridge toward Fram Strait. The time for FSBW to spread from Fram Strait along the Barents, Kara, and Laptev slopes to the eastern end of the Eurasian Basin is about 6 years and about 8 years is required for it to spread back to Fram Strait along

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the Lomonosov Ridge. The FSBW age along the East Siberian slope is about 8 years with no increase in age in the direction of the spreading path. This is caused by the introduction of well-ventilated, young shelf water into the FSBW along this spreading path. Oldest ages of 16 and 26 years are found in the central Eurasian and Canadian basins respectively. The spreading time of BSBW from its source region to the eastern end of the Eurasian Basin is 7–8 years and another 8 years is required for it to spread back along the Lomonosov Ridge to Fram Strait. The spreading time for the branch that crosses the Lomonosov Ridge and flows along the East Siberian margin is about 10 years between the ridge and the North Alaskan slope. This water does not mix extensively with well-ventilated shelf water as does the overlying FSBW. These flow patterns are based on data collected during the 1990s after the boundary between Atlantic and Pacific water shifted from the Lomonosov Ridge into the Canadian Basin. However, the ages of much of the FSBW and BSBW indicate a time of formation prior to the 1990s. Thus the flow patterns inferred from the age distributions represent a combination of circulation patterns before and after the boundary shift and the circulation patterns may still be evolving with time.

Decadal variability of the Greenland Ice Sheet mass balance as a cause of the "Great Salinity Anomalies" in the northern North Atlantic

Igor M. Belkin, University of Rhode Island

The "Great Salinity Anomalies" (GSA) originated in the early 1970s, 1980s, and 1990s, and propagated around the Subarctic Gyre (Belkin *et al.*, 1998). The GSAs appeared as low-S/low-T anomalies (initially, ~1.0 ppt/1°C, respectively) associated with a positive anomaly of sea-ice cover (GSA70: 330,000 km^2, Greenland/Iceland seas; GSA80: 410,000 km^2, Labrador Sea/Baffin Bay). The GSA70 initial salt deficit was ~72 Gt; roughly the same assumed for GSA80 and GSA90. Thus ~2,000 km^3 of fresh water would form a GSA. The GSA70 formed in the Greenland/Iceland seas due to the enhanced arctic freshwater/ice export via Fram Strait, whereas the GSA80 and GSA90 formed in the Labrador Sea-Baffin Bay due to wintertime atmospheric forcing, likely associated with the enhanced Arctic freshwater export via the Canadian Archipelago. The above mechanisms explain the GSAs quite well. It was noted, however (Belkin *et al.*, 1998), that all three GSAs were associated with iceberg armadas in the NW Atlantic, whose source was the Greenland Ice Sheet (GIS), hence the GIS iceberg discharge variations might be related to the GSA formation.

Variations of the GIS icebergs discharge and meltwater runoff could produce a low-S anomaly because: 1) The GIS discharge feeds the East/West Greenland Currents (EGC/WGC), then the Labrador Current (LC) exports it to the open NW Atlantic; 2) The EGC looses freshwater only *north* of the Denmark Strait (to the East Icelandic Current), where the GIS discharge is small; and 3) The GIS discharge occurs mainly *south* of the Denmark Strait, where the EGC/WGC receive water, not loose it, so the GIS discharge remains trapped in the EGC-WGC-LC, and therefore can fully contribute to the GSA formation.

The GIS mass balance components are precipitation, 753 km^3; runoff, 237–330 km^3/yr; and iceberg calving, 222–318 km^3/yr. Rates of change vary from the GIS-averaged thinning of 7 cm/yr to a net thickening of 23 cm/yr. The GIS is thought to exhibit decadal fluctuations comparable with the above. Aircraft laser-altimeter surveys revealed a rapid GIS attrition, up to ~10 cm/yr, hence enhanced freshwater discharge, conducive to the GSA formation. Thus the decadal variability of the GIS mass balance is a likely cause of the GSAs. The GIS precipitation variability contains a significant decadal signal, as well as a strong correlation with the North Atlantic Oscillation (NAO). A similar correlation between the GIS precipitation and the NAO was also found from ice-core data used to reconstruct an annual proxy NAO index for the last 350 years. The

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scatterometer data from 1978–1996 shows dramatic interannual and decadal changes in the GIS surface melt signatures that apparently increased lately: both the minimum (81,000 km^2) and maximum (250,000 km^2) melt extent occurred in the 1990s. Solid discharge (iceberg calving) might be very episodic, thus eventually producing fresh water pulses that might contribute to the GSA formation. Iceberg armadas might have been manifestations of such iceberg surges or massive iceberg releases from near-coastal areas. The surges might have been triggered by a rapid enhancement of basal sliding due to an increased precipitation and melting.

The iceberg discharge and meltwater runoff from the GIS might have been an alternative, or a complementary, mechanism accountable for the formation of the GSAs, observed in the second half of the 20th century. Under different climatic conditions, however, this mechanism might be solely responsible for the GSA origin. Such conditions had occurred in the past, leading to Heinrich events, and they might be encountered in the future.

Reference:

Belkin, I. M., S. Levitus, J. Antonov, and S.-A. Malmberg. 1998. "Great Salinity Anomalies" in the North Atlantic. *Progress in Oceanography* 41, 1–68.

Millennial-scale global events recorded in El'gygytgyn Crater Lake, eastern Siberia back to 400 ka

Julie Brigham-Grette, University of Massachusetts

El'gygytgyn Lake, located 100 km north of the Arctic Circle in northeast Russia (67° 30' N latitude and 172° 05' E longitude), was created 3.6 million years ago (n=11 Ar/Ar ages; Layer, In press) by a meteorite impact that generated a crater roughly 20 km in diameter. An international expedition to the lake in May 1998, successfully recovered sediment cores from the center of the 15 km-wide basin, penetrating nearly 13 meters in 175 m water depth using a percussion piston corer from the lake ice surface. The sediments consist of massive to finely laminated grayish to greenish muds with discrete intervals containing authigenic vivianite and perhaps lake ice-rafted clay clasts. Sub-millimeter laminated sections vary in thickness from 10 to 40 cm and represent intervals when the lake floor became anoxic (consistent with more vivianite). Distinct fluctuations in various sedimentological (stratification, clasts), physical (susceptibility), biochemical (TOC, TN, TS, δ^{13}TOC), and paleoecological (pollen, diatoms) parameters provide firm evidence that El'gygytgyn Lake and its catchment respond to environmental change at millennial time scales.

Geochronology on the core, including the timing of pollen transitions, the occurrence of the Blake (ca. 110 ka) and Laschamp (ca. 42 ka) magnetic excursions, optical luminescence ages and new AMS ^{14}C ages, confirms that our 13 m core extends back possibly as old as 400 ka; we are most confident to

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Marine Isotope Stage 6. Assuming our age model is correct, then Holocene and interglacial sedimentation rates averaged about 8–10 cm/1000 years, while rates during the Last Glacial Maximum may have been as low as 4 cm/1000 years Nevertheless, magnetic susceptibility clearly records the Younger Dryas event, stronger Dansgaard/Oeschger-Henrich tandems (like D/O-H4) but especially D/O interstadials 19 and 20, an inter-stage 5d event, and the "YD-like" event at the stage 5/6 transition. The striking similarity between the El'gygytgyn magnetic susceptibility record, the GISP2/GRIP $\delta^{18}O$ records from the Greenland Ice Sheet (to 110 ka, Grootes *et al.*, 1993), and some events recorded in carbonate records from the Bermuda Rise (Adkins *et al.*, 1997) and Bahama Outer Ridge (Keigwin *et al.*, 1994) provides the possibility for evaluating circumarctic and global teleconnections between ice core, marine, and terrestrial archives. Our geochronology is not good enough to fully determine leads and lags. In any case the lake sediment contains the best resolved record of the last interglacial (all of isotope stage 5) and the longest terrestrial record of millennial-scale climate change anywhere in the Arctic.

References:

Adkins, J. F., E. A. Boyle, L. D. Keigwin, and E. Cortijo. 1997. Variability of the North Atlantic thermohaline circulation during the last interglacial period. *Nature* 390, 154–156.

Grootes, P. M., M. Stuiver, J. W. C. White, S. Johnsen, and J. Jouzel. 1993. Comparison of oxygen isotope records from GISP2 and GRIP Greenland ice cores. *Nature* 366, 552+.

Keigwin, L. D., W. B. Curry, S. J. Lehman, and S. Johnson. 1994. The role of the deep ocean in North Atlantic climate change between 70 and 130 kyr ago. *Nature* 371, 323–326.

Layer, P. W. 40Ar/39Ar age of the El'gygytgyn impact event, Chukotka, Russia. Meteoritics and Planetary Science (In press).

Distribution of $\delta^{13}C$ in sediment organic carbon, Arctic Amerasian continental margin

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Recently Naidu *et al.* (2000) reported that there is a cross-shelf seaward increase in $\delta^{13}C$ of total organic carbon (TOC) of the continental margin sediments of the North Bering-Chukchi-East Siberian-Beaufort Sea, Arctic Amerasia. This trend is explained by a decrease in the deposition of land-derived TOC seaward from the coast. The terrestrial component of the TOC in the shelf sediments of the margin is estimated to be 35–70%. The above distribution pattern in $\delta^{13}C$ has a potential application in reconstructing the paleoceanography of the Amerasian margin, especially in context with changes in the relative proportions of supply and deposition of TOC from land and marine sources resulting from glacial-interglacial sea-level fluctuations. Further, it is suggested that the recycling and transport of terrestrially-derived carbon from the extensive Amerasian shelf could be a process causing the elevated total CO_2 in the upper halocline of the Arctic Basin.

Reference:

Naidu, A. S., L. W. Cooper, B. P. Finney, R. W. Macdonald, C. Alexander, and I. P. Semiletov. 2000. Organic carbon isotope ratios ($\delta^{13}C$) of Arctic Amerasian continental shelf sediments. *Geologische Rundschau*, R. Stein (ed.). Special Issue (in press).

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Foraging strategies of subarctic wood bison: Energy maximizing or time minimizing?

Carita M. Bergman, University of Guelph; John M. Fryxell; C. Cormack Gates; Daniel Fortin

Many classical models of ungulate foraging are premised on energy maximization, yet limited empirical evidence and untested currency assumptions make the choice of currency a nontrivial issue. The primary constraints on forage intake of ungulates are forage quality and availability. Using a model that incorporates these dual constraints, we predicted the optimal biomass of forage patches for subarctic ungulate grazers using an energy maximizing versus a time minimizing strategy. We tested these predictions on wood bison (*Bison bison athabascae*) grazing naturally occurring sedge (*Carex atherodes*). The digestive constraint was determined by a series of *ad libitum* feeding trials using sedge at different stages of growth. Sedge digestibility declined with biomass. *Ad libitum* intake of sedge by bison declined with sedge digestibility and thus decreased with sedge biomass. On the other hand, short-term sedge intake rates of wood bison increased with biomass. Incorporation of these constraints resulted in the prediction that daily energy gain of bison should be maximized by grazing patches with a biomass of 10 g/m^2, whereas a satisficing bison could minimize daily foraging time needed to fulfill its energy requirement by cropping patches with a biomass of 279 g/m^2. To test these predictions, we used a staggered mowing regime to convert even-aged stands of sedge to a mosaic of patches varying in quality and quantity. Observations of bison grazing these mosaics indicated that patches of biomass below 120 g/m^2 were avoided, while the patches of biomass 156 and 219 g/m^2 were highly preferred, with the greatest preference for the latter. These results indicate that bison were behaving as time minimizers rather than energy maximizers. Daily cropping times of free-ranging bison from the literature corroborate our results.

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"If you got everything, it's good enough": Perspectives on successful aging in a Canadian Inuit community

Peter Collings, Pennsylvania State University

Structured interviews with 38 Inuit in the community of Holman were conducted to examine Inuit definitions of successful and unsuccessful aging. Qualitative analysis of the interview data suggests that: 1) contrary to much of the literature about culture change in the Canadian North, there appear to be no significant differences in the ways Inuit of different age cohorts view aging and elderhood; 2) a successful old age is not one necessarily characterized by individual good health, but rather by the ability of the individual to successfully manage declining health; and 3) for Inuit, the most important determinants of a successful elderhood are not material, but ideological. That is, an individual's attitudes in late life, and in particular their willingness to transmit their accumulated wisdom and knowledge to their juniors, are the critical determinants of whether an elder is viewed as having a successful old age.

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Winner of the 4th annual ARCUS Award for Arctic Research Excellence

Methane emission and transport by arctic sedges in Alaska: Results of a vegetation removal experiment

Jennifer Y. King, University of California; William S. Reeburgh; Shannon K. Regli

Methane flux and below-ground methane profile studies were conducted in a wet meadow vegetation manipulation site at the Toolik Lake Long-Term Ecological Research (LTER) site during the summers of 1995 and 1996. Control plots, moss-removal plots, and sedge-removal plots were studied to determine the role of these vegetation types in wetland methane emission and to study the gas transport mechanism. Methane emission was greatest from plots with intact sedges. Depth distributions of root density collected in 1995 showed a strong inverse relationship to pore water methane concentration. Results on insertion of arrays of gas-permeable, silicone rubber tubing into the soil indicate that they are reasonable analogs for the physical process of gaseous diffusion through plants. The observed differences in flux between plots with and without sedges cannot be fully explained by differences in methane production or dissolved organic carbon concentrations in our measurements.

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Magma storage and mixing conditions for the 1953–74 eruption of Southwest Trident Volcano, Katmai National Park, Alaska

Michelle Coombs, University of Alaska Fairbanks; John C. Eichelberger; Malcolm J. Rutherford

Between 1953 and 1968, approximately 0.5 km^3 of andesite and dacite erupted from a newly formed vent on the southwest flanks of Trident volcano in Katmai National Park, Alaska, forming an edifice now known as Southwest (New) Trident. Field, analytical, and experimental evidence shows that the eruption commenced soon after mixing of dacite and andesite magmas at shallow crustal levels. Four lava flows (58.3–65.5 wt % SiO_2) are the dominant result of the eruption; these contain discrete andesitic enclaves (55.8–57.2 wt % SiO_2) as well as micro- and macro-scale compositional banding. Tephra from the eruption spans the same compositional range as lava flows; however, andesite scoria (56–58.1 wt % SiO_2) is more abundant relative to dacite tephra, and is the explosively erupted counterpart to andesite enclaves. Fe-Ti oxide pairs from andesite scoria show a limited temperature range clustered at 1000°C. Temperatures from grains found in dacite lavas possess a wider range; however, cores from large (>100 μm) magnetite and coexisting ilmenite give temperatures of ~890°C, taken to represent a pre-mixing temperature for the dacite. Water contents from dacite phenocryst melt inclusions and phase equilibia experiments on the andesite show that the two magmas last resided at a water pressure of 90 MPa, and contained ~3.5 wt % H_2O, equivalent to 3 km depth. Unzoned pyroxene and sodic plagioclase in the dacite indicate that it likely underwent significant crystallization at this depth; highly resorbed anorthitic plagioclase from the andesite indicates that it originated at greater depths and underwent relatively rapid ascent until it reached 3 km, mixed with dacite, and erupted. Diffusion profiles in phenocrysts suggest that mixing preceded eruption of earliest lava by approximately one month. The lack of any compositional gap in the erupted rock suite indicates that thorough mixing of the andesite and dacite occurred quickly, probably due to low density and viscosity differences. Disaggregation of enclaves, phenocryst transfer from one magma to another, and direct mixing of compositionally distinct melt phases were the three mechanisms by which hybridization was accomplished.

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mpacts of climate change on the arctic coastal Indigenous people

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Abstract not available.

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Marine mammals and seabirds as indicators of environmental variability in the Arctic

Sue E. Moore, National Oceanic and Atmospheric Administration

Marine mammals and seabirds are excellent indicators of environmental variability. Multiple studies, from the poles to the tropics, attest to their correspondence with meso-scale zones of oceanic productivity. In the Arctic, many species also serve the nutritive and spiritual needs of Native communities, as a primary source of food and a cultural keystone. Thus, environmental changes that effect seabirds and marine mammals also effect the health and well being of human inhabitants of the Arctic. What then can we learn by studying how marine mammals and seabirds respond to environmental variability? In short, we can explore arctic ecological pathways from the top down.

Research to date provides a rudimentary understanding of seabird and marine mammal responses to a changing environment. For example, black guillemots and horned puffins have expanded their nesting range to Cooper Island near Barrow, Alaska during the warming period of the last three decades. On a longer timeline, dovekies now routinely nest at high latitudes along the coasts of Greenland and Svalbard, as compared to fossil evidence of occurrence as far south as France. Finally, the oscillating dominance of common *or* thick billed murres on the Pribilof Islands reflect abrupt changes in marine community structure coincident with atmospherically driven oceanic regime shifts over the last four decades.

Perhaps because they are more elusive research subjects, clear examples of marine mammal responses to environmental variability are rare. Walrus and seals (ringed, bearded, spotted) depend in part on sea ice as a platform for breeding, feeding, and resting, so significant changes in ice thickness or extent have immediate ramifications. For example, foraging by Pacific walrus is compromised when, during extreme ice-minima years (*e.g.*, 1990 and 1997), their floating haul-outs retreat from productive Chukchi shelf waters into the deep basins of the central Arctic. Changes in whales' use of habitat and migration corridors are somewhat harder to discern. Bowhead, beluga, and gray whales have distinct summer and autumn habitats offshore Alaska, with autumn habitat selection seemingly influenced by sea-ice cover and transport (inflow) at Bering Strait. During the autumn migration, bowheads remain further offshore, in outer shelf and slope waters (50–2,000 m depth) when ice conditions are heavy (> 70% surface cover), but aggregate nearshore in inner-shelf waters (< 50 m depth) during years of open-water or light ice conditions. In contrast, belugas prefer slope and basin waters (> 200 m depth), no matter the ice conditions. Transport, rather than ice cover, seems to

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continued on next page

influence gray whale habitat selection, and possibly residence time in the Arctic prior to their autumn southbound migration. In years of high in-flow at Bering Strait, gray whales are especially tenacious in their use of shallow shoal waters of the Chukchi Sea, feeding there well into October.

While each of these scenarios can theoretically be related to prey availability, they provide a comparatively static view of whale responses to a changing environment. More dramatic are insights to whale movements, relative to physical features, provided by passive acoustic detection of calling bowhead whales, and by satellite-tagged belugas. A census for bowhead whales has been conducted periodically from Point Barrow since the late 1970s, augmented by acoustic detection of calling whales since the mid-1980s. Using acoustic-based tracking, the dynamic nature of the herd structure as it passes Barrow and weaves around ice has been described, with deep-keel "old" ice acting as barriers to migration, while smooth "new" ice poses no such restriction. On a much broader scale, the dramatic movements of belugas, from both the Eastern Chukchi Sea and the Beaufort Sea stocks, has recently exhilarated researchers. Satellite-tagged whales have moved swiftly from shallow coastal waters to the deep Arctic Basin, sometimes transiting over 1,000 km through very heavy ice conditions in a matter of a few days. Notably, as in sighting-based studies, belugas seemed to favor continental slope, canyon, and basin habitats. As apex predators in the Arctic, belugas are subject to comparatively high contaminant burdens through biomagnification processes, which in turn are passed on to Native consumers. This trophic position, coupled with their broad-scale movements suggest these whales, perhaps more than any other species, have the potential to integrate large-scale ecosystem variability and act as sentinels to environmental change in the Arctic.

Animals as agents of landscape evolution in the Arctic: The unquantified element

Kevin Hall, University of Northern British Columbia

The biology of arctic animals has long been a major research topic as too have been the role of animals within the arctic ecosystem and within the lifestyle of Indigenous peoples. Animals are also recognised to play a significant role within arctic ecotourism. What has not received attention is the actual role of the animals within the landscape, that they play a geomorphic role (potentially) comparable to other arctic landform agents such as glaciers, rivers, mass movement, etc. At one level this is surprising. Much of the Arctic is a region of fragile flora coupled with thermally sensitive permafrost, within which occur mobile, large herds of mammals coupled with less mobile, small, burrowing mammals. Present day numbers may also be far smaller than in the recent past when other mega-fauna such as mastodon and wooly rhinoceros were abundant. Any disturbance, particularly to permafrost conditions, by the action of these animals (direct erosion, compaction, trampling, overgrazing, etc.) can lead to a whole range of geomorphic responses—from thermokarst to slope failure. The impact of the animals is further exacerbated by other geomorphic processes (*e.g.*, needle ice, slope wash, aeolian erosion, etc.). In many instances, it is the ability of these other geomorphic processes to now operate as a result of animal action that is a major factor in landscape development, and one that is overlooked in landscape evolution. An example of an arctic landform (dells) being created by musk ox will be presented. The significance of arctic zoogeomorphology will also be put in the context of the necessity for its understanding for sustainable development or maintenance of arctic park areas, especially under potentially changeable climatic conditions.

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iving on the edge: Archaeology and coastal dynamics along the Gulf of Alaska coast

Aron L. Crowell, Smithsonian Institution

Alaska Native peoples—the Alutiit, Tlingit, Dena'ina, and Ahtna—lived along the geologically dynamic coastline of the Gulf of Alaska for 10,000 years, simultaneously at the edge of the sea and on the margin of colliding tectonic plates. Earthquakes, tidal waves, volcanic eruptions, glacial advances, and sinking shorelines are common and sometimes catastrophic occurrences, remembered in Native oral history and evident in the archaeological record of the region. Oral traditions, historical documents, and archaeological data offer insight into climate change in the region, including changes brought about by the Little Ice Age and by short-term fluctuations in North Pacific Ocean temperatures. Interdisciplinary field studies conducted in five Gulf of Alaska parks by the Smithsonian Institution and National Park Service (1993–1996) indicate that local Holocene glacial, climatic, tectonic, and sea level histories must be reconstructed as a first step toward regional level interpretations.

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The socio-demography of a Native Siberian village

John P. Ziker, Indiana University of Pennsylvania

With the collapse of the Soviet Union in 1991, remote Indigenous arctic communities have experienced significant economic changes: the dismantling of government-managed hunting enterprises that employed the majority of adults; a tenfold decrease in the value of average salaries and pensions, when received; and the speculative sale of alcohol. These economic changes appear to have brought on a demographic crisis in Native communities. Among the Dolgan and Nganasan of the Avam tundra (Taimyr Autonomous Region), mortality rates have doubled and fertility rates have fallen by 50% since 1993. The risk of violent death due to homicides, accidents, and traumas is greater now than before the fall of the USSR. Community census and death records for eleven years were used to analyze the age-sex structure of the community, as well as mortality and fertility. Analysis by ethnicity shows that the Nganasan, especially Nganasan females, are suffering greater mortality than the Dolgan within the Avam community. Intra-familial conflict is the main cause of violent death in the community. While some families have returned to subsistence foraging and hunting and fishing grounds, assigned to individuals during the Soviet era, many have returned to informal community tenure; the Dolgan and Nganasan live in a much more densely populated settlement than at any time in history. Domestic reindeer herds and the Dolgan's and Nganasan's semi-nomadic lifestyle were eliminated in the 1970s. In the long term, the modern settlement pattern and the structure of poverty have implications for renewable resource use. For example, there has been a steady decrease in the number of wild reindeer that migrate through the Ust Avam area since the 1980s, and without access to mechanized or animal-driven transportation, hunters are now pursuing small game on foot. These demographic and economic dilemmas are concerns within the Avam community and many others like it across the Russian North.

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The arctic upper atmosphere as a harbinger of global change and space weather

John Kelly, SRI International

The arctic upper atmosphere is an extremely sensitive region that reacts measurably to small changes in chemistry, temperature, and solar inputs. Severe solar eruptions and the resulting solar wind can cause major changes to the arctic upper atmosphere including greatly expanding the auroral oval, causing polar cap absorption, and the induction of large ionospheric electric currents. Ground-based instruments in the Arctic as well as from spacecraft instrumentation can measure these affects. The changes in ionospheric parameters resulting from the energy input carried by the solar wind is used by modelers to predict the effects of space weather on human activity. Also, the arctic mesosphere (the coldest place on earth) is the location of polar mesospheric clouds, noctilucent clouds, and metallic layers. Chemical changes and material transport, some of which results from human activity influence the existence of these clouds and layers.

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Arctic clouds at the edge of Space

John Olivero, Embry-Riddle Aeronautical University

Called noctilucent clouds or polar mesospheric clouds, these wispy silvery blue, light scattering layers are visible from the Earth's surface at high latitudes in mid-summer. Indirect evidence supports the hypothesis that these clouds are composed of water ice formed at the coldest point of the Earth system. Reliable observations of this phenomenon range back perhaps 120 years. There is a compelling scenario which attributes these lovely spectacles in the night sky to the long-term rise of methane and carbon dioxide in the atmosphere—hence they may have been the earliest signal of global change.

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Capt. Michael A. Healy: The man, his ships and the *Healy*

George Harper, Blacks in Alaska History Project Inc.

To commemorate the launching of the U.S. Coast Guard Cutter *Healy*, Mr. Harper collected historical photographs from the Healy family, the U.S. Coast Guard, Georgetown University, the National Archives, builders of the cutter, newspapers and museums. In this slide presentation, Mr. Harper emphasizes one man's impact on Alaska history. His talk covers the history of the Healy family, the naval career of CAPT Healy, and the ships on which he served, including the famous Revenue Cutter *Bear*. Mr. Harper also discussed the events surrounding the naming of the Cutter *Healy* and presented photographs of the vessel's launching.

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Poster presentations

The *Arctic Forum* is an opportunity for arctic researchers to exchange information at a diverse and interdisciplinary scientific meeting. The call for poster submissions is open to all arctic research and education topics, hence the *Arctic Forum* boasts a broad assemblage of information about the Arctic. Research topics addressed include space physics, oceanography, hydrology, environmental contaminants, climate change, past climate reconstruction, and modeling. Additionally, posters provided information about novel techniques for collecting data, agency research initiatives, relevant research and education programs, and science and data management organizations. Abstracts are arranged in alphabetical order by the last name of the first author. An author index is on page 96.

This year's *Arctic Forum* poster session demonstrated the variety methods available for presenting information using computers. Poster session participants had the opportunity to view and manipulate computer models of Arctic Ocean circulation patterns, sustainable development in arctic communities, and a digital elevation model of El'gygytgyn Crater Lake in Siberia, as well as interact with educational CD-ROM software and learn about recent developments in geographic information (GIS) systems.

Increasingly, the arctic system is being investigated through collaborative partnerships, improving our understanding of the arctic system within and between disciplines. Colleagues rely on one another to provide expertise, tools, and experience to build upon previous work and ideas. ARCUS looks forward to continuing to sponsor the *Arctic Forum* as a venue for arctic researchers to share information across disciplines, develop collaborative partnerships, and interact with representatives from agencies, organizations, and institutes conducting research in the arctic.

Geographic variation of selected PCB congeners in polar bears from Svalbard east to the Chukchi Sea

Magnus Andersen, Norwegian Polar Institute; E. Lie; S. E. Belikov; A. N. Boltunov; Andrew E. Derocher; G. W. Garner; J. U. Skaare; O. Wiig*

We present data on geographic variation in polychlorinated biphenyl (PCB) congeners in polar bears (*Ursus maritimus*) from Svalbard eastward to the Chukchi Sea. Blood samples from 90 free-living adult females were collected in 1987–1995. Six PCB congeners (PCB-99, -118, -153, -156, -180, and -194) were analyzed. Significant differences between areas were found in PCB levels and congener patterns.

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The Arctic Research Consortium of the United States

Arctic Research Consortium of the U.S. (ARCUS)

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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ARM Science Education and Training (ASET): Community-based education outreach for the Atmospheric Radiation Measurement Program (ARM), North Slope of Alaska

Arctic Research Consortium of the U.S. (ARCUS)

The Department of Energy's (DOE) Atmospheric Radiation Measurement (ARM) program is currently measuring solar and infrared radiation and supporting meteorological data at a Cloud and Radiation Testbed (CART) site on the North Slope of Alaska. This site is one of three in the world. As part of this program, ARM wishes to maintain good relations with the local communities and to provide science education opportunities to North Slope residents in association with the project. The program designed to meet these objectives is the ARM Science Education and Training (ASET) program, administered through a contract with the Arctic Research Consortium of the U.S. (ARCUS) and a subcontract with Iḷisaġvik College in Barrow, Alaska. The Small Contracts program is one part of ASET that supports classroom and community level science education initiatives. Funding of up to $2000 per applicant is available to educators and community members through a reviewed proposal process. The seed money provided through these small contracts has been effective in meeting the goals of the program to:

1. Expand the involvement of local students in science education on the North Slope;
2. Improve the delivery of science education on the North Slope; and
3. Improve mutual awareness and understanding among science educators, community members, and scientists working in the Arctic on efforts related to climate change.

Projects funded include:

- Students established an herbarium of indigenous plants and interviewed local elders about the traditional uses of the plants.
- Kindergarten and 4th grade students took home materials to perform a simple scientific experiment with a theme relevant to their local environment and asked a Native elder a question related to the experiment.
- Kindergartners hosted "Science Nights" by inviting their families to participate in activities related to classroom lessons including astronomy, meteorology, chemistry, and biology.
- Community members systematically investigated reports by Iñupiat hunters of the existence of dwarf spruce trees in river drainages on the North Slope.
- The construction of a scale-model solar system and purchase of a telescope in Barrow sparked a local interest in astronomy and inspired a series of related community activities.

An active working relationship with involved and supportive communities will benefit the ARM program and provide opportunities for applicable local knowledge to be integrated into the program.

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Barrow area research support recommendations

Arctic Research Consortium of the U.S. (ARCUS)

The Office of Polar Programs at the National Science Foundation (NSF-OPP) sponsored a community workshop in December 1998 to consider future support for scientific research in the area of Barrow, Alaska. At this workshop, more than 70 members of the arctic research community, policymakers, and leaders of Barrow met to develop recommendations regarding:

- broad research questions that could be or are being addressed in the general area of Barrow;
- research that is important but cannot currently be undertaken because of the lack of research support or logistics infrastructure; and
- supportive infrastructure and additional facilities that must be developed to sustain research.

The recommendations were published in *The Future of an Arctic Resource: Recommendations from the Barrow Area Research Support Workshop*, available from ARCUS.

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USCGC *Healy*, a new icebreaker to support polar research

Jonathan Berkson, U.S. Coast Guard; Commander George DuPree

U.S. Coast Guard Cutter *Healy*, the Coast Guard's new polar icebreaker, was designed as a multipurpose, high-latitude research platform capable of conducting a wide variety of research tasks in diverse fields of science and engineering and for extended polar operations. The Coast Guard intends to operate the ship primarily as an arctic research vessel scheduled for up to 200 operational days per year, with services equivalent to those provided on University-National Oceanographic Laboratory System (UNOLS) large research vessels.

Healy is 420 feet long and has a beam of 82 feet and displaces over 16,000 tons. The ship includes the latest in polar research equipment and systems, integrated by a modular science data network. Science systems and gear include a bottom mapping multibeam sonar system; a subbottom profiling system; a conductivity-depth-temperature data system; an expendable oceanographic probe system; an Acoustic Doppler Current Profiler; a jumbo coring system; a continuous flow, seawater sampling system; and a bow tower for clean air experiments.

The detailed design and construction contract, managed by the Naval Sea Systems Command, was awarded to Litton-Avondale Industries, Inc., New Orleans in July 1993. *Healy* was delivered to the Coast Guard in November 1999 and is now undergoing shakedown tests of the hull, machinery, and scientific equipment. In conjunction with UNOLS, the *Healy* Project Office has contracted with a group of scientists and technicians to conduct integrated testing of all science systems throughout the shakedown period. Following a series of warm water tests in the Gulf of Mexico and the Caribbean Sea, *Healy* transited to the eastern Arctic to conduct six weeks of icebreaking performance trials followed by four weeks of testing the scientific gear in ice conditions. Following these tests, *Healy* will transit to the homeport of Seattle. The vessel's first unrestricted science cruise is anticipated for 2001, after completion of maintenance and warranty work required by the shakedown tests.

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Hydrographic observations of the Atlantic/Pacific Front in the central Arctic Ocean

Timothy J. Boyd, Oregon State University

The distributions of heat and salt in the upper layers of the Arctic Ocean have been significantly different over the past decade than expected based on existing climatologies. One of the most profound differences is in the location of the region separating the regime of Pacific-derived waters from the regime of Atlantic-derived waters. In the past decade, this Atlantic/Pacific frontal region has been found well into the Canadian Basin from its climatological mean position near the Lomonosov Ridge.

Upper ocean temperature and salinity data collected from U.S. Navy submarines during the 1995–1999 Scientific Ice Experiment (SCICEX) program were used to determine the location of the Atlantic/Pacific Front (APF) during the latter half of the 1990s and to examine the mesoscale structure of the APF in an intensively surveyed area of the Alpha-Mendeleyev Ridge system.

The SCICEX data document showed the continued warming of the Atlantic layer core in the central Arctic and the return of the cold halocline to the southern Makarov Basin in the latter years of the 1990s.

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Scientific practice and community development in the circumpolar north

Michael T. Bravo, Scott Polar Research Institute

This project proposes a comparative international study of the role of scientific research in community development around the circumpolar north. The contribution of scientific studies to northern development since the Second World War has been profound, yet has received relatively little comparative attention. How have scientific field practices altered the culture of those northern communities where research facilities are located? Is the impact of science limited to those communities with direct involvement? How have ideas of "local participation" in science and development changed over the past thirty years in comparison with other parts of the world?

A historical, ethnographic approach to science studies drawing on archives and fieldwork in Nunavut challenges the best current sociological models of scientific research based on the accumulation of information (*e.g.*, Barnes, Latour). One problem with these received models is that they are typically based on metropolitan models of experimental practice, with little regard for the field sciences. Another problem is that they fail to incorporate the important strides made over the last two decades in understanding participatory development.

This project aims to produce a new model of relevance to northern societies. Its aim is to show how the institutional and cultural meaning of participation in science has changed in recent decades. A model of liberal paternalism and development, dominant in northern Canada until the 1970s, opened up key debates about the benefits of science. Distinctly northern cultures of scientific practice began to emerge by the 1980s. The recognition and institutionalization of specialized, community-based expertise transformed local understandings of science. More recently, rising costs of field research together with the growing politicization of knowledge in the 1990s has increasingly translated negotiations between scientists and northerners from the level of the community to the level of government policy. Plans to carry out further collaborative research at a range of scientific sites (*e.g.*, schools, research labs, on the land) should help to clarify future directions of scientific practice in this region.

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Seafloor Characterization And Mapping Pods (SCAMP): Recent results from SCICEX

Dale N. Chayes, Lamont-Doherty Earth Observatory of Columbia University; Margo Edwards; Bernard J. Coakley; Robert M. Anderson

The Seafloor Characterization And Mapping Pods (SCAMP) is a submarine-mounted underway geophysical survey system for mapping the seafloor and sub-seafloor. SCAMP consists of a Sidescan Swath Bathymetric Sonar (SSBS), a High Resolution Subbottom Profiler (HRSP), a Bell Aerospace BGM-3 gravity meter, and a physically compact Data Acquisition and Quality Control System (DAQCS). The system was installed on the U.S.S. *Hawkbill* and deployed to the Arctic on two unclassified SCICEX cruises (SCICEX98 and SCICEX99). During these two deployments, 21,155 nautical miles (1998: 8,886, 1999: 12,269) of underway data were collected in the data release area. The transducers for the SCAMP sonars are mounted in pods along the keel of the nuclear-powered submarine and the electronics for the sonars, the gravity meter and the data system are installed in the torpedo room. The data system time-stamps and logs ships own data (including navigation, attitude, and keel depth) along with the sonar data. The SSBS produces swath image data over a 135 to 140 degree swath centered at nadir and very high quality bathymetry over a 120 degree swath. In some cases the bathymetry data can be contoured at 10 meter intervals without significant artifacts. The HRSP produces bottom penetration in excess of 150 meters in some areas. Initial processing of the data has produced a number of interesting observations including evidence of ice berg and ice sheet scouring of the seafloor in water depths as deep as 900 meters, fresh vulcanism on the Gakkel Ridge and complex, possibly tectonic features on the Chukchi Plateau and Northwind Ridge.

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Water masses and shelf-basin exchange in the northern Chukchi Sea

John P. Christensen, National Science Foundation; Patricia A. Wheeler

A detailed hydrographic and nutrient survey was conducted in the U.S. portion of the Chukchi Sea in September 1996. Full water column CTD casts were taken at 204 stations and nutrients (nitrate, nitrite, ammonium, silicate) were collected at a subset of these. Many of these stations also had PON, POC, DON, DOC, alkalinity, and pH measurements. In early September in the Bering Strait, Anadyr and Alaskan Coastal Waters were identified in the western and eastern portions of the Strait and along the southern portion of the transect line along the U.S.-Russian boundary line. In the northern portion of this transect line, temperature-salinity plots show the presence of both a colder but moderately fresh Chukchi Sea water type and a colder, slightly more saline water type which appears to represent mixtures of the Chukchi waters with Halocline waters. Section plots show that this colder saline water occurs as a bottom intrusion at depths as shallow as 40 m. This intrusion is associated with a surface front separating the Chukchi Sea Water from waters characteristic of the Arctic Surface Water. An east-west, ice-edge transect passed in and out of this frontal boundary. Arctic Surface Water was found to depths of about 10–15 m. Below this resided Chukchi Sea waters diluted either with Arctic Surface Water or with Halocline Water. Near the bottom at many of the stations, waters highly enriched in Halocline Water was found at depths as shallow as 20 m. Near Barrow Canyon, large-scale upwelling advection of a water type similar to Halocline Water was seen on the western side of the Canyon extending a considerable distance into the shelf region. A core of remnant Alaskan Coastal Water was seen hugging the coast. These results suggest that:
1) Halocline Waters may at times be transported and mixed onto the shelf, and 2) that Arctic Surface Waters may actively exchange with the waters in the Chukchi Sea. Some nutrient characteristics of these waters will be discussed. This has implications for the upcoming study of shelf–basin exchange under the NSF ARCSS Program.

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mplications of N* distributions for sedimentary denitrification rates in Antarctica and the Arctic

Louis A. Codispoti, Horn Point Laboratory; Glenn F. Cota; Steve E. Gaurin

The parameter N* ((N* = N –16P + 2.9) x 0.87 μM kg^{-1}) is a potentially useful indicator of the extent to which nitrogen fixation (positive values of N*) or denitrification (negative values of N*) has caused the N/P relationship within a water parcel to deviate from the oceanic mean (Gruber and Sarmiento, 1997). We have used this property to make rough estimates of denitrification rates in a portion of the Arctic Ocean and the Ross Sea. Given the well-oxygenated waters in both regions, shelf and hemipelagic sediments are thought to be the major sites for denitrification (*e.g.*, Devol, 1991). Since the Arctic Ocean's adjacent and marginal seas have the earth's widest and shallowest shelves comprising about 25% of the global total whereas Antarctica has deep and narrow shelves comprising about 10% of the global total, one should expect higher rates of denitrification and more negative N* in the Arctic. This is what we found. Minimum N* values in our Ross Sea data were above -2 μM kg^{-1}, but data from the Arctic suggest that minimum N* values can go below -30 μM kg^{-1}. Combining N* values with flows through arctic straits, yields an estimated denitrification rate for the Arctic Ocean and its adjacent and marginal seas of about 45 Tg N yr^{-1}, in good agreement with some direct estimates of denitrification in Arctic sediments (Devol *et al.*, 1997). Our Ross Sea N* values combined with estimates of water mass residence times for this region suggest a much lower denitrification rate. Indeed, extrapolating the Ross Sea results to the entirety of Antarctic shelf sediments yields a denitrification rate of only ~4 Tg N yr^{-1}.

References:

Gruber, N., and J. L. Sarmiento. 1997. Global patterns of marine nitrogen fixation and denitrification. *Global Biogeochemical Cycles* 11, 235–266.

Devol, A. H. 1991. Direct measurement of nitrogen gas fluxes from continental shelf sediments. *Nature* 349, 319–321.

Devol, A. H., L. A. Codispoti, and J. P. Christensen. 1997. Summer and winter denitrification rates in western Arctic shelf sediments. *Continental Shelf Research* 17, 1029–1050.

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The new "Lithostratographic Lexicon of Svalbard"

Winfried Dallmann, Norwegian Polar Institute; Atle Mørk

The Committee on the Stratigraphy of Svalbard (SKS) has published a new reference book for this arctic archipelago:

- reviewing the history of lithostratigraphic nomenclature;
- revising and recommending the usage of lithostratigraphic nomenclature;
- defining and describing all post-Caledonian lithostratigraphic units.

In Svalbard, the history of geological unit names is unique due to the markedly international character of the research carried out in the archipelago. Geologists from Norway and the Soviet Union tried to communicate for several decades, but the political situation hampered the exchange of information. Different stratigraphic schemes developed in these two countries. Geologists from other countries, especially the United Kingdom and Poland, also made significant contributions to the geological exploration of Svalbard, and also to the increasing numbers of partly overlapping unit names.

The Committee on the Stratigraphy of Svalbard was established in 1990, with its secretariat at the Norwegian Polar Institute. With the Lithostratigraphic Lexicon of Svalbard, the Committee presents the results of many years of collecting data, correlative work and discussions among all relevant research groups.

Reference:

Dallmann, W. K. (ed.) 1999. *Lithostratigraphic Lexicon of Svalbard. Upper Palaeozoic to Quaternary bedrock.* Review and recommendations for nomenclature use. Committee on the Stratigraphy of Svalbard / Norsk Polarinstitutt. 320 pp.

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Barrow scale model of the Solar System

Earl Finkler; Craig George; Richard Glenn

The Iñupiat Eskimos of Alaska's North Slope have been energetic sky watchers for thousands of years, and have a rich sky lore. In the days before radios and space satellites, people would use the stars and planets to navigate around the vast land and water distances, to mark the passage of time, and to welcome the sun back after its lengthy absence. But despite this rich tradition, there was not a lot of supportive material or equipment in Barrow on astronomy. Thus, we developed a Scale Model of the Solar System in Barrow based on a 12-inch diameter sun placed at the Ipalook Elementary School. We constructed a series of metal street signs, several feet square, to show the sun and each planet at a scale which can be walked, but that illustrates the vast distances involved. Funding for this project was provided by the Department of Energy, Atmospheric Radiation Monitoring (ARM) Climate Change Research Project.

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Western Arctic Shelf-Basin Interactions (SBI) program

Jacqueline M. Grebmeier, SBI Project Office

The Western Arctic Shelf-Basin Interactions (SBI) program has been developed to improve our knowledge and understanding of shelf-basin exchange in order to enhance our predictive capability for global change impacts in the Arctic. The SBI program includes retrospective, laboratory, field, and modeling studies directed at elucidating the underlying physical and biological shelf and slope processes that influence the structure and functioning of the Arctic Ocean. The SBI program is going forward in three phases. Currently Phase I is in progress and involves regional historical data analysis, opportunistic field investigations, laboratory studies, and modeling. Phase II will constitute the core regional field investigations in the Chukchi and Beaufort seas, along with continued regional modeling efforts. Phase 3 will then investigate global change ramifications on the ecosystems of the arctic shelves and basin. This phase will involve development of a pan-arctic model (including embedded regional submodels) suitable for exploring "what-if scenario" studies related to global change. The SBI Phase I program (1999–2001) includes 18 projects, with 31 Principal Investigators (PIs) and co-PIs and various international collaborators. Funded projects include retrospective, experimental, and modeling studies in fields of biological, chemical, geological, and physical oceanography.

The SBI Phase II implementation plan outlines the field program to be initiated in 2002 for five years. Key measurements are essential to increase our understanding of the effects of global change on the processes associated with shelf productivity, fluxes, and shelf-basin interactions in the Arctic Ocean ecosystem, including physical, biogeochemical, biological, and geological (paleo) processes. Key measurements will include multidisciplinary moorings maintained over multiple seasonal cycles, with critical instrumentation to include currents, S/T, ice, nutrients, chlorophyll, optics, passive acoustics, and water samplers. In addition, seasonal sampling from vessels and other platforms (*e.g.*, ice camp) are required for rate measurements over critical spatial domains and to define spatial fields of variables. The combination of multidisciplinary moorings and measurements from cruises will be vital for ground truth/validation for physical-biological coupled models.

A SBI Project Office (PO) has been initiated to facilitate communication among SBI PI's and other ARCSS/OAII and interested scientists, along with other national and international research programs. The SBI PO also functions in supporting activities of the SBI Science Steering Committee (SSC), organiz-

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continued on next page

ing SBI annual PI meetings and workshops, acting as an information liaison for SBI science projects, assisting in the timely placement of data summaries from SBI PIs on the Internet-accessible SBI web server, and facilitating transfer of complete data sets to the ARCSS Data Coordination Center at the National Snow and Ice Data Center. Further information can be obtained by contacting Jackie Grebmeier, Director of the SBI Project Office (jgreb@utkux.utk.edu; phone 865/974-2592) and via the SBI web page: <utk-biogw.bio.utk.edu/SBI.nsf>. The SBI Science Plan [Grebmeier, J.M. *et al.* (eds.), 1998, *Arctic System Science Ocean-Atmosphere-Ice Interactions Western Arctic Shelf-Basin Interactions Science Plan*, ARCSS/OAII Report Number 7, Old Dominion University, Norfolk, VA, 65 pp.] is available via an html file on the OAII web page <arcss-oaii.hpl.umces.edu>, with a paper copy available upon request.

Ocean-Atmosphere-Ice Interactions (OAII)

Jane M. Hawkey, Horn Point Laboratory; Louis A. Codispoti

This poster gives an overview of the Ocean-Atmosphere-Ice Interactions (OAII) program, a component of NSF's Arctic System Science Initiative (ARCSS). The goals of the interdisciplinary ARCSS program are to study the Arctic System within the context of global change and to advance the scientific basis for predicting change and for formulating policy options in response to anticipated impacts. OAII focuses on the marine portion of these problems in collaboration with the other ARCSS programs.

OAII has supported a mix of large and small research programs. At present two large projects are underway: SHEBA (Surface Heat Budget of the Arctic Ocean), which is in its final stage; and Western Arctic Shelf-Basin Interactions (SBI), which is gearing up for a major field effort. OAII is also deeply involved in the Study of Environmental Arctic Change (SEARCH), which is a program that will be supported by multiple agencies and which will involve all ARCSS components.

The purposes of this poster are to review the OAII program and to show how investigators can become more involved with OAII research and with helping to determine what programs will be supported by OAII in the future.

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Application of a spatially distributed hydrologic model to a small watershed in the Siberian Arctic

Larry D. Hinzman, University of Alaska Fairbanks; Benjamin D. Johnson; Yuji Kodama; Matt Nolan

To further refine our understanding of the role of arctic regions in global hydrological and climatic dynamics, it is necessary to quantify the linkages among atmospheric and terrestrial processes across a variety of landscape types throughout the circumpolar Arctic. Two independent hydrologic analysis techniques previously developed in the Alaskan Arctic were applied to the small Tania watershed near Tiksi in Northern Siberia, Russia.

First was a hydrologic model that calculates the water balance over each element considering precipitation or snowmelt, evapotranspiration, runoff, and soil storage. During the summer of 1997 meteorological data were collected and the stream discharge was gauged for the Tania watershed and these data were used to verify this model. Only one meteorological station was operating near the basin, so the spatial variability of the input data could not be distributed across the watershed. In spite of these limitations, the simulated results of stream discharge and water balance compare reasonably well to the measured values.

Next, we utilized RADARSAT Synthetic Aperture Radar (SAR) imagery to provide estimates of soil moisture in the Tania Basin. We accomplished this by applying a neural network previously trained with field measurements of soil moisture, maps of vegetation classification, and selected ERS-1 and 2 SAR images, all from the Alaskan Arctic. We applied these techniques using RADARSAT imagery, a Digital Elevation Model (DEM), and a vegetation map of the Tania Watershed. The only available RADARSAT image of the study area was collected on May 25, 1997, during early stages of snowmelt. The results display broad areas of high moisture content. Several of the hydrologic features such as streams and ponds are clearly visible. This analysis was conducted with no retraining or recalibration of the neural network and demonstrates the viability of this technique.

These studies will permit cross-site comparisons between these two watersheds. The validation of these models on the Tania Watershed verifies that accurate simulation of hydrologic processes is achievable in widely varying basins throughout the Arctic.

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Hydrologic response and feedbacks to a warmer climate in arctic regions

Larry D. Hinzman, University of Alaska Fairbanks; Douglas L. Kane; Douglas J. Goering; Julie A. Knudson

The objective of our research is to improve the understanding of the role that soil moisture and surface play in affecting the surface energy balance, sub-surface thermal dynamics and vegetation distribution of the Arctic, as well as characterize the variability of these relationships in different climatic regimes. Soil moisture storage in the active layer seems to be the key variable in understanding most ecological process interactions and atmospheric/terrestrial linkages. Therefore we will focus our field measurement program and modeling efforts on understanding the interdependent controls on and responses to soil moisture. A basin scale water balance is the indisputable method to quantify these hydrologic processes and enable valid comparisons among watersheds in different regions, and we are in the processes of implementing a spatially-distributed hydrologic model in three arctic watersheds: near Ivotuk, Kougarok, and Council, Alaska. Each site will have one 10 m tower and two 3 m towers to profile temperature, precipitation, relative humidity, and wind gradients. Runoff will be measured in the two small basins on the Seward Peninsula (Kougarok and Council). Other field instrumentation will enable the continuous recording of soil moisture and temperature, and radiation components. Grids (1 km x 1 km) will be surveyed and installed in all three study areas to ground truth soil moisture measurements derived from satellite-borne SAR images. Utilizing all of these field data, we will refine and/or adapt our model of coupled thermal and hydrologic processes to address questions related to physical differences among watersheds existing in slightly different climatic regimes of the Arctic.

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MSA from a Svalbard icecore in relation to air temperature, sea ice, and SST variability

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In 1997, a 120 m deep ice core was drilled on Lomonsovfonna (78°51'53" N, 17°25'30" E, 1230 m asl) the highest ice field in Svalbard. In the uppermost 36 m annual signals are preserved in several of the ion records and this has made it possible to obtain an annual time scale back to 1920.

The methansulfonic acid (MSA) record from the ice core and air temperature data from Longyearbyen are correlated on a multi-year basis suggesting that MSA at the core site reflects the local climate to a large degree. A close comparison of the MSA record an the sea ice record over the 1920–1997 period suggests that they are closely related. MSA concentrations are higher for warm years with reduced ice cover. Years with little sea ice probably enables more DMS production and thus more MSA, and vice versa. This is in not in agreement with data from Greenland ice cores which shows the opposite relationship over the same time period.

Prevailing easterly winds suggest that conditions in the Barents Sea should have a strong influence on the amount of MSA deposited in the Svalbard glacier. This is confirmed by a comparison of MSA concentrations with Barents Sea sea surface temperature and ice cover, with respective correlation coefficients of 0.58 and -0.66 in the summer, and 0.55 and -0.51 in the winter.

It is difficult to make a direct causative connection between a single parameter and the MSA in the ice core since climatic variables are not mutually independent, and MSA may be influenced to varying degrees by many different parameters, however these results show that on a decadal scale the MSA record is a useful proxy of the climate of the surrounding region.

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BCAO (International Bathymetric Chart of the Arctic Ocean)—The state of the knowledge of the arctic seafloor in Y2K

Martin Jakobsson, Stockholm University; Norman Cherkis; John Woodward; Ron Macnab; Jennifer Harding; Bernard Coakley; With contributions from the Editorial Board for IBCAO

A major effort to upgrade the state of the knowledge of the Arctic Ocean seafloor has been underway for the last three years. A team of seafloor and GIS experts from eight nations has been compiling and interpreting currently identified bathymetric and geophysical data, in order to achieve the goal: a new International Bathymetric Chart of the Arctic Ocean (IBCAO). A fully contoured bathymetric map is envisioned as one of the final products. In the interim, however, we present a shaded relief view, created from a gridded model of the data on which analysis is presently underway.

To construct the database, several vintages of public-domain observations were extracted from world and national data centers, and complemented by newly released measurements that were collected by U.S. and British submarines operating beneath the permanent polar ice pack between 1958 and 1988. These data were further enhanced by original observations collected in recent years by U.S. Navy submarines during unclassified SCICEX missions from 1993 to 1999, and by Swedish and German icebreakers from 1990 to 1997. The sum of these digital holdings represents a substantial quantity of information, but their geographical distribution was not uniform. In several areas, therefore, additional depth values in the form of point soundings or bathymetric contours were derived from charts and maps published by the Russian Head Department of Navigation and Oceanography (HDNO), the U.S. Naval Research Laboratory (NRL) and National Imagery and Mapping Agency (NIMA). To portray surface relief above sea level, a copy of the GTOPO30 grid was used to portray land topography at a gridding interval of about one kilometer.

This effort has the full endorsement and support of the Intergovernmental Oceanographic Commission (IOC) and the International Arctic Science Committee (IASC). The Office of Naval Research-Europe (ONR-Eur) provided additional support for the project.

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With contributions from the Editorial Board for IBCAO, http://www.ngdc.noaa.gov/mgg/bathymetry/arctic/arctic.html

A 1500-year record of accumulation at Amundsen Western Dronning Maud Land, Antarctica, derived from electrical and radioactive measurements on a 120 m ice core

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During the Nordic EPICA pre-site survey in Dronning Maud Land in 1997/1998 a 120 m long ice core was retrieved (76°00' S 08°03' W, 2400 m above sea level). The whole core has been measured using the electric conductivity measurement (ECM) and dielectric profiling (DEP) techniques, and the core chronology has been established by detecting major volcanic eruptions. In a nearby shallow core radioactive traces from nuclear tests conducted during the 1950s and 1960s have been identified. Altogether, 13 ECM and DEP peaks in the long core are identified as originating from specific volcanic eruptions. In addition two peaks of increased total b activity are identified in the short core. Accumulation is calculated as averages over the time periods between these dated events. Accumulation rate is 62 mm w. eq./yr for the last 181 years (1816 A.D. to present) and 61 mm w. eq./yr for the last 1457 years (540 A.D. to present). Our record shows an 8% decrease in accumulation between 1452 and 1641 A.D. (*i.e.,* part of the Little Ice Age), compared to the long-term mean.

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Streamflow modeling in an Alaskan watershed underlain by permafrost

Julie A. Knudson, University of Alaska Fairbanks; Larry D. Hinzman

Prediction of streamflow in subarctic regions can be challenging due to the host of unique environmental factors present. Discontinuous permafrost, extensive aufeis, and fluctuating active layers are several of the factors to be contended with in this region. In addition, reliable historical data is nonexistent for much of Interior Alaska, potentially limiting the robustness of hydrologic models even in relatively uniform conditions. Our long-term goal is to conduct hydrologic forecasting in a variety of basins by compensating for the aforementioned variability and limitations. This particular project serves to confirm the effectiveness of the HBV model in this endeavor, with the incorporation of additional factors as needed. The HBV model was chosen due to its previously demonstrated success in predicting streamflow in arctic and subarctic conditions, as well as its simplicity and ability to accurately forecast in cases of limited historical data. For our analyses, the model was used to predict streamflow for several subbasins with varying degrees of permafrost in 1994 within the Caribou-Poker Creeks (CPCRW) watershed. This research watershed is located in interior Alaska, northeast of Fairbanks. The model reproduced the measured hydrographs with good success.

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Annual water balance for three nested watersheds on the North Slope of Alaska

Elizabeth K. Lilly, University of Alaska Fairbanks; Douglas L. Kane; Larry D. Hinzman; Robert E. Gieck

Alaska's North Slope is underlain by continuous permafrost with an active layer varying in thickness from 25 cm to greater than 100 cm. We have been collecting snowpack, runoff, precipitation, and meteorological data at three nested watersheds: Imnavait Creek Watershed (2.2 km^2), Upper Kuparuk Watershed (146 km^2), and the entire Kuparuk River Basin (8140 km^2). In 1993 we began collecting data for the Upper Kuparuk Watershed. Initially one precipitation gauge was located at this site. In spring 1996 five additional gauges were installed and we found considerable difference in precipitation across the watershed because of topography. We reconstructed the precipitation in 1993–1995 based on trends detected in the 1996–1997 data. From these data, we compare water balances at three different watershed scales between 1993 and 1997. During the ablation period, snowmelt-generated runoff dominates while evapotranspiration dominates during summer months, particularly in the low gradient coastal plain.

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Effects of possible changes in the St. Lawrence Island polynya on a top benthic predator, the spectacled eider

*James R. Lovvorn, University of Wyoming; *Jacqueline M. Grebmeier; Lee W. Cooper*

The Spectacled Eider, a diving duck listed as Threatened under the Endangered Species Act, is a principal top predator on benthos southwest of the St. Lawrence Island polynya in the Bering Sea. During winter, these birds dive to depths of 40–60 m in subfreezing water among leads in the shifting pack ice, and the high costs of foraging require high intake rates at the bottom. There are very high densities of clams southwest of the polynya, resulting from high supply of organic matter (OM) to the benthos in a rather well-defined area. This OM may be supplied by production and brine-rejection currents in the polynya, by ice algae deposited locally by late-melting ice, or by production deposited at other times and then transported to the area by brine-rejection or other currents. Sampling over several decades suggests that the benthic community has shifted from larger to smaller species of clams, along with changes in grain size and organic content of sediments. We here describe development of an empirically-based computer model of the foraging energetics of Spectacled Eiders, to assess effects of an altered prey base on their overwinter survival and body condition. We also explore integration of the energetics model with physical and biological models of polynya function, to examine how interdecadal weather changes might be linked to the population energetics of this Threatened top predator and its prey.

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A 1/12 degree eddy-permitting, pan-arctic, coupled ice-ocean model: Preliminary results

*Douglas C. Marble, Naval Postgraduate School; *Wieslaw Maslowski; Yuxia Zhang; Donald Stark; Albert J. Semtner*

Selected results from the first decade of model spin-up are presented along with comments on the development of a high-resolution, eddy-permitting, coupled ice-ocean model, plans for future model improvements and anticipated results.

The model is configured on a rotated spherical coordinate grid, with 45 vertical levels and an effective horizontal resolution of 9 km or 1/12°. The model domain extends from 35° N in the Pacific Ocean, across the North Pole, to roughly 40° N in the Atlantic Ocean. Model bathymetry is derived primarily from the recently released International Bathymetric Chart of the Arctic Ocean (IBCAO, Jakobsson *et al.*, 2000), and the National Geophysical Data Center ETOPO5 database. Vertical layer thickness varies from five meters to 300 meters with twenty layers in the first 500 meters. The high resolution will improve simulation of eddies, surface, intermediate and deep currents, Arctic Ocean inflow and outflow, and important shelf processes such as water mass modification and halocline maintenance.

The ocean model is based on the Los Alamos National Laboratory Parallel Ocean Program, with a free surface formulation (Dukowicz and Smith, 1994), prescribed river runoff and passive and active tracer capability. In its final form, the dynamic-thermodynamic, energy conserving (Bitz *et al.*, 2000) sea-ice model will include elastic-viscous-plastic rheology (Hunke and Dukowicz, 1997), multiple thickness categories, multiple levels, brine pocket parameterization, a snow layer, and the assimilation of observed sea-ice motion and concentration.

Started from rest using merged Environmental Working Group (EWG)-Levitus ocean climatology, the model is forced with realistic daily varying atmospheric data from European Centre for Medium-Range Weather Forecasts (ECMWF) reanalyses. The ocean surface and vertical domain boundaries are restored monthly to the merged climatology. To allow interannual variability, Bering Strait flow is not prescribed and an artificial, 160 km-wide, 500 m-deep channel was created through North America to balance Pacific Ocean inflow to the Arctic Ocean. Realistic steric height differences have

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developed between the Pacific and the Arctic oceans and an average Bering Strait through-flow is approaching observed values.

Vigorous eddy fields, strong boundary and topographically steered currents, significant seasonal ice growth and decay, and complex ice structure and dynamics are already evident in the output. The ability to simulate inter-basin exchanges, thermohaline and wind driven circulation, regional and shelf processes, and Arctic Ocean inflow and outflow at an unprecedented resolution should prove exceptionally useful in climate change related studies.

A forecast version of the coupled model will transition to operational use as the U. S. Navy's Polar Ice Prediction System (PIPS) upgrade, to PIPS 3.0. PIPS 3.0 will run on a distributed, shared memory computer at the Fleet Numerical Meteorology and Oceanography Center in Monterey, California with output provided to the National Ice Center in Suitland, Maryland. It is anticipated the improved ice-ocean model will provide more accurate forecasts in the marginal ice zone, improved ice convergence-divergence and lead orientation forecasts and better predictions of upper-ocean stratification.

References:

Bitz, C. M., M. M. Holland, A. J. Weaver, and M. Eby. Simulating the ice-thickness distribution in a coupled climate model. *Journal of Climate*. (submitted)

Dukowicz, J. K., and R. D. Smith. 1994. Implicit Free-Surface Method for the Bryan-Cox-Semtner Ocean Model. *Journal of Geophysical Research* 99, 7991–8014.

Hunke, E. C., and J. K. Dukowicz. 1997. An elastic-viscous-plastic model for sea ice dynamics. *Journal of Physical Oceanography* 27, 1849–1867.

Jakobsson, M., N. Z. Cherkis, J. Woodward, R. Macnab, and B. Coakley. 2000. New grid of Arctic bathymetry aids scientists and mapmakers. *Eos* 81, 89+.

Plankton database of the Barents and Kara seas as the tool for the study of changes in the Arctic

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A database being developed for the Barents and Kara seas is described. Presented are physical and biological data collected during 111 scientific cruises in the Barents Sea-Kara Sea region performed in the period 1913–1999 and data on phytoplankton collected in the period 1996–1999 during cruises of Russian nuclear ice-breakers. Listed are phyto- and zooplankton species of the Arctic Seas. The ecological and geographic characteristics are given for each phytoplankton species. Pictures of live cells illustrate the dominant species. The seasonal cycle of the plankton development is described. The seasonality is phyto- and zooplankton in the 30s, 50s, and 90s is presented. It is demonstrated that the observed differences substantially exceed the error resulting from the use of various methods of plankton sampling.

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Teachers Experiencing the Antarctic and Arctic—TEA

Debra Meese, Cold Regions Research and Engineering Laboratory; Stephanie Shipp; Clarice Yentsch

The centerpiece of the Teachers Experiencing Antarctica and the Arctic (TEA) program is a research experience in which a K–12 teacher participates in a polar expedition. The TEA teacher works closely with scientists, participates in cutting-edge research, and is immersed in the process of science. Enveloping this field experience is a diversity of professional development opportunities through which TEA teachers increase content knowledge, enhance teaching skills, transfer the experience to the classroom, assume leadership roles, and collaborate with a network of researchers and education colleagues. TEA is a partnership between teachers, researchers, students, the school district, and the community. TEA is sponsored by the Division of Elementary, Secondary, and Informal Education (ESIE) in the Directorate of Education and Human Resources (EHR) and the Office of Polar Programs (OPP) of the NSF and facilitated by Rice University, the Cold Regions Research and Engineering Laboratory (CRREL), and the American Museum of Natural History (AMNH).

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Year-round acoustic observation of temperature variation in the Arctic Ocean

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The U.S./Russian Transarctic Acoustic Propagation (TAP) experiment, carried out during a week in April 1994, proved the feasibility of using low-frequency acoustics for remote observations of changes in the average water temperature along transarctic paths. Observations of the travel times of the first three acoustic modes allow us to measure the average temperature changes in the upper mixed layer, the Atlantic Layer, and deeper waters in the Arctic. The TAP acoustic "section" was the first basin-scale observation of an increase of almost 0.4°C in the maximum temperature of the Atlantic Layer in the Arctic Ocean in comparison with historical climatology. The acoustic thermometry technique is being used in the Arctic Climate Observations using Underwater Sound (ACOUS, from the Greek word "ακους" meaning "listen!") program for year-round observation of long-term changes in the average Arctic Ocean temperature on a path from Franz Victoria Strait to the Lincoln Sea. The acoustic source was installed in October 1998 and at the same time an autonomous receiver array was installed in the Lincoln Sea. The source has been transmitting a 20 min signal every four days. The Lincoln Sea array will be recovered in September 2000 and replaced. The source was designed for a three-year life. In April 1999 two of the regular transmissions were recorded at Ice Camp APLIS which was established in the Chukchi Sea approximately 2700 km from the source. Preliminary analysis indicates that the maximum temperature of the Atlantic core layer in the Arctic Ocean increased by approximately 0.4–0.5°C since the TAP measurement over almost the same path 5 years earlier. These results are also consistent with SCICEX submarine SSXCTD measurements made in 1995, 1998, and 1999 over this same path. Plans are underway for an expanded, cabled mooring-based monitoring grid that would include oceanographic and biogeochemical sensors as well as acoustic thermometry in the Arctic Ocean.

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Data management support for arctic field projects

James A. Moore, University Corporation for Atmospheric Research; Greg Stossmeister

The University Corporation for Atmospheric Research (UCAR) Joint Office for Science Support (JOSS) has received support from the NSF to develop and implement a comprehensive data management strategy for selected arctic research field projects over the last four years. They include the Surface Heat Budget of the Arctic Ocean (SHEBA) Project, the Land-Atmosphere-Ice Interactions (LAII) Arctic Transitions in the Land-Atmosphere System (ATLAS) Project, and the International Tundra Experiment (ITEX).

All of these projects have been designed as international and interdisciplinary multi-year projects with many investigators and varied instrumentation over various portions of the Arctic Basin. An integrated data management activity is important to assure that a complete database is provided for easy access to all project investigators and the science community in general. Critical factors that determine the approach include: understanding what data are planned for collection by the various components of the program, providing guidelines for the participants related to the acquisition and provision of field data (in-field record keeping, backing up field data), data set format and documentation, required special processing, data quality control and submission of preliminary and final data sets to the archive.

JOSS has worked with the Science Management Offices, Project Offices, and investigators to support their ongoing data management efforts while implementing a consistent strategy that makes sense for the project science objectives. JOSS assists the project with some or all of the following tasks:

- Provide on-line field catalog or project web pages at JOSS as appropriate.
- Prepare data management plan including data format and documentation standards.
- Collect supporting operational data (soundings, satellite, model, etc.) for use during analysis.
- Provide access point for project operational data and for preliminary and final research data sets as they become available via JOSS data management system.
- Provide specialized processing for selected data sets including parameter extraction, data set compositing, and display.
- Collaborate with National Data Centers for archival and access of project specific data sets and important supporting information.
- Coordinate the transfer of datasets to the final archive at the National Snow and Ice Data Center (NSIDC).

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The multidisciplinary data set from these projects will prove to be a rich resource for all types of arctic regional studies. JOSS role is to aid these investigators with the archival and sharing of this data set for field, modeling, and remote sensing studies in the Arctic Basin. In the longer term, educators and the larger science community will be able to access and use this information for improving their understanding of the arctic environment.

Remote data collection in climatologically extreme environments

George S. Mueller, University of Alaska Fairbanks; Douglas L. Kane

Continuous data sets are the goal of all hydrologists and meteorologists. As we attempt to expand our data collection effort in extreme climatological environments this challenge is increased. On the North Slope of Alaska we operate 18 remote sites that collect hydrologic and meteorological data. The most remote sites have scheduled visits only twice per year. If equipment problems or malfunctions developed, considerable time (and therefore considerable data) could be lost before the problem was discovered. Therefore, a system needed to be developed with the following capabilities: daily data communication access to each site, redundant data communication paths, two-way data communication for error checking and problem determination, low power consumption with 12-volt battery source, reasonable initial and operating costs, operate at extreme temperatures, and unattended data collection.

The installed system consists of a communication network of computer to modem to telephone to cellular to VHF radio modems to data logger. Computers via telephone modems are able to access base stations (two bases for path redundancy) in Prudhoe Bay that relay data requests to the appropriate site via VHF radio. Because of distances involved (approximately 200 km [120 miles] from Prudhoe Bay to the limits of the upper Kuparuk River Basin), two repeaters were installed on elevated points within the basin. While this communication system does provide all the capabilities listed above, there are several problems that still cause considerable concern. During the summer our largest problem has been bears. They have destroyed antennas, radios, co-axial cables, and equipment enclosures. During the winter our problems are the extreme cold and rhime. The extreme cold reduces the capacity of the batteries and has frozen them. The rhime detunes antennas and reduces the range of the radio communications.

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National Science Foundation/Office of Polar Programs: An overview of recent arctic research and arctic education as conveyed in a visual montage with captions

National Science Foundation, Office of Polar Programs

The Arctic Sciences Section of the Office of Polar Programs has been immersed in ongoing research and education projects as shown in the accompanying visual montage:

Marine Research: Oceanographic research in the Arctic encompasses a variety of disciplines whose goal is to develop knowledge of the structure of the Arctic Ocean and adjacent seas, their physical and biological interactions with the global hydrosphere, and the formation and maintenance of the arctic sea-ice cover.

Surface Heat Budget of the Arctic (SHEBA): SHEBA involved measurements of ice-ocean-atmosphere parameters controlling the annual cycle of sea ice albedo and surface radiation feedback mechanisms. It involved collaboration among the U.S. (NSF, ONR, NASA, DOE, U.S. Navy, and Alaska SAR facility), Canada, and Japan.

Terrestrial Research: Barrow, Alaska serves as a site for interdisciplinary studies of climate, ecology, and soil processes expected to be affected by global warming. Predictions indicate that an increase in global temperatures is likely to affect the Arctic first, with the greatest severity.

Summit Camp Observations: Four researchers spent the winter of 1997/98 (to be repeated in 2000/01 and 2001/02) at the top of the Greenland Ice Cap (10,600 m) making measurements of atmosphere and snow properties that are transferred into the ice record. The winterover experiment elucidates how the year-round record of atmospheric chemistry is transferred into snow falling at the site and how that record is incorporated into the ice record.

Greenland Ice Core Research: Cores recovered by the Greenland Icecore Project (GRIP) and Greenland Ice Sheet Project Two (GISP2) provide exceptionally high-resolution information about climate change over the last 110,000 years. These records of accumulation rates, concentrations of chemicals, and stable isotopes have allowed researchers to examine details, such as the precise nature and timing of rapid climate change events, that have important implications for understanding the earth's climate system.

Teachers Experiencing Antarctica/Arctic: Teachers Experiencing Antarctica and the Arctic (TEA) is a program in which teachers travel to the polar realms to participate in ongoing research. The program, sponsored by the National Science Foundation (NSF), is a partnership between teachers, researchers, and school districts. This program infuses the polar research experience into the classroom in rich, engaging, and innovative ways that underscore the relevance of science to society and individuals.

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Modern trends in the long-term variability of thermohaline structure in the main gates to the Arctic Ocean

Ole Anders Nøst, Norwegian Polar Institute; Jane O'Dwyer; Vladimir K. Pavlov

Unlike other parts of the World Ocean, in forming of water masses of the Arctic Ocean, advective processes prevail. The vertical extent of water layers of arctic origin, in which maximum intra-annual modification occurs makes only 2–5% of all water masses of the Arctic Ocean. The remaining 95–98% of Arctic Basin waters are waters of neighbouring oceanic basins or the results of their transformation.

The monitoring of heat and salt fluxes in the main straits, can give a clear representation of the condition and variability of the thermohaline structure of the water masses of the Arctic Ocean.

The purpose of this work is the analysis of a long-term series of CTD observations in the Fram Strait, in the strait between Svalbard and Norway and the Bering Strait, and the detection of trends during the last five decades.

Using historical and recent NPI data, climatological data from the Joint American-Russian Atlas of the Arctic Ocean (1997, 1998), a statistical analysis of the thermohaline structure (TS) in each of these straits is made. Results of analysis allow us to make the following conclusions.

Formation of large-scale temperature anomalies in North European and Amerasian Subbasin of the Arctic Ocean has an anti-phase character. Negative mean-decadal anomalies of water temperature in the Bering Strait and the Chukchi Sea correspond to the positive anomalies in the Fram Strait and Greenland Sea.

During 1950s–1980s there was a decrease of mean-decadal water temperature in summertime and an increase of mean-decadal water temperature in wintertime in the West-Spitsbergen current.

The interannual variability of water temperature in the Fram Strait is tightly connected with the atmospheric circulation. The maximum values of water temperature were observed in the years with maximum values of the NAO index.

In the 1990s there was a basic reorganization of the thermohaline condition of water masses in the main straits of the Arctic Ocean. In the Fram Strait and the strait between Svalbard and Norway the maximum temperature has significantly increased in connection with an intensification of the inflow of Atlantic water. In the Bering Strait in the 1990s the opposite situation was observed: there was a reduction of the Pacific current and as a consequence an increase of maximum temperatures.

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Reference:

Joint U.S.-Russian Atlas of the Arctic Ocean. 1997. National Snow and Ice Data Center, Environmental Working Group, Boulder, Colorado (on CD-ROM).

Exchanges between the Norwegian and Barents seas measured by ship-mounted ADCP

Jane O'Dwyer, Norwegian Polar Institute

Between July 1997 and November 1999 the Norwegian Polar Institute conducted a series of cruises along the boundary between the Norwegian and Barents seas (Fugløya–Sørkapp) with the aim of measuring the exchanges across the boundary. Direct measurements of the flow in the surface 200 m were made using a ship-mounted acoustic Doppler current profiler (ADCP).

The ADCP data show strong tidal currents of up to 40 cm s^{-1}. Output from a tidal model is therefore used to remove the tidal contribution. The residual flow, of typically 10 cm s^{-1}, is strongly barotropic, emphasizing the need for direct current measurements for transport calculations.

The ADCP measurements show that there are large fluctuations in transport on short space and time-scales, probably caused by fluctuations in the wind field. However, the mean flow appears to be controlled by the topography. South of Bjørnøya there is a mean transport into the Barents Sea of 1.8 (± 1) Sv. This is made up of a broad eastward flow off the Norwegian coast with a westward recirculation on the slope south of Bjørnøya. North of Bjørnøya, the transport is smaller, with a mean of -0.2 (± 0.4) Sv.

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Seasonal and long-term variability of the sea level in the marginal seas of the Arctic Ocean

Vladimir K. Pavlov, Norwegian Polar Institute

The basic problem of climatic monitoring of the Arctic Ocean is the choice of the most representative predictors of large-scale variability. One such parameter is the sea level of the Arctic Ocean, integrating practically all static and dynamic processes in the hydrosphere and atmosphere of the Arctic. Mean monthly sea level data at 44 coastal and island stations in the Kara, Laptev, East Siberian, and Chukchi seas in the years 1950–1990 were used to analize the seasonal and interannual variability. Sea level has a significant annual cycle. The magnitude (from peak to peak) of the intra-annual sea level variability in the coastal zone of the Arctic seas is 20–30 cm on average.

The analysis of interannual and inter-decadal changes has shown that at practically all stations of the Kara, Laptev, East-Siberian, and Chukchi seas in the period from the beginning of the 50s until the 90s there is a steady increase of sea level. On average for a coastal zone of the Siberian shelf the sea level in the 80s was 5–6 cm higher than in the previous decades.

The excellent agreement between observed decadal mean values of the sea level and the results of diagnostic simulations gives grounds to believe that the tendency of rise of sea level in the Arctic seas is connected with the change of the thermohaline condition and reorganization of large-scale water circulation of the Arctic Ocean, rather than lowering of the coasts of the Arctic seas, as was suggested previously.

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Remote sensing of landscape degradation around the Noril'sk factories in northern Siberia

Gareth Rees, Scott Polar Research Institute; Olga Toutoubalina

This poster describes the environmental situation around the city of Noril'sk in north central Siberia. The city contains very large facilities for smelting non-ferrous metals, especially nickel, resulting in catastrophic atmospheric emissions of sulphur dioxide amongst other pollutants. Our research combines field investigation with the analysis of satellite remote sensing techniques to characterize the spatial extent of the resulting vegetation damage, and its evolution over time.

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Hydrogeochemistry and microbiology in subarctic ground water: Implications for natural attenuation of trichloroethene

Sharon A. Richmond, U.S. Geological Survey; Joan F. Braddock

Understanding the biogeochemistry of subarctic ground water is necessary to predict the potential for natural attenuation of ground water contaminants. We examined hydrogeochemical and microbiological effects on trichloroethene (TCE) degradation in aerobic (treated by air sparging) and anaerobic (untreated) ground water at a site near Fairbanks, Alaska. Ground water at the site is naturally anaerobic, even with a seasonal influx of highly oxygenated surface water. Currently used indicators of terminal electron-accepting processes (TEAPs) were not diagnostic but thermodynamically favorable *in situ* Gibbs free energies for Fe(III) and sulfate reduction and methanogenesis suggested that these TEAPs co-occurred. Our results support the recent finding (Jakobsen *et al.*, 1998) that TEAPs may co-occur in very cold ground water with high concentrations of electron acceptors, a favorable condition for TCE degradation. Numbers of heterotrophic bacteria were significantly higher at sparged wells. Although sparging increased dissolved oxygen concentrations at treated wells, decreased sulfate and increased sulfide concentrations suggested active sulfate reduction. At those wells, plugging may have created discrete, highly anaerobic microenvironments in which reductive dechlorination could occur, as evidenced by an increase in cis-DCE after sparging began. Site-wide methane concentrations ranged between 0 and 100 ppm and may have supported methanotrophic bacteria in aerobic (treated) ground water. Numbers of methanotrophs were higher in sparged ground water, suggesting a possible mechanism for removal of TCE and less chlorinated intermediates of reductive dechlorination. Overall, TCE concentrations decreased, partly due to active treatment. However, there was also evidence that biological reductive dechlorination, methanotrophic activity and possibly anaerobic mineralization may have resulted in transformation of TCE and less chlorinated intermediates. Also, geochemical indicators of TEAPs at this site suggest that in very cold systems, equilibrium may not be achieved, thereby allowing multiple TEAPs to co-occur.

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Reference:

Jakobsen, R., H.-J. Albrechtsen, M. Rasmessen, H. Bay, P. L. Bjerg, and T. H. Christensen. 1998. H_2 concentrations in a landfill leachate plume, Grindsted, Denmark: *in situ* energetics of terminal electron-accepting processes. *Environmental Science and Technology* 32, 2142–2148.

The role of thermal regime in glacier hydrology and dynamics in an arctic polythermal glacier

David M. Rippin, University of Cambridge; Neil S. Arnold; Ian C. Willis; Andrew Hodson

The hydrology of glaciers is generally acknowledged to be one of the fundamental controls on glacier dynamics over a wide range of spatial and temporal scales, due to the link between basal water pressure and basal movement (either through sliding of the ice over its bed or as deformation of subglacial sediments). This is particularly true for temperate glaciers, where ice is at the pressure melting point (PMP) throughout. Field studies have shown that short-lived, high-velocity events occur on such glaciers in late spring/early summer, caused by the onset of surface melting which is routed to the base of the glacier, leading to changes in basal water pressure and reorganisation of the subglacial hydrological system.

This study aims to investigate the links between glacier hydrology and dynamics on an arctic polythermal glacier, Midre Lovénbreen, in northwest Spitsbergen. Polythermal glaciers are composed of temperate ice at the PMP, and 'cold' ice below the PMP, with the temperate ice typically occurring at the base of the glacier, and 'cold' ice surrounding it at the sides and towards the terminus. A network of 17 stakes was established on the glacier surface in the summer of 1998, and surveyed repeatedly during that summer, and again in summer 1999. These surveys were complemented by meteorological data collected by an automatic weather station deployed on the glacier, and by ground-penetrating radar (GPR) surveys to determine the location and extent of temperate ice.

The upper half of the stake network was located where the overall ice thickness was greatest, and it was also underlain by a layer of temperate ice at the base of the glacier. These stakes, as expected, showed the highest net rates of movement over the whole summer (due to the direct link between driving stress and ice thickness), but also showed shorter (day-to-day), very clear periods of higher velocity. These events coincided with periods of warm weather, when melt rates were higher. These results provide good evidence that surface derived melt (or precipitation) can reach the bed of polythermal glaciers in areas where the bed is at the PMP in sufficient quantities to influence their dynamics. In contrast, the areas of the glacier underlain by cold ice showed a very

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subdued response to air temperature, probably caused by the acceleration of ice upstream and the resulting change in longitudinal stresses, rather than a local basal control.

This work has possible implications for the response of polythermal glaciers to climatic change, as increases in meltwater production could result in increased flow velocity for longer periods in the summer. This would result in a more rapid transport of ice from the accumulation area to the ablation area of such glaciers, accelerating their volumetric decay, and increasing their contribution to sea level change.

With thanks to John Moore (Arctic Centre, University of Lapland) and Jack Kohler (Norsk Polarinstitutt) for some GPR-survey data.

Circum- and cross-polar investigations of the arctic near-earth space environment disturbances triggered by solar-terrestrial interactions

Gulamabas G. Sivjee, Embry-Riddle Aeronautical University

Polar disturbances in the arctic mesosphere, thermosphere, and ionosphere are investigated through electro-optical remote sensing of auroral and airglow emissions over Longyearbyen, Svalbard (78° N, 16° E); Sondrestromfjord, Greenland (67° N, 51° W); Eureka, Canada (80° N, 86° W); and Resolute Bay, Canada (77° N, 95° W). When combined with similar data from the Canadian, Scandinavian, and Russian chain of arctic stations, our measurements permit studies of the following arctic phenomena: 1) atomic, molecular, and plasma processes in various sectors of the auroral oval; 2) the effects of solar magnetic cloud (SMC) and coronal mass ejection (CME) events on the thermospheric composition and thermodynamics; 3) polar cap arcs and patches and their relation to the interplanetary magnetic field (IMF); 4) Joule heating effects on the thermospheric composition and thermodynamics; and 5) planetary, tidal, and gravity wave modulations of the mesosphere and lower thermosphere (MLT) composition and thermodynamics. These studies have shown that: 1) auroras associated with SMC/CME events are characterized by the precipitations of electrons with average energy of about 500eV; 2) the O_2 At (1,1)/(0,1) ratio decreases above 150 km; 3) charge transfer reaction in the ionosphere facilitates monitoring the effects of Joule heating on the thermosphere; 4) F-layer patches occur mostly when the IMF B_Z is negative while polar cap auroral arcs are more likely to be formed when the IMF B_Z is positive; and 5) all tidal harmonics, in the arctic MLT region, are zonally symmetric. This poster summarizes our arctic research activities and some of the results listed above.

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Estimates of water and solute diffusion in frozen ground utilizing pulsed-field-gradient nuclear magnetic resonance

Ronald S. Sletten, University of Washington; Thomas P. Pratum; Steven A. Grant

There is limited knowledge about ionic solute transport mechanisms in the perennially frozen subsoils of permafrost terrains. Solute migration may occur due to solute rejection during freezing, and subsequent formation of high ionic strength pockets of unfrozen water or in liquid-water films at the ice-soil mineral interface that persist at temperatures well below 0°C. The thickness of the liquid-water film, and hence the mobility of water and solutes, depends primarily on temperature, chemical composition of soil solution, and soil texture. Due to its importance in frost heaving, transport of liquid water in frozen soils has been studied extensively. In contrast, scientific study of solute transport in frozen soils has been limited to a few empirical studies under idealized conditions. The amounts and potential mobilities of liquid water and ionic solutes in perennially frozen subsoils can be predicted by direct measurements of liquid water and ionic solute self-diffusion rates, complemented by complex chemical equilibrium modeling. We are measuring directly self-diffusion coefficients of unfrozen water, sodium, and lithium in frozen soils using the nuclear magnetic resonance pulsed-gradient method. Above the nominal freezing temperatures, the measured self-diffusion rates change little in the unfrozen soil solution. Near the nominal freezing temperature of the solution, the self-diffusion rates of liquid water and ionic solutes in soil solutions are 1–2 orders of magnitude less than those in bulk solutions. Below the nominal freezing temperatures, the self-diffusion rates in soils decrease sharply with decreasing temperature. Unfrozen water may persist in fine-textured or porous soils to temperatures substantially below the nominal freezing point, but this water may have limited mobility. An unanswered but pertinent question remains on the availability or role of this unfrozen water to biological systems, which are increasingly reported to be active to subzero temperatures.

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BERPAC: A long-term ecological research program of the Bering and Chukchi seas and Pacific Ocean

*Gregory Smith, Biological Research Division, USGS; *Jacqueline M. Grebmeier; Steven Kohl; Alla V. Tsyban*

The BERPAC (Bering Sea-Pacific Ocean) Research Program, established in 1977, represents a strong U.S.-Russian science partnership. Long-term studies of the Bering and Chukchi sea ecosystems have determined key processes and the current health of these fragile environments. The Bering and Chukchi seas are unique basins of the World's Oceans and are situated in the subarctic and arctic zones. They are characterized by a combination of unique physical and chemical conditions and processes resulting in a wide species diversity of marine organisms, as well as in high biological productivity. The Bering and Chukchi seas, like other arctic marine ecosystems, play an exceptional role in global climate processes and, in particular, in the fate of atmospheric carbon dioxide. The arctic and subarctic ecosystems are highly vulnerable to perturbations and human impacts.

The goals of the BERPAC program are: 1) determine oceanographic and hydrochemical processes in the Bering and Chukchi seas; 2) understand the state of biological processes occurring in the pelagic and benthic environments; 3) study the biogeochemical cycles of contaminants in the Bering and Chukchi seas; 4) understand processes determining the assimilative and adaptive capacity of arctic marine ecosystems with respect to contaminants and climate change; and 5) assess the ecological consequences of anthropogenic impacts, including climate changes, in the region of the Bering and Chukchi seas.

The attributes of the BERPAC program including long-term time series observations in the region (about 20 years), repeated sampling of standard spatial locations in both seas, an interdisciplinary approach to ecosystem investigations, regular convening of joint expeditions and scientific symposia in Russia and the U.S., and systematic publication of monographs. To date, there have been six integrated ecological expeditions in the Bering, Chukchi, and East Siberian seas, and northern Pacific Ocean (1977, 1981, 1984, 1988, 1993, and 1995). In addition, more than 20 symposia and seminars, seven monographs in Russian and English, and many peer-reviewed scientific papers have resulted from this international collaboration.

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Arctic clouds

Taneil Uttal, National Oceanic and Atmospheric Administration; Matthew Shupe

Clouds are an integral and high-impact element of the arctic climate system. Clouds-radiation feedback mechanisms exert strong controls on surface temperatures, and the resulting rate of annual melting and re-freezing of the ice pack. Despite their importance, cloud measurements over the Arctic have been scarce and approximate. Surface observers are limited by the extended polar night and frequent surface ice fogs. Satellite observations have been hampered by low contrast between clouds and the underlying ice- and snow-covered surfaces, often invalidating low-latitude cloud detection techniques.

A year-long cloud data set was taken during the NSF Surface Heat Budget of the Arctic Ocean (SHEBA) project with ship-based radar, lidar, and radiometers. By combining the information from these sensors, it is possible to retrieve detailed information on cloud properties, including location of boundaries, cloud phase, hydrometer sizes and concentrations, and cloud optical depths; all of which are germane to the determination of cloud radiation properties. This data set is being compared to satellite observations of clouds over the Arctic Ocean and validated with extensive *in situ* aircraft observations which were taken as a part of the NASA/FIRE Arctic Clouds Experiment. Using the information from this diverse array of sensors, the techniques for retrieving cloud properties are being custom fit to arctic conditions, and will be applied to long-term (10-year) radar and radiometer observations of clouds being taken in Barrow, Alaska by the DOE Atmospheric Radiation Measurement Program. These measurements will in turn be used to validate the cloud sensors on the Terra satellite as a part of the NASA Mission to Planet Earth Validation Studies Program.

The arctic atmosphere is dry, which means that the radar data, which is the foundation of these retrievals, is not contaminated by vapor paths or the moderate-to-heavy precipitation events, which can be problematic for millimeter-wave radars. In addition, the environmental conditions limit the insects and other convectively lofted boundary layer targets, which often clutter the boundary layer at lower latitudes. Therefore, radar measurements of arctic clouds tend to be very "clean."

Radar-radiometer retrieval techniques for obtaining information on cloud microphysics have been developed for single-layer clouds that are either all ice or all liquid.

The preliminary comparisons between radar-radiometer retrievals of ice particle sizes and liquid

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droplets with those collected by research aircraft show good agreement for cases when clouds are clearly all ice or all liquid. Unfortunately, the SHEBA data sets indicate that simple, single-phase, single-layer clouds are the exception rather then the rule. Most of the time, (in excess of 85% depending on season) clouds are either mixed phase (liquid droplets and ice crystals mixed in the same volume), or separate ice cloud layers coexisting in the same atmospheric column as liquid cloud layers. This provides significant challenges for determining cloud properties in the Arctic both from the ground and from space.

Summary of ocean-ice physics experiments performed in the central Greenland Sea in winter 2000

Peter Wadhams, Scott Polar Research Institute; Jeremy Wilkinson; Nick Hughes; Arthur Kaletzky; Richard Hall

Between 16 February and 10 March 2000 the Research Vessel (RV) *Jan Mayen* performed a detailed study of the central Greenland Sea in winter. The purpose of the cruise was threefold.

Firstly, the determination of the winter 2000 hydrography of the central Greenland Sea gyre region, including the location and depth of convective events and the structure of the Jan Mayen Current, especially where it emerges from the East Greenland Current.

Secondly, the determination of the distribution and role of sea ice in winter processes in the region and to match the winter hydrography to the distribution and physical properties of the pancake icefield which normally occupies the region influenced by the Jan Mayen Current. The developing ice cover contributes a salt flux, via brine drainage, to the surface water which helps determine the extent and depth of winter convection.

Finally, the distribution and life cycle of phytoplankton in the region during winter. A significant event of 2000 was the complete failure of the region to develop the 'Odden' ice tongue. Even the East Greenland ice edge itself lay far to the west of its normal winter position. This meant that the cruise became a special opportunity to investigate the hydrographic, glaciological, and meteorological factors involved in creating an Odden-free year.

CTD sections revealed that the freshwater layer of the Jan Mayen Current was absent and that the warm saline waters of the northern Norwegian Sea had swept northward, across the Mohn Ridge, into the Greenland Sea. As a consequence, ice production was not possible in this region of the Greenland Sea. Despite this, a large and varied amount of sea ice work was performed in the East Greenland Current. Whenever the ship was in ice and weather conditions appropriate an ice station was performed. These stations followed a set routine with either pancake/brash ice being lifted on board for analysis and/or scientists being lowered onto larger floes for *in situ* analysis.

The hydrography not only revealed the absence of the Jan Mayen Current but also that convection in the region was limited to less than 1000 m. Furthermore, we were able to confirm the observations with

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RV *Valdivia* from 1999 in that the depth to which plankton was detected coincided with the penetration depth of oceanic convection. Below the pycnocline biomass was virtually zero. Other experiments performed included the release of ten pancake ice motion monitoring buoys (PIMMS). These buoys use low earth orbiting satellites to transmit GPS position, air and sea temperatures, and in some cases, the wave spectra back to the UK. Furthermore an inlet was set up above the bridge of the ship with the intention of sampling the boundary layer in the atmosphere for pertinent chemical tracers. The data gathered on the cruise can be divided into a number of groups. These are: ice-ocean processes, hydrographic structure, Ocean and ice dynamics, phytoplankton, and finally atmospheric chemistry. Each one of these groups forms a section on the poster.

Arctic sea ice trends—observations and simulations with a Global Climate Model

John W. Weatherly, Cold Regions Research and Engineering Laboratory; Warren M. Washington; PCM Collaboration Team, National Center for Atmospheric Research

Significant reductions in sea ice extent and thickness have been observed in the Arctic Ocean in recent years (Vinnikov *et al.*, 1999; Rothrock *et al.*, 1999). It is not known whether these are long-term climatic changes, caused by increases in greenhouse gas concentrations (from anthropogenic sources), or natural climatic variations on decadal (and longer) time scales. Global climate models can be used to simulate whether such changes can be produced by natural variability, human-induced forcing, or external forcing from changes in the solar luminosity. Climate models have improved their representation of the arctic climate, sea ice, and its variability in recent years, however, most models still have significant biases in the polar regions (Weatherly and Zhang, 2000).

A global atmosphere-ocean-sea ice general circulation model (GCM) called the Parallel Climate Model (Washington *et al.*, 2000) is used in simulations of climate with greenhouse gas concentrations and sulfate aerosols prescribed from observational data (1870 through 1995), and future projections (1995 through 2100). Simulations that include the variability in solar flux over 1870–1995 are also performed. The observed greenhouse gases and aerosols produce a net warming of about +0.5°C, mostly occurring between 1960 and 1995. Arctic ice thickness decreases by 25% after 1960, and ice area decreases by 5%. An increase in solar flux of 4 Wm^{-2} over years 1890 to 1950 causes an additional global temperature change of +0.3°C in the model in those years, including about 0.2°C warmer for 1995. The future doubling of CO_2 and other greenhouse gases produce an increase in global temperature of 1.25°C over 70 years, with significant decreases in arctic ice thickness and area.

The recently observed decreases in arctic sea ice extent and thickness are consistent with the overall 'greenhouse warming' simulated by the climate model. However, they are also consistent with the increase in solar flux, and the dominant mode of the Arctic Oscillation/North Atlantic Oscillation since 1987.

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References:

Rothrock, D. A., Y. Yu, and G. A. Maykut. 1999. Thinning of the Arctic ice cover. *Geophys. Res. Lett.* 26, 3469–3472.

Vinnikov, K. Y., and 8 others. 1999. Global warming and Northern Hemisphere sea ice extent. *Science* 286, 1934–1937.

Washington, W. M., J. W. Weatherly, G. A. Meehl, A. J. Semtner, T. W. Bettge, A. P. Craig, W. G. Strand, J. Arblaster, V. B. Wayland, R. James, and Y. Zhang. 2000. Parallel

Climate Model (PCM) control and transient simulations. *Climate Dynamics* (in press).

Weatherly, J. W. and Y. Zhang. 2000. The response of the polar regions to increased CO_2 in a global climate model with elastic-viscous-plastic sea ice. *J. Climate* (in press).

Advanced technological education computer-based training modules in the environmental sciences for college-level students

Melanie A. Wetzel, Desert Research Institute; Randolph D. Borys

The primary objective of an NSF/DUE/ATE project was the development of computer-interactive, CD-ROM-based training modules in atmospheric, water resource, and air quality technology, and their respective field project design and measurement principles. Although not directly related to the arctic environment, these training modules introduce the first- or second-year college student to basic scientific principles and primary measurement methods and measurement technologies that would be used in any environment. There are three CD-ROMs, each addressing a separate topic. The first is concerned with atmospheric measurement technology, as seen through a working scenario of a new hire at a firm which assesses remote sites for solar and wind energy potential. The student is introduced to sensors for temperature, wind, solar energy flux, humidity and data loggers, and given a site to assess with real data, working through a real-life decision-making process to achieve a final assessment. The second module is centered around water resources and hydrology covering aspects of measurement technology of stream flow, rain, snowpack, and ground water. The third module (available summer 2000) is focused on air quality including sources of pollutants, their health effects, measurement technologies, and mitigation strategies. All three modules are designed to be used as an enhancement of classroom activities in the environmental sciences or to be the core of a special class utilizing the modules as a guide and exercise source. These modules are available for purchase by contacting the authors and will be demonstrated at the poster session.

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Abstract not available.

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Arctic Forum program

Wednesday, 17 May 2000

ENVIRONMENTAL CHANGES IN THE ARCTIC AND THEIR INTERACTIONS WITH PEOPLE AND THE GLOBAL CLIMATE

8:30 a.m. Welcome and introduction ..... *Arctic Forum Chair: Wieslaw Maslowski*
Member, ARCUS Board of Directors

8:40 a.m. Keynote address: A new environmental initiative for NSF and advances in climate modeling of the Arctic ..... *Warren M. Washington*
National Science Board

9:30 a.m. The Arctic Oscillation: Implications for arctic research ..... *John (Mike) Wallace (presenting) and David W.J. Thompson*
Department of Atmospheric Sciences, University of Washington

10:00 a.m. Are recent arctic climate variations consistent with greenhouse projections? ..... *John Walsh*
Department of Atmospheric Sciences, University of Illinois Urbana

10:30 a.m. BREAK

10:45 a.m. The summer arctic frontal zone as seen in the NCEP/NCAR reanalysis ..... *Mark Serreze*
Cooperative Institute for Research in Environmental Sciences
National Snow and Ice Data Center, University of Colorado

11:15 a.m. Why is the arctic ice cover so thin? ..... *Drew Rothrock*
University of Washington

11:45 a.m. Towards prediction of arctic climate change ..... *Wieslaw Maslowski*
Department of Oceanography, Naval Postgraduate School

12:15 p.m. LUNCH

1:30 p.m. Present and future oceanographic studies in the Canadian Arctic: Change and biodiversity
Eddy Carmack
Institute of Ocean Sciences, Department of Fisheries and Oceans, Canada

2:00 p.m. An update on the study of environmental arctic change ..... *James Morison*
University of Washington

2:20 p.m. Circulation of Atlantic-derived intermediate water in the Arctic Ocean
William M. Smethie, Jr. (presenting) and Peter Schlosser, et al.
Lamont-Doherty Earth Observatory of Columbia University

2:45 p.m. Decadal variability of the Greenland Ice Sheet mass balance as a cause of the "Great Salinity Anomalies" in the northern North Atlantic ..... *Igor Belkin*
Graduate School of Oceanography, University of Rhode Island

3:10 p.m. Millennial-scale global events recorded in El'gygytgyn Crater Lake, eastern Siberia back to 400 ka
Julie Brigham-Grette
Department of Geosciences, University of Massachusetts

3:35 p.m. The continental margin-basin coupling for origin of DOC in the upper halocline of the Arctic Ocean ..... *Sathy Naidu*
Institute of Marine Science, University of Alaska Fairbanks

4:00 p.m. BREAK

4:20 p.m. Presentations of student papers by winners of the *ARCUS Award For Arctic Research Excellence*
Session Chair: Mark Serreze

4:30 p.m. Foraging strategies of subarctic wood bison: Energy maximizing or time minimizing?
Carita M. Bergman
University of Guelph

4:50 p.m. "If you got everything, it's good enough": Perspectives on successful aging in a Canadian Inuit community..... *Peter Collings*
Pennsylvania State University

5:10 p.m. Methane emissions and transport by arctic sedges in Alaska: Results of a vegetation removal experiment ..... *Jennifer Y. King*
University of California-Irvine

5:30 p.m. Magma storage and mixing conditions for the 1953–68 eruption of Southwest Trident Volcano, Katmai National Park, Alaska ..... *Michelle Coombs*
University of Alaska Fairbanks

5:50 p.m. Adjourn to Reception

ARCUS Annual Reception and Banquet
Holiday Inn Capitol
Reception: 6:00 p.m. - Discovery I and II
Banquet: 7:00 p.m. - Columbia II

Award Ceremony
ARCUS Award for Arctic Research Excellence

Special Presentation
George Harper
Blacks in Alaska History Project, Inc.
Captain Michael A. Healy: The Man, His Ships, and the Healy

Thursday, 18 May 2000

ENVIRONMENTAL CHANGES IN THE ARCTIC AND THEIR INTERACTIONS WITH PEOPLE AND THE GLOBAL CLIMATE

8:30 a.m. Welcome and introduction ..... *Arctic Forum Chair: Wieslaw Maslowski*
Member, ARCUS Board of Directors

8:40 a.m. The impacts of climate change on the arctic coastal Indigenous People ..... *Caleb Pungowiyi*
Special Advisor on Native Affairs, Marine Mammal Commission

9:10 a.m. Marine mammals and seabirds as indicators of environmental variability in the Arctic . *Sue Moore*
National Marine Mammal Laboratory, NOAA

9:40 a.m. Zoogeomorphic impacts of animals in the Arctic ..... *Kevin Hall*
Geography Program, University of Northern British Columbia

10:05 a.m. BREAK

10:20 a.m. Archeology and coastal dynamics of the Gulf of Alaska ..... *Aron Crowell*
Arctic Studies Center, Smithsonian Institution

10:45 a.m. The socio-demography of a native Siberian village ..... *John Ziker*
Indiana University of Pennsylvania

11:10 a.m. The arctic upper atmosphere as a harbinger of global change and space weather ..... *John D. Kelly*
SRI International

11:35 a.m. Arctic clouds at the edge of Space ..... *John Olivero*
Embry-Riddle Aeronautical University

12:00 p.m. LUNCH

1:00 p.m. Poster Session

3:00 p.m. Adjourn

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This list includes presenters, first authors, program chairs, Arctic Forum *participants, and ARCUS staff. Contact information for additional authors is listed in each abstract.*

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