ARCTIC SCIENCE SUMMIT WEEK
ASSW 2009

Bergen, Norway, 22-28 March 2009

Welcome to ASSW 2009

In 1999, the first Arctic Science Summit Week (ASSW) was organized in Tromsø, Norway. This summit was set up to hold the meetings of all Arctic science organizations together on one location in one week. The platform was created to provide opportunities for international coordination, collaboration and cooperation in all disciplines of Arctic science. It was meant to combine science with management meetings. In this way business meetings were combined with a science and a project day, and the host country was offered the opportunity to present its most recent Arctic research. Side meetings organized by other groups with interest in Arctic science and policy took place at the same time.

Now, after ten ASSWs organized in ten different countries all over the world, the organizations behind this event decided to change the concept of the week by including not only annual meetings of the Arctic science organizations, but also an Open Science Symposium. Instead of the science and project day, a three days international symposium was organized under the ambitious theme: Arctic Connections - results of 150 years of Arctic research. It is the intention of the organizers to make this the official symposium for International Arctic Science. We hope that the model we have chosen for the symposium will give you the possibility to get an impression of the wide specter of research activities that have taken place in the Arctic throughout the history.

After ten years the ASSW is back in Norway. This time, it is organized in Bergen; one city - endless opportunities. We wish you welcome to the Arctic Science Summit Week-2009 in Bergen.

Louwrens Hacquebord Harald Loeng

Co-chairs of the Open Science Symposium of the ASSW 2009.

The Arctic Science Summit Week: A brief history and outlook

This year marks the 10th anniversary of the annual Arctic Science Summit Week (ASSW). The first such meeting was organized by the International Arctic Science Committee (IASC) and was held in Tromsø, Norway in April 1999. The following year a much larger ASSW was held in April in Cambridge, UK. The concept of a meeting which would bring together many of the organizations responsible for supporting and facilitating science in the Arctic was gaining momentum and the Arctic Ocean Sciences Board and the European Polar Board both joined the gathering. It was during the Cambridge meeting that the first "Science Day" was held.

Science Days have been a regular occurrence at all ASSWs with such themes as "Sustainable Marine Resources and Climate Variability," "Interactions between the Arctic and the Temperate Zones," and "Arctic Climate Change: Actual Effects and Potential Teleconnections." The purpose of Science Day was to highlight interesting scientific results and it was an opportunity for all the participating organizations to join together to hear presentations on a wide variety of topics.

Each year, the ASSW is organized by an International Coordinating Group (ICG), made up of the secretaries of the various participating organizations. In 2001, the ICG added a Project Day to highlight a few new projects. These projects often cut across the interests of more than one participating organization.

In early 2006, IASC appointed an international group of experts to evaluate IASC activities over the 10-year period, 1996-2005, and recommend strategies for the future. One of their recommendations was to reorganize and revitalize the ASSW and provide a major cross-disciplinary venue centered around a science symposium.

The meeting in Bergen in 2009 marks not only the 10th anniversary of the ASSW, but the first science symposium of the ASSW. In the future, once every two years the ASSW will be held in conjunction with such an open international science symposium. Every other year, the ASSW will only combine the business meetings of the governing bodies of the ASSW affiliated partners. The IASC Secretariat will ensure that the participating organizations have time for cross fertilization and collaboration.

Volker Rachold
Executive secretary IASC

Sara Bowden
Secretary AOSB

Programme

	09-13	14-18	18.30-20.30
March 22		Pacific Arctic Group (PAG)	
		European Polar Board (EPB)	
		Arctic Ocean Sciences Board (AOSB) - ICARP II Marine Roundtable	
March 23	European Polar Board (EPB)	Arctic Ocean Sciences Board (AOSB)	Association of Polar Early Career Scientists (APECS)
	Pacific Arctic Group (PAG)		
	Ny-Ålesund Science Managers Committee (NySMAC)		
March 24	Symposium: Plenary		Icebreaker Reception
March 25	Symposium: Parallel Sessions		International Arctic Science Committee (IASC) - Science Forum and Reception
			Svalbard Integrated Arctic Earth Observing System (SIOS) Status Meeting
March 26	Symposium: Parallel Sessions		Conference Dinner
March 27	International Arctic Science Committee (IASC) - Council	Forum of Arctic Research Operators (FARO)	International Science Initiative in the Russian Arctic (ISIRA)
		International Study of Arctic Change (ISAC)	
		Arctic Coastal Dynamics (ACD)	
		Arctic Council Project: Maximizing the Legacy of IPY	
March 28	IPY Oslo Conference Steering Group Meeting		

business meeting	evening event
symposium	side meeting

by invitation only

Room allocation

Date	Meeting	Room
22 March	EPB	Institute of Marine Research
	PAG	Institute of Marine Research
	AOSB – Marine Roundtable	Institute of Marine Research
23 March	EPB - morning	Sydneshaugen
	PAG - morning	Teatergaten
	NySMAC - whole day	Dragefjellet
	AOSB - afternoon	Teatergaten
	APECS - evening	Sydneshaugen
25 March	IASC Science Forum - evening	Nocturne
	SIOS Status meeting - evening	Galgebakken
26 March	Conference Dinner	Dragefjellet
27 March	IASC - morning	Teatergaten
	FARO - afternoon	Teatergaten
	ISAC - afternoon	Dragefjellet
	ACD - afternoon	Tårnplass
	Arctic Council Project - afternoon	Sydneshaugen
	ISIRA - evening	Hødden
28 March	IPY Oslo Conference	Hødden

ASSW 2009 SCIENCE SYMPOSIUM 24-26 MARCH 2009

ARCTIC CONNECTIONS – THE RESULTS OF 150 YEARS OF RESEARCH

Book of Abstracts

Overview of sessions

1. **Sea Ice changes and the impacts on Biodiversity and Human Communities**
   Session Chairs: Koji Shimada , Ignatius Rigor and Lawson W. Brigham
2. **Arctic Climate Variability – Past to Future**
   Session Chairs: Harro Meijer, Peter Lemke and Eystein Jansen
3. **The Role of the Arctic in the Global Change Process**
   Session Chairs: Sung Ho Kang, Jingping Zhao and Peter Schlosser
4. **Evolution of Arctic Ecosystems in a Warming World**
   Session Chairs: Terry Callaghan, Svein Sundby and Falk Huettmann
5. **Indigenous Cultures – Past to Future**
   Session Chairs: Joan Nymand Larsen, Grete K. Hovilsrud and Deanna Kingston
6. **Coastal Environments as a link between Land and Sea in the Arctic**
   Session Chairs: Paul Overduin, Karen Frey and Hugues Lantuit
7. **Risks to Human Health from a changing Arctic**
   Session Chairs: Larisa Abryutina, Maarten Loonen and Nazune Menka
8. **History of Arctic Science**
   Session Chairs: Susan Barr, Jörn Thiede and Erki Tammiksaar

Timetable

Tuesday 24 March	Dragefjellet + Teatergaten - 2nd floor
0900 – 1055	*Plenary*
1055 – 1125	Health Break
1125 – 1235	*Plenary*
1235 – 1400	Lunch
1400 – 1545	*Plenary*
1545 - 1615	Health Break
1615 – 1750	*Plenary*
1900	Reception

Wednesday 25 March	Dragefjellet 2nd floor	Teatergaten 2nd floor	Galgebakken 4th floor	Panorama 8th floor
0830 - 1030	*Session 2*	*Session 7*	*Session 3*	*Session 6*
1030 – 1100	Health Break	Health Break	Health Break	Health Break
1100 – 1240	*Session 2*	*Session 4*	*Session 3*	*Session 6*
1240 – 1400	Lunch	Lunch	Lunch	Lunch
1400 – 1600	*Session 2*	*Session 4*	*Session 3*	*Session 6*
1600 - 1620	Health Break	Health Break	Health Break	Health Break
1620 – 1800	*Session 2*	*Session 4*	*Session 3*	*Session 6*

Thursday 26 March	Dragefjellet 2nd floor	Teatergaten 2nd floor	Galgebakken 4th floor	Sydneshaugen 2nd floor
0830 - 1030	*Session5*	*Session 4*	*Session 3*	*Session 1*
1030 – 1100	Health Break	Health Break	Health Break	Health Break
1100 – 1240	*Session 5*	*Session 4*	*Session 3*	*Session 1*
1240 – 1400	Lunch	Lunch	Lunch	Lunch
1400 – 1600		*Session 4*	*Session 8*	*Session 1*
1600 - 1620		Health Break	Health Break	Health Break
1620 – 1800			*Session 8*	*Session 1*

Plenary Session 24 March

0900 Opening Session

09:45 Keynote Session

09:45 *History of the Arctic Science*: Dr. Michael Bravo, Scott Polar Research Institute, United Kingdom

10:20 *Sea Ice Changes and the Impacts on Biodiversity and Human Communities*: Dr. Hajo Eicken, University of Alaska at Fairbanks

10:55 Break

11:25 *Risks to Human Health from a Changing Arctic*: Dr. Jay Van Oostdam, Chemical Management Directorate, Environmental Health Surveillance Division, Canada

12:00 *Indigenous Cultures – Past to Future*: Dr. Grete Hovlesrud, Centre for International Climate and Environmental Research, Norway

12:35 Lunch Break

14:00 *Arctic Climate Variability – Past to Future*: Professor Dorthe Dahl-Jensen, University of Copenhagen, Denmark

14:35 *Evolution of Arctic Ecosystems in a Warming World*: Dr. Hiroshi Kanda, National Institute of Polar Research, Japan

15:10 *New approaches to arctic conservation in times of accelerating climate change* Neil Hamilton, World Wildlife Foundation

15:45 Break

16:15 *Coastal Environments as a link between Land and Sea in the Arctic*: Professor Søren Rysgaard, Greenland Institute of Natural Resources, Greenland

16:50 *The Role of the Arctic in the Global Change Process*: Dr. Eddy Carmack, Department of Fisheries and Oceans, Canada

17:25 *The University of the Arctic:* Anders Oskal, International Centre for Reindeer Husbandry, Norway

17:50 Adjourn

Session 1: Sea Ice Changes and Impacts

Thursday 26 March 2009

08:30 - 08:50	**Sara de la Rosa**: Experiments on Frazil, Grease and Pancake Ice growth
08:50 - 09:10	**Sebastian Gerland**: The Sea Ice Component of the new Arctic Cryosphere Climate Project "SWIPA"
09:10 - 09:30	**Sebastian Gerland**: Fast ice monitoring in Svalbard: Kongsfjorden, Storfjorden and Hopen
09:30 - 09:50	**Naoyuki Kurita** : Impacts of the Arctic storm to accelerate autumn freeze in the Arctic Ocean
09:50 - 10:10	**Maria Tsukernik**: Present and Future Roles of the Atmospheric Forcing on Fram Strait sea ice export
10:10 - 10:30	**Natalia Ivanova**: Comparison of the Arctic sea ice extent and area time series obtained from different algorithms for sea ice concentration using passive microwave sensor data
11:00 - 11:20	**James Overland**: Causes of the Recent Arctic Warm Period within a Hundred Year Context
11:20 - 11.40	**Koji Shimada**: A perspective on further catastrophic reduction of sea ice caused by activations of sea ice motion and the upper ocean circulation in the Arctic Ocean
11:40 - 12:00	**Jean Claude Gascard**: Arctic sea-ice variability
12:00 - 12:20	**Vladimir Ivanov**: Atlantic Water warming accelerates Arctic sea-ice reduction?
14:00 - 14:20	**Eiji Watanabe**: Pacific water transport in the Arctic Ocean simulated by an eddy-resolving coupled sea ice-ocean model.
14:20 - 14:40	**Kohei Mizobata**: Inter-annual variability of chlorophyll-a distribution related to ice-ocean circulation in the western Arctic Ocean
14:40 - 15:00	**Jacqueline Grebmeier**: Organic Carbon Export and Benthic Population Dynamics with Changing Ice Conditions in the Northern Bering Sea
15:00 - 15:20	**Karen Frey**: Impacts of recent sea ice decline on biological productivity in the northern Bering and Chukchi Seas
15:20 - 15:40	**Gary Griffith**: Environmental factors controlling the sea-ice ecosystem of the seasonally ice-covered shelf of the Chukchi Sea
15:40 - 16:00	**Liqi Chen**: A Potential Carbon Pool in the western Arctic Ocean during Seaice Shrinking
16:20 - 16:40	**Michael Carroll**: Sea Ice Variations Influence Benthic Community Growth Rates over Decadal Scales: Evidence from Bivalve Population near the Barents Sea Polar Front
16:40 - 17:00	**Eva Leu**: Climate effects on planktonic food quality and trophic transfer in Arctic Marginal Ice Zones (CLEOPATRA)
17:00 - 17:20	**Eva Leu**: The effect of high irradiances and UV radiation on algal growth and food quality
17:20 - 17:40	**Laurent Bertino**: Data assimilation and reanalysis of the Arctic Ocean within the European MyOcean project

Session 2: Arctic Climate Variability

Wednesday 25 March 2009

08:30 - 08:50 **Inger Hanssen-Bauer**: Climate in the "Norwegian Arctic" during the 20th and 21st century

08:50 - 09:10 **Yvan Orsolini**: Projected changes in Arctic summer cyclones under global warming in the Bergen climate model

09:10 - 09:30 **Vladimir Alexeev**: Vertical structure of recent Arctic warming from observed data and reanalysis products

09:30 - 09:50 **John Cassano**: Changing Greenland Precipitation: A Weather Perspective

09:50 - 10:10 **Sergey Pisarev**: Spatial interannual variability of the Arctic Cold Halocline margins.

11:00 - 11:20 **Øystein Skagseth**: Observed transport variability of Atlantic Water through the Norwegian Sea to the Arctic based on long-term current-meter mooring arrays.

11:20 - 11:40 **Maria Pisareva**: Large – scale variability of the upper water masses characteristics within the Eurasian Basin observed by ITPs.

11:40 - 12:00 **Bjørg Risebrobakken**: Holocene climate extremes in the south-western Barents Sea

12:00 - 12:20 **Kirstin Werner**: Holocene Variability of Atlantic Water Advection in the Fram Strait

12:20 - 12:40 **H. A. J. Meijer**: Greenland Holocene temperatures obtained by differential diffusion studies

14:00 - 14:20 **William D'Andrea**: Mid- to late-Holocene NAO-type variability and the impacts of climate change on Saqqaq, Dorset and Norse occupation in West Greenland based on lacustrine alkenones and compound-specific hydrogen isotopes

14:20 - 14:40 **Liguang Sun**: A 7500-year Oxygen and Carbon Isotope Record within the Shell Remains in Ny-Alesund, Svalbard, Arctic: Linkage with Solar Activity and Episodes of Ice-rafting in North Atlantic

14:40 - 15:00 **Mikhail Ivanov**: Polar Urals glaciers variability past to Future

15:00 - 15:20 **Michael Fritz**: How ground ice studies may contribute to paleoenvironmental reconstructions at the easternmost edge of Beringia (Herschel Island, western Canadian Arctic)

15:20 - 15:40 **Reinhard Pienitz**: Postglacial paleoclimates of the Foxe Peninsula, Nunavut, Canada: new insights from chironomid and sedimentological analyses.

15:40 - 16:00 **Nazarova**: Reconstruction of Holocene Climate Variability in Yakutia, North Eastern Siberia, made with regional calibration data set and chironomid inference model

16:20 - 16:40 **Aleksandra Zemskova**: Ground ice and cryogenic morphology of Quaternary deposits of Yeniseyskiy bay coast and floral variety along the northern part of Yenisey river (research in the frames of IPY 2007-2009)

16:40 - 17:00 **Sebastian Wetterich**: Late Quaternary environmental history inferred from permafrost exposures on Kurungnakh Island, Lena Delta, Northeast Siberia, Russia

17:00 - 17:20 **Alexey Lupachev**: Soil-Cryogenic Complex of Russian North-east in Modern and Future Climate Conditions

17:20 - 17:40 **L. X. Yuan**: Striking association between North Atlantic climate and seabird populations in Ny-Alesund, Svalbard, Arctic between 12 and 4 kyr ago

Session 3: Role in Global Change Process

Wednesday 25 March 2009

08:30 - 08:50 **Robert Dickson**: Towards an integrated Arctic Ocean Observing System (iAOOS)

08:50 - 09:10 **Lars H. Smedsrud**: Barents Sea Heat - Oceanic advection and surface fluxes

09:10 - 09:30 **Igor Esau**: Vertical structure of the Arctic warming: The effect of the Arctic planetary boundary layer decoupling.

09:30 - 09:50 **Florian Geyer**: Dense Overflow at the Storfjorden Sill: Mean Seasonal Cycle, Variability and Wind Influence

09:50 - 10:10 **Malgorzata Cisek**: Role of the west Spitsbergen shelf and slope in the interactions between the Atlantic and Arctic type water masses in summers 2005-2008.

10:10 - 10:30 **Helene Reinertsen Langehaug**: Changes in the Distribution and Properties of the Deep Water Masses in the Fram Strait for the period 1984-2005

11:00 - 11:20 **Vidar S. Lien**: Is the Barents Sea cooling the Arctic Ocean?

11:20 - 11:40 **Bert Rudels**: The Barents Sea inflow branch & its interactions with the Arctic Ocean water column

11:40 - 12:00 **Ole Henrik Segtnan**: Cross-isotherm currents in the southwestern part of the Barents Sea: flow field derived from ocean temperature observations and surface heat fluxes

12:00 - 12:20 **Anders Sirevaag**: Upper ocean turbulence measurements during the 2008 ASCOS experiment

14:00 - 14:20 **Tor Eldevik**: Variability and constraints of the Arctic-North Atlantic thermohaline circulation

14:20 - 14:40 **Gabriel Wolken**: Snow and ice facies variability on pan-Arctic land ice, 1999-2008

14:40 - 15:00 **Waldemar Walczowski**: Changes of the Thermohaline Circulation of the Nordic Seas and Climate

15:00 - 15:20 **Steingrimur Jonsson**: The upstream path of the Denmark Strait overflow water through the Iceland Sea

15:20 - 15:40 **Vigdis Tverberg**: Winter heat loss from the West Spitsbergen current due to eddy exchange across the shelf edge front.

16:20 - 16:40 **Marius Årthun**: Ice-Ocean climate variability in the Barents Sea: A model study

16:40 - 17:00 **Idar Barstad**: A Modeling study of the baroclinicity and surface fronts near the ice-edge

Thursday 26 March 2009

08:30 - 08:50 **Vladimir Alexeev**: Polar amplification dynamics: results from an idealized model, reanalysis products and observations

08:50 - 09:10 **John Burkhart**: Atmospheric Change in the Arctic; an update of focused campaigns under POLARCAT

09:10 - 09:30 **Jinping Zhao**: Arctic Oscillation, a spatially varied and non-seesaw-like oscillation

09:30 - 09:50 **Svetlana Sorokina**: Atmospheric energy flux across 70ºN from the International Global Radiosonde Archive

09:50 - 10:10 **Rasmus Gjedssø Bertelsen**: Climate Change and New Security in the North Atlantic

11:00 - 11:20 **Gerard Duhaime**: Poverty in Nunavik, Arctic Canada.

11:20 - 11:40 **Kjetil Lygre**: Carbon uptake by the ocean, subject to biological feedback

11:40 - 12:00 **Jorun K. Egge**: Osmotroph responds to organic-C enrichment in an arctic pelagic ecosystem

12:00 - 12:20 **Namyi Chae**: Carbon dioxide emission from tundra soil in Ny-Ålesund, Svalbard

Session 4: Evolution of Arctic Ecosystems

Wednesday 25 March 2009

11:00 - 11:20 **Miyuki Kondo:** Isotopic Signatures of Soil Organic Carbon and its Relation to Vegetation in a Successional Glacier Foreland in Ny-Ålesund, Svalbard

11:20 - 11:40 **Dmitry Kaverin**: Upper permafrost as a part of tundra soil system

11:40 - 12:00 **Lise Øvreås**: Microbial diversity in Arctic tundra

12:00 - 12:20 **Alexander Tveit**: Temperature effects on arctic methane producing microorganisms

12:20 - 12:40 **Ryosuke Nakai*:*** Spore-forming halophilic bacteria isolated from Arctic terrain: Implication for tropospheric

14:00 - 14:20 **Rik Van Bogaert:** European aspen in a warming sub-Arctic—competitive interaction between aspen and birch moderated by invertebrate and vertebrate herbivores and climate warming

14:20 - 14:40 **Qi Zhao**: A primary photosynthetic study on polar plants

14:40 - 15:00 **David Hik**: Ecosystem and plant community responses to climate change: do biotic interactions matter

15:00 - 15:20 **Isla Myers-Smith**: How will increasing shrubs alter tundra ecosystem function?

15:20 - 15:40 **Stef Bokhorst**: Will winter warming counter the effects of summer warming in the sub-Arctic?

15:40 - 16:00 **Kieran O'Donovan**: Adaptive foraging behaviour of the collared pika (Ochotona collaris) and influences on the alpine tundra community in the southwestern Yukon.

16:20 - 16:40 **Zhenlin Yang:** Topoclimate model at 50 metres' resolution and its potential applications around Abisko, Swedish Lapland

16:40 - 17:00 **Larisa Frolova**: Cladocera assemblages from the surface sediments of Northern Siberia (Russia) lakes and their indicative potential for palaeoclimatic research

17:00 - 17:20 **Donald McLennan**: The Role of Ecological Integrity Monitoring in Managing Canada's Arctic National Parks in a Changing World

17:20 - 17:40 **Alexandre Forest**: Three-year assessment of particulate organic carbon fluxes in Amundsen Gulf (Beaufort Sea): Satellite observations and sediment trap measurements

17:40 - 18:00 **Ingrid Helene Ellingsen**: Primary production in a warmer Barents Sea

Thursday 26 march 2009

08:30 - 08:50 **Martin Emil Blicher**: Does sea ice cover affect the annual production of marine macrobenthos through bottom-up processes?

08:50 - 09:10 **Kenneth Drinkwater**: Ecosystems responses to recent climate variability: Comparison of 4 Northern Hemisphere regions

09:10 - 09:30 **Chie Sato**: Pilot study of marine planktonic archaeal distribution in the Arctic Ocean

11:00 - 11:20 **Kathrine Michalsen:** The Barents Sea Ecosystem survey: in a historic perspective

11:20 - 11:40 **Elizabeth Logerwell**: Beaufort Sea Survey 2008: Geographic and Historical Comparisions

11:40 - 12:00 **Kathrine Michalsen**: The Barents Sea Ecosystem Survey: Climate impacts on pelagic species distribution and interactions

12:00 - 12:20 **Kim Jochum**: Does the polar bear's behaviour change in relation to short-term sea ice shortage? Lessons from Data-Mining for animals with a socially complex community structure

12:20 - 12:40 **Cecilie Kvamme:** NEA cod in the Barents Sea: the relationship between sea emperature, cod distribution and trawl fisheries

14:00 - 14:20 **Peter Glazov**: The Waterfowl Population Status on the Kolguev Island.

14:20 - 14:40 **Jan Erik Stiansen/Geir Odd Johansen**: Fish stocks distribution in the future: presenting the projects FishExChange and NorExChange

14:40 - 15:00 **Charlotte Moshøj**: Temporal and spatial variations in wildlife population fluctuations in Greenland; The effect of climate, environment and man

15:00 - 15:20 **Alastair Jenkins**: Entropy Production, Polar Ecology and Economics

Session 5: Indigenous Cultures

Thursday 26 March 2009

08:30 - 08:50 **Lawrence Amos***:* Inuvialuit Observations of Climate Change and Adaptation Strategies

08:50 - 09:10 **Winfried Dallmann**: Monitoring of Development of Indigenous Land Use Areas in the Nenets Autonoums Okrug, NW' Russia

09:10 - 09:30 **Deanna Kingston**: "Down at East End, our people were closer": Spatial Proximity as an Important Element of Community Cohesion After Relocation

09:30 - 09:50 **Elizabeth Marino**: (Re)Locating Home : Contemporary Environmental Relocations in the Alaskan North

11:00 - 11:20 **Joan Nymand Larsen**: Human Development in the Arctic: Devising a set of indicators to track change

11:20 - 11:40 **Raila Salokangas**: The Meaning of Education for Inuvialuit Youth and Families

11:40 - 12:00 **Vyacheslav Shadrin**: Ethnic culture of forest yukaghirs: problems of safety and adaptation in conditions of globalization

12:00 - 12:20 **Zoe Todd**: The Impact of Participation in the Wage Economy on Traditional Harvesting, Dietary Patterns and Social Networks in the Inuvialuit Settlement Region

Session 6: Coastal Environments

Wednesday 25 March 2009

08:30 - 08:50 **Janet Rethemeyer**: Carbon cycling and export from permafrost soils into the Kongsfjorden, Ny-Alesund: a lipid biomarker-based study

08:50 - 09:10 **Anna Urban**: Palsas on Kurungnakh-Sise Island, the Lena river delta

09:10 - 09:30 **Antonina Chetverova**: Hydrochemical characteristics of Arctic Rivers in West Siberia. Characteristic of dissolved matter run-off.

09:30 - 09:50 **Karen Frey**: Impacts of terrestrial permafrost degradation on biogeochemical fluxes to the Arctic Ocean

09:50 - 10:10 **Carolyn Wegner**: Land-Shelf-Ocean Interaction - Seasonal Sediment Transport Dynamics on the Laptev Sea Shlef (Siberian Arctic)

10:10 - 10:30 **Hans-Wolfgang Hubberten**: Evolution and current state of sub-sea permafrost and the zone of gas-hydrate stability in rifts on the Arctic shelf of eastern Siberia

11:00 - 11:20 **Donald Forbes**: State of the Arctic Coast 2009: Scientific Review and Outlook

11:20 - 11:40 **Kathleen Parewick**: Climate Change and the Built Community: Practical Lessons for Adaptation Governance

11:40 - 12:00 **Lawson Brigham**: Coastal Arctic Environments and Future Marine Operations

12:00 - 12:20 **Falk Huettmann**: Protecting Coastal and Marine Arctic as one protected Park and in times of Climate Change and Intense Development: A MARXAN and GIS application.

12:20 - 12:40 **Kate Wedemeyer**: Arctic Fisheries Research Related to Offshore Energy Development in Alaska

14:00 - 14:20 **Hugues Lantuit**: An update on circumarctic rates of coastal erosion

14:20 - 14:40 **Paul Overduin**: The first circumarctic map on coastal erosion

14:40 - 15:00 **Mateusz Strzelecki**: The cold coast of warm uncertainty - why to focus on polar coast geoecosystem from a perspective of young researcher

15:00 - 15:20 **Irina Streletskaya**: Current Coastal Research of Western Taymyr, Russia

15:20 - 15:40 **Alexander Vasiliev**: Coastal Environment and Thermal Regime of Permafrost in the Transit Zone of Western Yamal

15:40 - 16:00 **Mario Neves**: Shore platform evolution by intertidal ice erosion. First results from South Shetland Islands (Antarctica)

16:20 - 16:40 **Leif Anderson**: High pCO2 levels in Siberian Shelf Seas caused by decay of terrestrial organic material

16:40 - 17:00 **Kirill Egorov**: The structure of the surface layer and fluxes from the ocean in the presence of ice floes

17:00 - 17:20 **Gisle Nondal**: Optimal evaluation of the surface CO2 system in the northern North Atlantic using data from Voluntary Observing Ships.

17:20 - 17:40 **Alexey Pavlov**: Seawater optical properties in West Spitsbergen coastal waters

17:40 - 18:00 **Sue Moore**: Impact of inter-annual variability in ocean conditions on bowhead feeding near Barrow, Alaska

Oleg Dudarev: New Data about the Semenov Shoal Morphosculpture as Island Relict on the Laptev Sea Shelf

Session 7: Risk to Human Health

Wednesday 25 March 2009

08:30 - 08:50 **Jon Øyvind Odland**: Human Health and Climate Change -Effects and Adaptation Processes in a Sustainable Development Perspective

08:50 - 09:10 **Natalia Belisheva**: The Cosmic Ray Intensity Dependence of Human Health in the High Latitude

09:10 - 09:30 **Sergey Chernouss**: Dependence of Heart Rate Variability on variations of Space Weather parameters in Arctic

09:30 - 09:50 **Bjørnar Ytrehus**: Weather related disease outbreaks in Arctic ungulates - a warning of changes to come?

09:50 - 10:10 **Maarten Loonen**: Dynamics of bird diseases and their risk for human health

Session 8: History of Arctic Sciences

Thursday 26 March 2009

14:00 - 14:20	**Erki Tammiksaar**: IPY (1882–1883): difficulties in the preparation, solutions, budget
14:20 - 14:40	**James Overland**: The Birth of Arctic Climate Science: the Synoptic Research Program of the First International Polar Year (1882-1883)
14:40 - 15:00	**Jörn Thiede**: The First German Expeditions Towards the North Pole
15:00 - 15:20	**Sergey Chernouss**: Auroral studies by the Russian-Swedish expedition to Spitsbergen 1899-1900
15:20 - 15:40	**Susan Barr**: 100 years of Norwegian institutionalised research in Svalbard
16:20 - 16:40	**Urban Wråkberg:** Functions and Meanings of Polar Research Field Stations
16:40 - 17:00	**Shuo Li**: Research on the Arctic Ocean with the new concept of underwater vehicle
17:00 - 17:20	**Rupert Wienerroither**: The marine fish diversity in the area of Jan Mayen Island, NE Atlantic
17:20 - 17:40	**Marty Bergmann**: Arctic aircraft and field logistics in Canada - Polar Continental Shelf Program's involvement with international research initiatives in the Canadian Arctic

Plenary Session

Legacies of Arctic Science from Humboldt to the High Arctic

Dr. Michael Bravo,
Head of History and Public Policy Research Group, Scott Polar Research Institute, University of Cambridge, United Kingdom

This paper takes as its point of departure the 150th anniversary of the publication of Darwin's *On the Origin of* Species and Alexander von Humboldt's *Cosmos,* two of the nineteenth century's works most credited with establishing scientific legacies. Given that Darwin and Humboldt became commemorated for their voyages to the species rich tropics, how should historians understand the legacy of International Polar Years and similar high latitude research networks and expeditions in a global context?

The paper proposes five provisional answers. First, the Arctic has been integrated both regionally and globally through a division of labour based on traditions of disciplined observation. Second, there is an inherent tension between the stability of scientific paradigms or models of knowledge on which scientific legacies depend, and the changing research problems, practices, instrumention, and conven-tions of scientific communication around which all research networks organise themselves. Third, the wider social and political concerns in relation to which observation networks are justified and sustained (e.g. geopolitics, climate change) are generally fragile and can be suddenly disrupted. Fourthly, practices of observation (e.g. design and deployment of instrumentation, site selec-tion, and experimental technique), while creating opportunities for making scientific reputations and careers, could also jeopardise personal and collective legacies. Fifthly, the reception of key scientific texts like *Cosmos* by different audiences has been instrumental in evaluating their legacies. In summary, scientific legacies are complex phenomena, expressions of continuity, stability and significance, within diverse and rapidly changing societies.

Sea ice changes and impacts on biodiversity and human communities

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The Arctic sea-ice cover has undergone major transformations over the past few decades: a reduction in summer minimum ice extent concurrent with replacement of much multi-year by first-year ice, changes in circulation patterns and ice velocities, and shifts in the seasonality of the annual ice cycle. These changes are due to a combination of factors, including increased greenhouse gas radiative forcing, enhanced absorption of solar radiation due to changes in the ice pack and the overlying snow cover, changes in surface wind and temperature forcing and oceanic change.

Impacts of this change on marine ecosystems include potential increases in the biological productivity of (seasonally) ice-covered seas, changes in the migratory patterns of species such as walrus or whales, altered dispersal patterns of ice-associated organisms, large-scale shifts in the distribution of ice-dependent species, and both positive and negative effects on the health and diversity of biological communities and organisms whose life cycle is tied to the ice.

Direct impacts on Arctic coastal communities through changes in the distribution of and access to species that are key to subsistence and the subsistence economy, and through changes in the coastal environment are compounded by large-scale geopolitical and socio-economic change. The latter are at least in part also tied to alterations in the Arctic ice cover. One of the challenges for scientists is to provide useful information to Arctic communities and other stakeholders at a time of increasing conjoined uses of the ice cover.

What exciting results have emerged to date? What do these results mean from the broadest perspective? How have these advances funda-mentally changed our view of the Arctic and its role in the Earth system and what will be required to make the next advances?

Notes:
- with ice velocity speeding up, what does this mean for genetic isolation of stocks of, e.g., arctic cod or polar bear? What are the implications for dispersal of fauna? Can this result in greater coupling between productive and non-productive areas? What does this mean for management?

- discuss in the context of SISS!

Risks to Human Health from a Changing Arctic

Dr. Jay Van Oostdam,
D.V.M., M.P.H., Senior Epidemiological Advisor, Health Canada, Healthy Environments and Consumer Safety Branch, Ottawa, ON, CANADA. And Canadian Co-chair, Arctic Monitoring and Assessment Programme, Human Health Assessment Group

A number of populations in the arctic have health status and longevity that are the best in the world. Compared to these populations many of the indigenous populations of the arctic often have less access to health care and overall poorer health. The Arctic Monitoring and Assessment Program (AMAP) has undertaken several assessments of contaminants (eg. POPs, metals, radionuclides), human health and climate change over the last 18 years. The most recent AMAP human health assessment has found that the concentrations of some legacy POPs and metals are declining in some indigenous populations but new contaminants are being found in the arctic. The findings presented in this AMAP human health assessments also suggest that there are subtle but significant health impacts on learning ability, the cardiovascular system and the immune system in some arctic populations at the current levels of contaminant exposure. A major dietary shift is also taking place in the arctic with increases in intake of sugar and unhealthy fats which may have significant health implications in the future. Climate change is a complex phenomenon which will likely have a significant impact on redistribution of contaminants in the arctic; resulting in a change in human exposure to contaminants. This may be due to changes in contaminant levels in food chains and traditional foods of arctic peoples and / or changing availability of various arctic species. Oil and gas and other industrial developments are also taking place across the arctic. New employment opportunities and population interactions from these developments as well as direct environmental impacts and emissions from these industries will effect arctic populations. There are a number of studies that are attempting to assess the impacts of a changing arctic on contaminants and human health plus health researchers across the circumpolar arctic are working together to better assess health status of arctic peoples. This talk will present an overview of some of the important factors affecting human health in a changing arctic plus outline some of the challenges that health researchers must address in the near future.

Indigenous Cultures - Past to Future

Dr Grete K. Hovelsrud,
Senior Researcher CICERO – Center for International Climate and Environmental Research-Oslo, Norway

Indigenous peoples of the Arctic are viewed by many as living under harsh and inhospitable conditions. From the perspectives of the indigenous peoples themselves this may be a misrepresentation, lacking an understanding of the basis for these indigenous cultures. The Arctic environment and its resources and climate, are what people have adapted to and survived in for thousands of years. Through history their cultures and values have to a large extent been shaped by the environment. Currently we see a varying degree of sensitivity or vulnerability to changes in the environmental, societal and political conditions. The rate and magnitude of climate change is higher in the Arctic than elsewhere which pose significant challenges for many indigenous and also non-indigenous societies. For others the changes may provide new opportunities. For example, the loss of sea-ice will have consequences for the peoples hunting ice-dependent species, such as ringed seals, and the opening up of Arctic shipping routes will have consequences for coastal communities. A warmer climate may compro-mise access to berries, fish, caribou and marine mammals, and it may also increase the growing season and result in new fish species. Climate change is, however, but one driver of change and do not occur in isolation from other changes. The combined changes will have different, direct and indirect, consequences for the indigenous peoples living in the Arctic. Indigenous cultures in the Arctic are considered resilient and highly adaptive, but the current changes may pose greater challenges than before. With climate change as an entry point, and with the knowledge that all cultures are dynamic, I will discuss change in Arctic indigenous cultures. I will explore the cultural aspects that may be most likely to strengthen or reduce the resilience of the indigenous cultures in the context of globalization and global warming. I will also explore the parallels between indigenous and non-indigenous societies in the Arctic and how we may transfer our current knowledge to societies and peoples beyond the Arctic.

Climate of the Arctic – an influential player in the Earth's Climate System

Dorthe Dahl-Jensen,
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Temperature changes in the Arctic are enhanced compared with the global changes because of the high sensitivity of the high latitudes and the major landmasses in the Northern Hemisphere. The sea ice in the Polar Ocean and the Greenland Ice Sheet in the Arctic region, further amplifies the impact of changes in the North due to albedo- temperature feedback mechanism and sea level changes.

New results show that the atmosphere circulation can change abruptly from year to year resulting in major climate changes. The climate system is very complex and the internal forcing of the system causes changes of the same scale as those from external forces as changing solar irradiance.

The recent increase of greenhouse gasses and the global warming will lead the climate into a new state. Will this increase the risk of abrupt changes and can we identify tipping points of our climate system??

Ecosystem change and carbon cycle on a glacier foreland in the high Arctic

Hiroshi Kanda,
National Institute of Polar Research, Tokyo

Recent decades, glaciers throughout much of the Northern Hemisphere have drastically retreated because of warming climate. The Arctic terrestrial ecosystem at the foreland of glaciers is thought to be extremely sensitive to climate change. However, an overall response of the ecosystem carbon cycle to climate change is still hard to predict.
Ecosystems with some succession stages at the high Arctic glacier foreland are expected to understand the ecosystem carbon cycle and to predict future ecosystem response to climate change. Such glacial retreat areas provide new habitat for plant colonization and hence organic carbon accumulation.

In this review, we focused on several recent studies conducted to clarify the pattern of the carbon cycle on the deglaciated areas in Ny-Alesund (79˚57'N, 11˚21'E), Svalbard in the high Arctic. Cryptogamic data will contribute to the major proportion of phytomass in the later stages of succession. However, even in the latter stages, the size of the soil carbon pool was much smaller than those reported from the low Arctic tundra and their net primary production was smaller than that of the vascular plants. The compartment model that incorporated major carbon pools and flows suggested that the ecosystem of the latter stages is likely to be a net sink of carbon at least for the summer season.

A comparison between ecological features in Ny-Alesund, with maritime climates and in Ellesmere, Canadian Arctic (Oobloyah valley, 80˚51'N, 82˚50'W) with those of continental climates is significant for evaluating response to climate change in near future.

Coastal Environments as a link between Land and Sea in the Arctic

Prof. Søren Rysgaard*,*
Greenland Institute of Natural Resources, 3900 Nuuk, Greenland

Coastal areas in the Arctic represent a link between land and the sea and, as such, are sensitive to changes in processes both on land and at sea. The annual average temperature in the Arctic has increased at almost twice the rate of that of the rest of the world over the past decades. Widespread melting of glaciers and sea ice and a shortening of the snow season have changed dynamics of coastal areas. Increases in glacial melt and river runoff add more freshwater to the sea. This affects stratification of the water column and water circulation in coastal areas as well as the exchange with shelf waters. Historically, the Arctic has been regarded as a relatively simple system, in which species interactions and environment-organism dynamics are straightforward and easily described. Recent research has, however, revealed a complex ecological interconnectedness in this sensitive region. Reduced sea-ice cover, improved light conditions and more nutrients to coastal areas will stimulate primary production and affect the biological structure and function of the ecosystems. However, increased thawing of permafrost and coastal erosion may also lead to increased runoff of suspended matter to coastal areas reducing light availability for primary producers in some areas. While reduction in sea ice will drastically shrink marine habitats for polar bears, ice-inhabiting seals and some birds, it may affect other species differently. Less sea ice will, for example, prolong the period in which walruses can feed on the bivalve-rich coastal communities each summer, whereas it will negatively affect walruses that are dependent on sea ice as a resting platform above offshore feeding grounds. Displacement of

species within the Arctic and invasion of new species will increase the complexity of interactions and thus pose a challenge for predictions of the future. Reduced and unstable sea ice conditions already cause problems for traditional hunting and fishing, whereas it will lengthen the navigation season and increase commercial marine access to natural resources in the Arctic as well as increasing possibilities for mining, hydropower, oil and gas exploitation. Compared with the rest of the world, investigations covering a full annual cycle are scarce in the Arctic. However, a recent study in High Arctic Greenland extended methane flux measurements beyond the growing season into early winter, and reported an unexpectedly large release of methane into the atmosphere at the onset of soil freezing comparable to methane emission over the entire growth season. In addition, recent studies of biogeochemical processes in sea ice during winter and summer suggest that sea ice may play an important role for CO_2 uptake in the region as well. Thus, an extension of monitoring programs, such as Zackenberg Basis and Nuuk Basis (www.g-e-m.dk), is urgently needed to collect long-term data quantifying seasonal and inter-annual variations and long-term changes in the biological and geophysical properties of the terrestrial, freshwater and marine ecosystem compartments in relation to local, regional and global variability and change.

The Role of the Arctic in the Global Change Process

Dr. Eddy Carmack,
Department of fisheries and Oceans, Canada

The Arctic is changing fast, and to understand why requires a view of its two-way inter-connection with Subarctic domains. First, the Arctic and Subarctic oceans surrounding northern North America and Eurasia are fully connected to one another and fulfill an absolutely critical role in global-scale hydrological and thermohaline cycles. Second, while it has long been suspected that the high latitudes will respond fastest and largest to climate forcing, the changes actually observed over the past 2 -3 years have far out-paced the most pessimistic of model predictions used in the 4th IPCC report of 2007. Third, humans are inextricably linked to the changes we are observing today, both as drivers of change through our greenhouse gas emissions and as the very populations needing to prepare for the uncertainties that lie ahead. This talk will review the Arctic's place in the global climate system, highlight changes we are seeing in the physical world of ocean currents and sea ice cover, and then explore what such changes - as components of a coupled system - will mean in terms of marine life and ecosystems, invasive species, ocean acidification and challenges to governance. Given that the broad purpose of climate monitoring is to collect sets of relevant, inter-comparable data over sustained periods of time so as to allow quantification of change within a system for decision-making purposes, and given that policy horizons and model predictions look forward to the year 2050, then institutional commitments for observational programs must be made on the same time frame.

Session 1

Sea Ice Changes and the Impacts on Biodiversity and Human Communities

Sara De La Rosa
Experiments on Frazil, Grease and Pancake Ice Growth

De La Rosa, S., S. Kern, R. Wang, H.H. Shen, L.H. Smedsrud and J. Wilkinson

The accelerated Arctic summer sea ice loss appears to lead to a transition towards an Arctic Ocean with increased wave fetch affecting the autumn freeze up of larger open water areas. Ice formation processes in these areas, such as the frazil and grease ice development into pancake ice, is one of the least well documented mechanisms within sea ice research. We present integrated measurements from two 20m long, 3m wide and 1m deep salt water tanks located in Hamburg (the Arctic Environmental Test Basin, AETB). Ice was grown at -12°C under wave conditions generated by a paddle placed at the end of each tank and operating at varying frequencies and amplitudes. The full transition from open water waves through to an ice cover consisting of congealed frazil and pancake ice was sampled at 1 hour intervals and continuously monitored with an infrared camera, CTD's, and ultrasonic sensors. The ice concentrations and salinities measured are comparable to field measurements from Svalbard. We present rate of ice growth and the brine drainage during different ice growth stages, as well as heat flux estimates with reference to the changing open water (grease ice) area compared to that covered by solid (pancake) ice. By analysis of the gradual compaction and thickening of the grease ice layer, a relationship between the ice properties and wave parameters is also suggested.

Sebastian Gerland
The Sea Ice Component of the new Arctic Cryosphere Climate Project "SWIPA"

Gerland, Sebastian, Kim Holmen and Mats Granskog

The main objective of the new Climate Change and Cryosphere assessment project "SWIPA" (Snow, Water, Ice, and Permafrost in the Arctic) is to provide the society and the Arctic Council with up-to-date and synthesized scientific knowledge about the present status, processes, trends, and future consequences of changes in Arctic sea ice, melting of the Greenland ice sheet, and changes in the terrestrial Arctic cryosphere beyond Greenland. The main aim of the project will be to produce an updated report on the status of the Arctic Cryosphere by 2011. One third of SWIPA is devoted to Arctic sea ice, and this component is lead by Norway through the Norwegian Polar Institute and co-lead by USA. Over the past decades, Arctic sea ice has changed: Ice extent and ice thickness was reduced, and recently less multiyear ice was observed versus first-year ice. However, leading climate models deviate from direct observations, when modeling Arctic sea ice extent. In the report of the Arctic Climate Impact Assessment (2005) gaps of understanding and knowledge about climate processes and feedbacks were stated. In the sea ice component of SWIPA, the following topics are dealt with: 1) Sea ice extent, 2) sea ice thickness, 3) feedback processes, 4) biology related impacts, and 5) impacts on human society. The results from GCM models will also be synthesized. The SWIPA component on sea ice anticipates including the newest results that came out after the recent assessments, especially those related to projects in the still ongoing International Polar Year (IPY).

Sebastian Gerland
Fast ice monitoring in Svalbard: Kongs-fjorden, Storfjorden and Hopen

Seasonal land-fast sea ice off the coasts of Svalbard affects the physical environment (surface energy balance) and the Arctic ecosystem. Sea ice in general is an often used climate indicator, responding relatively fast to climate change. The fast-ice evolution in Kongsfjorden is monitored as a part of a long-term project at the Norwegian Polar Institute systematically since 2003. Occasional observation data exist since the 1980s. The past three winter-spring seasons, fast ice in Kongsfjorden was significantly reduced compared to the years before. At Inglefieldbukta, on the western coast of Storfjorden, currently the fourth time in a row the French sailboat "Vagabond" winters over frozen into the fast ice, where data are collected as a part of the EU project "DAMOCLES" and an NPI internal project. Fast ice in Storfjorden forms earlier than on the western coast of Spitsbergen, and snow accumulation is relatively high. The amount of snow affects also the sea ice evolution. At Hopen, an island in the Barents Sea southeast of Edgeøya, fast ice thickness was monitored since 1966, and the corresponding time series is one of the longest in-situ measured sea ice thickness datasets existing. Over the past 40 years, a negative trend in seasonal ice thickness at Hopen was observed, overlaid by a relatively high interannual variability (relative to the time of season). A status on fast ice observations from the three locations will be presented and data series intercompared, followed by a discussion of future perspectives on setups for coastal-based monitoring of sea ice.

Naoyuki Kurita

Impacts of the Arctic storm to accelerate autumn freeze in the Arctic Ocean

Naoyuki Kurita, Koji Shimada and Takashi Kamoshida

The satellite data showed that Arctic sea ice extent reached its seasonal minimum in September, and then it increased rapidly. The trigger of this seasonal shift is probably a decrease in the daytime hours of the Polar region; however high interannual variability of ice growth rate in autumn suggests that a more complicated system such as ocean-ice-atmosphere interaction plays an important role. Here we examined the reason why autumn sea ice growth rate has been so fast using the R/V Mirai International Polar Year 2008 cruise data. The R/V Mirai observation was carried out not only hydrographic observations, but also atmospheric observations (radiosonde, Doppler radar, etc) from September 01, 2008 to October 05, 2008 over the open water region from southern Canada basin to the Makarov basin.

Results showed that the observed variability of meteorological data reflects the temporal change of synoptic scale atmospheric conditions rather than the latitudinal change of the boat position. A remarkable seasonal shift was observed when the strong northerly wind associated with an Arctic storm blew over the Canada basin. The time series of relative humidly showed a gradual decrease coincident with the strong northerly cold winds associated with this system. Relative humidity reached around 50% during the storm, distinctively lower than the 80% to 100% range observed earlier in September. At this same time, precipitatative systems also changed from stratiform snow to convective snow. These suggest that cold wind accelerates evaporation from the sea surface; moisture and heat from relatively warm ocean surface supplied water vapor to generate convective snow clouds. Accelerated evaporation flux associated with the blowing of cold wind also contributes to heat removal from the ocean surface, so that sea ice extent rapidly increased. Arctic storm activity must play an important role in the rapid increase of sea ice extent in autumn.

Maria Tsukernik

Present and Future Roles of the Atmospheric Forcing on Fram Strait sea ice export

The recent decline of Arctic sea ice extent has attracted widespread scientific attention. Explanation of this decline is attributed to change in both the thermodynamic component (sea ice melt) and the dynamic component (sea ice export). Our project focuses on the latter – sea ice export through Fram Strait into lower latitudes. Previous studies have shown that the relationship between large-scale atmospheric circulation patterns such as the North Atlantic Oscillation (NAO) and sea ice export through Fram Strait is inconclusive. We utilize observational and modeling data to examine in more detail the relationship between sea level pressure (SLP) and sea ice motion in Fram Strait. We use NCEP Reanalysis data for SLP and Polar Pathfinder 25-km gridded product for sea ice motion. We also utilize CCSM 3.5 simulation for the 21st century. Our observational results reveal an atmospheric pattern with an east-west distribution of the main centers of action: Barents and Greenland. The east-west dipole is associated with strong northerly winds and therefore promotes increased sea ice export through the Fram Strait. The east-west SLP dipole signifies as the second EOF of the SLP in the Northern Hemisphere and occurs in association with cold-air outbreaks in Scandinavia. We argue that the localized east-west SLP dipole is crucial in forcing sea ice export through Fram Strait, while the relationship between the monthly NAO index and sea ice export might be coincidental. We test how this localized SLP influence on Fram Strait sea ice export changes in the future.

Natalia Ivanova

Comparison of the Arctic sea ice extent and area time series obtained from different algorithms for sea ice concentration using passive microwave sensor data

Ivanova, N. and Ola M. Johannessen

Estimates of the sea ice concentrations in Arctic and therefore sea ice extent and area differ significantly dependently on which sea ice algorithm was used. In this investigation the data from the passive microwave sensor were used. The difference in retrieval from one algorithm to another leads to uncertainties in the ice change understanding and consequently in forecast of the sea ice characteristics for the future. The time series of the sea ice extent and area were obtained using several existing algorithms. It is suggested that apart from different calculation methods the algorithms can give discriminating results due to using of different input data rows of brightness temperatures. This investigation is aimed to understand probable causes of the disagreement in the algorithms on the basis of the sea ice extent and area values analysis.

James Overland
Causes of the Recent Arctic Warm Period within a Hundred Year Context

Overland, J.E and M . Wang

Arctic climate in the recent decade is unique relative to the 20th century. The Arctic appears to be on a fast track for summer sea ice loss with autumn temperature anomalies of greater than +5 C. Anthropogenic greenhouse gas forcing appears to be a necessary condition for major loss of sea ice, but the recent influence of natural variability in the form of warm years combined with ice/ocean feedbacks meant that the observed loss of summer sea ice occurred many decades earlier than expected from greenhouse gases alone. Unlike the summer sea ice loss in 2007 which was supported by favorable winds, initial sea ice conditions in spring were a primary loss factor for summer 2008. The sequential extreme conditions in 2007 and 2008 suggest that rather than a continuation of rapid sea ice loss over the next decade, i.e. a tipping point, it may take the occurrence of several additional rare warm years to continue the sea ice decline. Model results suggest an expected value for a nearly sea ice free Arctic in the 2030s. Unlike the early 21st century, the 1930s Arctic warm event was centered in the Atlantic Arctic. Intrinsic temporal/spatial atmospheric variability coupled to ocean processes was a major causal factor relative to external forcing or hypothesized cyclic climate processes. Much of the multiyear to interdecadal variability in arctic surface air temperature anomaly patterns is explained by the chaotic time-varying superposition of the AO/NAO, PNA, and a rare meridional wind pattern in the 1930s and 2000s.

Koji Shimada
A perspective on further catastrophic reduction of sea ice caused by activations of sea ice motion and the upper ocean circulation in the Arctic Ocean

Shimada, Koji, Kohei Mizobata, Motoyo Itoh, Eddy Carmack, Fiona McLaughlin and Andrey Proshutinsky

The summer minimum sea ice extent in 2008 was resulted in the second minimum record after the passive microwave observation since 1979. The sea ice extent is slightly smaller than that in 2007. Does this mean that the Arctic sea ice begins to recover? This would not be true. We should pay attention to the sustained retreat pattern of sea ice and the changes in underlying ocean. In the Pacific sector, the sea ice motion was substantially accelerated in 2007/2008 winter due to fragmented sea ice near the coast of Canadian Archipelago in the eastern Canada Basin. Why was the fragmentation of sea ice occurred there at that timing? We assume that sustained thinning of sea ice due to less sea ice formation associated with the ocean warming is important. From our sustained observation in the Canada Basin by R/V Mirai and Canadian ice breakers, we have detected the recent anomalous changes in the upper ocean. (1) Huge amount of Pacific Water was delivered onto the Northwind Ridge and Chukchi Plateau area. (2) Upward heat flux from Pacific Summer Water layer was increased due to deepening of surface mixed layer. From these observational evidences suggests that the Pacific sector of the Arctic Ocean is now changing from an ocean covered by multiyear ice into an ocean with seasonal ice cover.

Jean Claude Gascard
Arctic sea-ice variability

Why is the Arctic sea-ice retreating so much in summer, becoming thinnner and thinner, younger and younger and moving faster and faster? Is sea-ice thickness interacting with sea-ice drift? Is sea-ice drfit involved in sea-ice extent and summer minimmum sea-ice retreat? Is sea-ice thickness depending on sea-ice age? Have melting and freezing conditions changed recently? Is the atmosphere, the solar radiation or the ocean or both responsible for most of the changes observed in sea-ice? What did we learnt during the IPY regarding the Green House Effect versus the Albedo effect in the Arctic? In this presentation we will briefly review this critical set of questions and we will focus attention on two active processes investigated during the IPY and the Damocles project. One is dealing with summer melting (melt ponds and leads) and the other one is dealing with winter freezing of sea-ice at depth ("deep ice"). Both are playing an important role for sea-ice melting and freezing and consequently for sea-ice extent and thickness.

Vladimir Ivanov
Atlantic Water warming accelerates Arctic sea-ice reduction?

Ivanov, Vladimir and Igor Polyakov

Unprecedented low sea-ice concentration in the Arctic Ocean observed in September 2007 suggests that the reduction of the Arctic sea-ice is going much faster than climate models predict. Multiple factors control sea ice parameters and they are neither well-documented nor well-represented in models. Probably, the most uncertain factor among the others is the amount of sensible heat from the Atlantic Water layer in the Arctic Ocean eventually affecting sea ice. Atlantic Water (AW) reaching the Arctic

Ocean is considered to be the major heat source for the ocean interior. However, since after passing Fram Strait AW 'submerges' the upper waters, loosing direct contact with the atmosphere, the question whether the major amount of stored heat is released upwards affecting sea ice, or it stays in the deep being eventually flashed out of the Arctic Ocean, is a big unresolved issue. This issue became especially critical after 1991 when substantial warming in AW was recorded. Rapid reduction of the Arctic ice cover in 1990-2000s, questions possible contribution of AW heat in this process as well. We present observation-based results which demonstrate substantial heat/salt exchange between the upper part of AW and overlaying halocline water layer. Our model estimations show that throughout the last few decades continuous AW warming accompanied by weakening of vertical stratification accelerated upward heat transfer from AW resulting in anomalous heat flux of 0.5 W/m2. This is the equivalent of 5 cm of annual ice-thickness loss or up to 70cm of ice thickness loss since the late 1970s.

Eiji Watanabe

Pacific water transport in the Arctic Ocean simulated by an eddy-resolving coupled sea ice-ocean model

Watanabe Eiji and Hiroyasu Hasumi

The Pacific water from the Bering Strait is predominant sources of heat, freshwater and nutrients in the Arctic Ocean, and its transport has a great influence on sea ice condition and primary production especially in the western Beaufort Sea. Previous studies indicate mesoscale eddy activities play an important role in the shelf-to-basin transport, while traditional basin-scale models cannot explicitly resolve such local processes. In this study, mechanisms controlling the Pacific water transport from the Chukchi shelf to the southern Canada Basin are investigated by using an eddy-resolving coupled sea ice-ocean model. The simulation results show that the Pacific water inflow into the Canada Basin differs depending on sea ice condition during summer. When sea ice margin is located in the basin, mesoscale eddies are vigorously generated by instability of the Barrow Canyon jet and promote the Pacific water transport into the basin. Winter sea ice growth in the southern Canada Basin is delayed by oceanic heat which the Pacific water gains in the Chukchi shelf. On the other hand, when sea ice remains in the shelf even in late summer, sea ice-ocean stress and surface heat loss contribute to braking the jet. In that case, the eddy generation and the Pacific water inflow are suppressed, and the winter sea ice growth becomes larger than in the former case. These findings indicate an existence of positive feedback process between the Pacific water transport and recent sea ice retreat in the western Arctic Ocean.

Kohei Mizobata

Inter-annual variability of chlorophyll-a distribution related to ice-ocean circulation in the western Arctic Ocean

Saitoh, Atsushi Matsuoka and Amane Fujiwara

Recently, drastic sea ice reduction and changes in ocean circulation have been observed in the western Arctic Ocean. Changes of oceanic physical environment have an impact on both climate system and marine ecosystem. In the western Arctic Ocean, phytoplankton biomass is a key parameter to understand the whole ecosystem, because of short food chains. In this study, we attempted to explain recent chlorophyll-a (chl-a) distribution (as a proxy of phytoplankton biomass) in the western Arctic Ocean using hydrographic datasets from R/V Mirai cruise and satellite ocean color remote sensing. Hydrographic observations revealed relatively high chl-a concentration (~1.0 mg m-3) distributed from Hanna Canyon to Barrow Canyon in 2008. Satellite ocean color sensors, SeaWiFS and MODIS show northwestward long distance transport of high chl-a waters from Barrow Canyon and from the estuary of the Mackenzie River in 2007 and 2008, implying the intensified clockwise ice-ocean circulation in the Beaufort Sea. Intensified ocean circulation will assist northwestward transport from the Barrow Canyon, resulting in anomalous chl-a over the Hanna Canyon. In the subsurface layer, relatively high amount of nutrients have been revealed over Hanna Canyon in 2002, 2004 and 2008. Especially, in 2008, nutrient-rich water and high chl-a water were found in the subsurface layer over Hanna Canyon and off Hanna Canyon, respectively. Around Hanna Canyon, light availability is increasing due to recent sea ice reduction. Those indicate the probability of increase in primary productivity around Hanna Canyon in the future.

Jacqueline Grebmeier

Organic Carbon Export and Benthic Population Dynamics with Changing Ice Conditions in the Northern Bering Sea

Jacqueline M. Grebmeier, Adam B. Humphrey, Lee W. Cooper, Karen E. Frey and James R. Lovvorn

Variable sea ice duration, low seawater temperature, and low zooplankton populations in the spring in the northern Bering Sea result in high export of labile organic carbon to the sediments. Both sediment oxygen uptake (short-term indicator of carbon supply to the benthos) and benthic biomass (longer-term

indicator of carbon export) respond at different time scales to organic carbon reaching the sediments. A large spatial grid of stations were occupied in spring 2006 and 2007 from the USCGC Healy as part of a continuing multi-decadal effort to assess status and change in the highly productive northern Bering Sea benthic ecosystem. Sediment oxygen uptake ranged from <1-28 mmol O2 m-2 d-1, and reoccupation of a subset of these stations during the same cruise facilitated tracking the timing and impact of export production on the benthic system as sediment oxygen uptake rates increased following organic carbon deposition from the spring bloom. Measurements of benthic infaunal biomass, with values ranging from 2-48 g C m-2, indicate that the dominant bivalve, polychaete and amphipod community structure varies depending upon water mass structure and sediment type, but the observed decline in benthic biomass likely results from changes in the timing of ice retreat and its impact on spring ice algal phytoplankton production. The changing benthic prey fields directly impact top benthic predators in this system, such as diving sea ducks and walrus.

Karen Frey
Impacts of recent sea ice decline on biological productivity in the northern Bering and Chukchi Seas

Frey, Karen E., Lee W. Cooper, Jacqueline M. Grebmeier and Prajjwal K. Panday

The northern Bering and Chukchi Seas are among the most productive marine ecosystems in the world and act as important carbon sinks, particularly during May and June when seasonal sea ice-associated phytoplankton blooms occur throughout the region. Sea ice melt and breakup during spring strongly drive this production by enhancing light availability in the system, increasing stratification and stabilization of the water column, and introducing a new source of nutrients to surface waters. Recent dramatic declines in seasonal sea ice cover across the northern Bering and Chukchi Seas should therefore have profound consequences for this spring phytoplankton production. Here, we utilize multi-sensor satellite observations of sea ice cover (passive microwave SMMR, SSM/I and AMSR-E) and chlorophyll biomass (Aqua-MODIS and SeaWIFS) to investigate these linkages. Observations of sea ice cover show significant declines particularly during the shoulder months adjacent to the open water season, which is also associated with trends in earlier sea ice breakup and later sea ice formation. Earlier sea ice breakup is in turn linked with earlier and slightly more intense phytoplankton blooms (observed with Aqua-MODIS and SeaWIFS-derived chlorophyll-a concentrations). However, if sea ice breakup occurs even earlier past a potential tipping point, sunlight conditions may not yet be ideal for photosynthesis and the intensity of chlorophyll-a peaks may instead be dampened. The potential implications of these shifts in the timing of sea ice breakup may ultimately include a lowered amplitude of overall productivity if earlier spring sea ice retreats continue as expected.

Gary Griffith
Environmental factors controlling the sea-ice ecosystem of the seasonally ice-covered shelf of the Chukchi Sea

Griffith G.P and Y.H. Spitz

Sea-ice algae in the bottom skeletal layer of the Arctic Ocean are an important source of primary production for the sympagic and pelagic ecosystems. The environmental factors controlling the sea-ice ecosystem are still poorly understood. A new one-dimensional (1-D) sea-ice ecosystem model was developed and compared to available physical and biological data to investigate the importance of different growth limitation factors in regulating ice algal biomass of the sea-ice algae in the seasonally ice covered shelf of the Chukchi Sea. The physical component incorporates a wavelength dependant irradiance model and new equations representing the exchange of ecosystem matter between the ice and water. The biological component is based on the concept of dynamic growth with temperature, with limitations imposed by nutrients, light and salinity. Various simulations are presented of the impact of changes in sea-ice cover on the timing and magnitude of positive net production and growth of sea-ice algae.

Liqi Chen
A Potential Carbon Pool in the western Arctic Ocean during Seaice Shrinking

Chen, Liqi, Zhongyong Gao, Wei-Jun Cai, Rik Wanninkhof and Wen Yu

The underway pCO2 measurement system with a dissolved oxygen probe and fluorometer to measure Chlorophyll- a, has been installed on the R/V Xuelong and be operated in First to Third Chinese National Arctic Research Expedition (CHINARE-Arctic) from 1999 to 2008 in summertime in the western Arctic Ocean(wAO). A quickly seaice shrinking in large scale area could be observed from Xuelong's northernmost navigation respectively 75ºN in 1999, 80ºN in 2003 and 85ºN in 2008. The results suggest that an ice-free Arctic Ocean would be most likely an increased atmospheric CO2 sink. An overall

pCO2 distribution pattern presents in the wAO basin and margins and the subarctic region with a relatively high pCO2 in the excessive ice-melting area in Beaufort Slope and Canada Basin and extremely low pCO2 in the northern Bering Sea, Bering Strait and Chukchi. The pCO2 distribution in the these areas are consistent with the observed DIC and TA distributions which indicate biological uptake of CO2 in the extremely low CO2 but high salinity area and mixing control in the relatively high pCO2 but very low salinity area. Our finding agrees only partially with spatially more limited earlier results, suggesting further research on pCO2 variability and underlying control mechanisms is necessary for understanding carbon cycling in the wAO and predicting future changes.

Michael Carroll

Sea Ice Variations Influence Benthic Community Growth Rates over Decadal Scales: Evidence from Bivalve Population near the Barents Sea Polar Front

Carroll, Michael L., William G. Ambrose Jr., Ben Levin, Adam Ratner, Stuart Ryan, Jeanette Hardy and Greg Henkes

We examined internannual patterns of growth in two Arctic bivalves species (Clinocardium ciliatum and Hiatella arctica) on either side of the polar front in the Barents Sea to assess the relationships between environmental parameters and biological responses. Analysis of annually-deposited growth rings in bivalve shells provides a means to assess these relationships over decades (Clinocardium) to more than a century (Hiatella), thus encompassing both warmer and colder climatic phases of the last century. Growth patterns of both species corresponded to hemispheric climatic oscillation, represented by the Arctic Climate Regime Index (ARCI), and local parameters, especially ice cover and precipitation. There were, however, significant local variations in growth responses depending on proximity to the polar front and corresponding sea ice regime. Growth of Hiatella from locations near the polar front was positively correlated with the number of ice free days and negatively correlated with maximum ice extent while those in Atlantic water had the opposite response. Growth was related to the ACRI at stations in Atlantic water but not polar front stations. Together, ice conditions and precipitation explained up to 82% of annual variation in Hiatella growth. Clinocardium growth was positively correlated to maximum ice extent in polar front and non-front stations and to the ACRI at Atlantic water and some front stations. These results validate the approach of using growth rate analyses of bivalves to reconstruct biophysical relationships over decades to centuries, thereby overcoming the limitations of interpreting climate change effects from "snapshot" views afforded by traditional arctic sampling campaigns.

Eva Leu

Climate effects on planktonic food quality and trophic transfer in Arctic Marginal Ice Zones (CLEOPATRA)

Leu E., J.E. Søreide, S. Falk-Petersen and J. Berge

The retreating ice cover in the Arctic is changing profoundly the underwater light climate and hence the living conditions for primary producers representing the basis of the marine food web. The Norwegian IPY-project CLEOPATRA aimed at investigating the importance of light for timing, quantity and quality of primary and secondary production in seasonally ice-covered Arctic marine systems. A two-fold approach was chosen in this project: in 2007, we carried out an extensive seasonal study of a high Arctic ecosystem at 80° N (Rijpfjorden, Nordaustlandet, Svalbard), to follow the timing and seasonal variability of algal food quantity and quality, as well as reproduction and life cycle of the key herbivorous zooplankton species, Calanus glacialis. A similar field study was carried out in 2008 in close collaboration with the Canadian IPY-project CFL (Circumpolar Flaw Lead Study) in the Amundsen Gulf, Beaufort Sea. Also in 2008, we conducted a series of experiments addressing the effect of several environmental drivers on algal food quality, as well as the importance of food availability and food quality on the successful reproduction of C. glacialis. First results show a tight coupling of primary and secondary production that seem to be perfectly adjusted to the current conditions. We assume therefore that substantial changes in ice thickness and concentrations that we have been observing during the recent years, will pose a major challenge to the timing of ecological key processes at the basis of the marine food web.

Eva Leu

The effect of high irradiances and UV radiation on algal growth and food quality

Leu E., A. Wulff and M. Graeve

Algal blooms in ice-covered marine ecosystems usually start at the bottom and inside the sea ice. Pelagic blooms occur after ice break up in a strongly stratified layer close to the sea surface. During this period, algae might be exposed to fast changing and very high irradiances. Previous studies have shown that this can be rather detrimental for their growth and food quality (measured in terms of fatty acid

composition). To investigate these effects under controlled conditions, we performed in situ experiments with four different Arctic diatom species (3 pelagic, 1 ice algae) exposed at 0.5 and 8 m depth for 40 hours, respectively, in a high Arctic fjord (79°N). Experiments were performed with and without previous acclimation to ambient light. The specific impact of UV radiation was also addressed. Three out of four species showed a significant reduction in cell numbers at 0.5 m compared to 8 m after 40 hours. In two of them, we also found a reduction of growth due to UV radiation at 0.5 m. A moderate reduction of the relative amount of polyunsaturated fatty acids was found in three species, but it was less pronounced than anticipated. It therefore seems that diatoms can adapt rather well to high irradiances, although the amount and quality of biomass produced might be impaired slightly.

Laurent Bertino
Data assimilation and reanalysis of the Arctic Ocean within the European MyOcean project

Bertino L., P. Sakov, F. Counillon, A. Samuelsen and E. Simon

The European MyOcean Integrated Project aims at providing a Marine Core Service over the global oceans, aiming at: maritime security, oil spill prevention, marine resources management, climate change, seasonal forecasting, coastal activities, and monitoring sea-ice, water quality and pollution. The Arctic Monitoring and Forecasting Center in MyOcean will provide data assimilative operational short-term forecasts (10 days ahead, run daily) and a reanalysis of the last 20 years.

The present Arctic forecasts are provided by the TOPAZ system, developed at the Nansen Center and exploited in met.no's operational suite. TOPAZ uses an Atlantic and Arctic configuration of the Hybrid Coordinate Ocean Model (HYCOM) at a horizontal resolution up to 11 km, the 3D ocean model is coupled to a sea-ice model and uses the Ensemble Kalman Filter (EnKF) with a 100 dynamical members. The system assimilates satellite altimeter data, SST data, sea-ice concentrations, sea-ice drift and temperature and salinity profiles from the Argo profiling floats. Numerical data are served freely using an OPeNDAP (http://topaz.nersc.no/thredds or http://thredds.met.no).

The presentation will describe the plans for the data assimilative reanalysis, the data to be assimilated and the distribution of numerical data. The applications will be illustrated among which the forecasting iceberg trajectories and the coupling of the TOPAZ system with the Norwegian Ecosystem Model (NORWECOM). New methods are used for data assimilation of ocean colour data from satellites to update the non-Gaussian 3D ecosystem variables.

Session 2
Arctic Climate Variability—
Past to Future

Inger Hanssen-Bauer
Climate in the "Norwegian Arctic" during the 20th and 21st century

Hanssen-Bauer, I. and E. J. Førland

Historical climate observations from Norwegian Arctic station have recently been updated and reanalysed as part of the IPY project "BIAC". The series show considerable increase in temperature and precipitation in the Svalbard area during the last ~100 years. The temperature has increased more than what one might expect as a consequence of changes in the atmospheric circulation during the same period. The temperature changes are correlated to changes in the sea-ice extent in the area. Novel climate projections for the Svalbard region and Northern Norway were recently derived in "NorACIA" - the Norwegian follow-up to the Arctic Climate Impact Assessment (ACIA). A Regional Climate Model (RCM) with spatial resolution of 24x24 km was established over an area including Svalbard. This presentation will highlight results from the recent NorACIA RCM simulations for present climate (downscaling for 1960-2000 based on ERA40) as well as for control and scenario time slices (1961-90, 2021-2050 and 2071-2100). The improved spatial resolution reveals interesting modelled climate gradients across the Svalbard region. Results from statistical downscaling at selected sites will be presented in order to put the RCM scenario in a wider context.

Yvan Orsolini
Projected changes in Arctic summer cyclones under global warming in the Bergen climate model

Orsolini, Yvan J. and Asgeir Sorteberg

Using the coupled ocean-atmosphere Bergen Climate Model, and a Lagrangian vorticity-based cyclone tracking method, we investigate current climate summer cyclones in the northern hemisphere and their change by the end of the 21st century, with a focus on northern Eurasia and the Arctic. The two scenarios A1B and A2 for increasing greenhouse gas concentrations are considered. In the model projections, the total number of cyclones in the northern hemisphere is reduced by about 3-4%, but the Arctic Ocean and adjacent coastal regions harbour slightly more and slightly stronger summer storms, compared to the model current climate. This increase occurs in conjunction with an increase in the high-latitude zonal winds and in the meridional temperature gradient between the warming land and the ocean across Northern Eurasia. Deficiencies in climate model representations of the summer storm tracks at high latitudes are also outlined, and the need for further model inter-comparison studies is emphasized.

Vladimir Alexeev
Vertical structure of recent Arctic warming from observed data and reanalysis products

Alexeev, V.A., I. Esau, I.V. Polyakov, S.J. Byam and S. Sorokina

Spatial distribution of recent arctic air temperature changes is complex however knowledge of its vertical structure and geographical distribution may shed light on physical mechanisms driving this warming. Sparseness of high-latitude observational network has implications for the quality of available datasets. In this study, the spatiotemporal patterns of the recent air temperature trends are evaluated using three reanalysis datasets and compared against rawinsonde data. Our analysis focused on 1979-2008 reveals large differences between the datasets due to changes in the data assimilation procedure used in reanalysis. This casts certain doubts on the robustness of recently documented Arctic trends. Both NCEP products as well as NARR show consistent results regarding recent Arctic temperature trends. ERA-40 tends to be better in terms of root mean square error although it has certain jumps in the behavior of tropospheric temperature. A change of sign in the winter temperature trend (from negative to positive) since 1980th-90th is documented in the upper troposphere/lower stratosphere with a maximum over the Canadian Arctic. This result seems to be robust and is reproduced by NCEP reanalysis products and NARR. This change is associated with weakening of the stratospheric polar vertex and shift of its maximum toward Siberian coast.

John Cassano
Changing Greenland Precipitation:
A Weather Perspective

Cassano, John J. and Keah Schuenemann

The mass balance of the Greenland ice sheet is an item of great concern under a changing climate. Precipitation over the ice sheet provides a positive contribution to the Greenland ice sheet mass balance, and an increase in precipitation over the ice sheet may help to offset loss of ice through melt and ice discharge. The IPCC AR4 models indicate increased

precipitation over Greenland during the 21st century, although the reliability of these projections and the attribution of this projected change are not clear. Using a data analysis technique known as self-organizing maps we have analyzed the IPCC AR4 model data from a weather perspective, providing a unique method of assessing the reliability of the model projections and for determining the processes responsible for the projected changes in precipitation over the ice sheet.

Sergey Pisarev
Spatial interannual variability of the Arctic Cold Halocline margins

Actic halocline works as screen insulating upper mixed layer and ice cap from heat flux from Atlantic Water below. Therefore so called Cold Halocline (CH) layer disappearance in Amundsen basin and shift one of CH margin from the common position along the Lomonosov ridge to the Mendeleyev-Alfa ridge in mid 1990s is an event of great importance for Arctic climate. T,S data observed during 1991-2008 within the Central Arctic Basin with comparatively high spatial resolution (different types of autonomous buoys, SCICEX, some icebreaker's and ice camp's sections including the measurements on four ice camps within the North Pole region in Aprils of 2007 and 2008) were used to investigate the meso-scale structure of the frontal zone between the types of the Arctic halocline. The same data and all others historical and modern observed data as well were used for the estimations of the interannual variability of the positions of the Cold Halocline margins during 1937 - 2008. It was determined, that (1) CH characteristics follow generally to cyclonic and anticyclonic types of AB circulation; (2) climatic mean position of the transitional zones between CH and Pacific type of halocline (PH) lies rather along the Transpolar Drift line than along the Lomonosov Ridge; (3) retreat of CH from Amundsen Basin occurred in 1994, CH returns to Amundsen Basin in 1999, in 2000 transitional zone between CH and PH returned to Lomonosov ridge, but at 2001 it shifted back to Mendeleyev - Alfa ridge;(4) positions of CH margins are more flexible than it was considered before.

Karin Refsnes
The Svalbard Integrated Arctic Earth Observing System – Description and Status

Karin Refsnes; Georg Hansen; Kim Holmén; Gunnar Sand

The Svalbard Integrated Arctic Earth Observing System (SIOS) is a Norwegian initiative for a European Research Infrastructure, which was accepted in the revised roadmap of the European Strategy Forum on Research Infrastructures (ESFRI) in December 2008. The main goal of the initiative is to establish an Arctic Earth Observing System in and around Svalbard that integrates the studies of geophysical, chemical and biological processes from all research and monitoring platforms. This will be done through:
(1) Organize all infrastructure and all research and monitoring activities into four observation platforms being land-based, sea-based, glacier/icebased and space/air-based.
(2) Assess the present infrastructure and activities to identify gaps and weaknesses in the system. Invest in additional infrastructure and activities to close these gaps.
(3) Establish a Knowledge Centre in Longyearbyen for data assessment, storage and delivery, education and outreach, cooperative efforts, and input to Earth System modeling.
(4) Take actions to coordinate the SIOS initiative with complementary ESFRI efforts as well as other (Arctic) Earth Observation Systems, e.g., the Sustained Arctic Observing Network (SAON) and related modelling efforts.
The practical first steps to be taken after the approval for the revised ESFRI roadmap are to perform a scientific and infrastructure related gap analysis, to establish a consortium and to apply for a SIOS Preparatory Phase project from the European Commission. At the ASSW meeting in Bergen we will give an overview of the status of activities and further plans in 2009.

Øystein Skagseth
Observed transport variability of Atlantic Water through the Norwegian Sea to the Arctic based on long-term current-meter mooring arrays.

Skagseth, Ø., A. Beszczynska-Møller, R. Ingvaldsen, H. Loeng, K.A. Orvik, and U. Schauer

The Norwegian Atlantic Current (NwAC) through the Norwegian Sea is the main conduit of warm and saline water from the Atlantic – to the Arctic Ocean. In this paper we investigate the splitting of the NwAC current to the West Spitzbergen Current and into the Barents Sea. This is resolved by three strategically located moorings arrays; west of Norway at 63oN, in the Fram Strait, and in the western entrance to the Barents Sea. These arrays have been operated since the mid 1990ies, all more than 10 years. Together these arrays provide key information on the flow, i.e. fluxes and their properties, through the Norwegian Sea over a broad range of time scales. The observed variability in the transports and how these affect the Arctic Ocean will be discussed. A special focus will

be on the role of the wind forcing on these observed changes.

Maria Pisareva
Large – scale variability of the upper water masses characteristics within the Eurasian Basin observed by ITPs

About 3500 CTD profiles observed by WHOI Ice - Tethered Profiler (ITP) during April 2007-December 2008 within the Eurasian Basin are analyzed to determine the large-scale variability of the halocline and Atlantic waters (AW). The levels of upper and lower margins and core of the AW; heat content, average and maximum temperatures and salinity were calculated for the AW. Levels and salinity of the halocline base, salinity within the 40 – 60 and 60 - 80 m and fresh water content were calculated while characteristics of the halocline were analysed. To compare ITP data with climatic ones the same characteristics were calculated for three climatic fields. Five regions, where comparisons of characteristics of ITPs data with the historical observed ones were reasonable to determine the inter-annual variability for 6 particular years at least, were determine as well. WODB and selected old Russian observations were used as a collection of the historical data. It was determined that during 2007 - 2008 the AW is warmer practically everywhere within the Eurasian Basin while compared with climatology. The AW of the Fram Strait Branch which turns the Ermack Plateau is warmer up to 1 deg C for example. The comparison of ITP measurements with the historical observed data detected that the more warm AW characteristics were observed sometimes during last 10 years. The comparison of the ITP halocline characteristics with climatology and historical data detected the reduced upper layer salinity and weakness of the halocline, though even weaker halocline was observed sometimes during last 15 years.

Bjørg Risebrobakken
Holocene climate extremes in the south-western Barents Sea

Risebrobakken, Bjørg, Matthias Moros, Elena Ivanova and Natalia Chistyakova

The Holocene section of the marine sediment core PSh-5159N, located in the Ingøydjupet depression in the south-western Barents Sea (71°21`80 N and 22°38`77 E at 422 m water depth), has been studied at high resolution with a multi-proxy approach. Two periods, one in the early Holocene (11-9.8 ka BP) and another in the late Holocene (2-1 ka BP), show conditions that are unparalleled in the Holocene. These intervals are characterised by a well-stratified water column, due to a winter sea ice cover and a fresh, warm surface layer during summer. The sea ice and fresh water layer entailed a shielding of the ocean-atmosphere interaction. Both the gas and the heat exchange with the atmosphere were reduced due to this shielding, entailing among others increased bottom water temperatures. The establishment and maintenance of this climate regime was probably related to the existence of a predominant high-pressure system over the Nordic Seas and the Arctic Ocean. The late Holocene interval has a more episodic character and a reduced amplitude of change compared to the early Holocene interval. These dissimilarities were probably related to different boundary conditions due to different external forcing and background climate. During the mid Holocene most of the water column in the south-western Barents Sea was characterised by rather stable and generally cold conditions.

Kirstin Werner
Holocene Variability of Atlantic Water Advection in the Fram Strait

Werner, Kirstin and Robert F. Spielhagen

The Fram Strait is the only deep-water passage for Atlantic Water masses to enter the Arctic Ocean. Sediment cores from the Western Svalbard margin and the Yermak Plateau obtained during cruise leg MSM05/5b of RV "Maria S. Merian" in summer 2007 are analyzed to reconstruct fluctuations of Atlantic Water advection to the Arctic, the sea ice extent, and the structure of the water column during the Holocene. Geochemical, micropaleontological, and sedimentological approaches are used to establish multiproxy data sets with a centennial to decadal time resolution. Foraminiferal oxygen and carbon isotope records allow conclusions on salinity and the structure of the water masses, whereas relative abundance counts of polar vs. subpolar foraminifers reveal variations in water temperature and the related intensity of Atlantic Water advection during the last thousand years. Our records furthermore allow reconstructing the environmental changes within the last centuries for an area presently responding rapidly to global warming.

H. A. J. Meijer

Greenland Holocene temperatures obtained by differential diffusion studies

van der Wel, L.G. (1), B. M. Vinther (2), S. J. Johnsen (2) and H. A. J. Meijer (1) (1) Centre for Isotope Research, University of Groningen, the Netherlands (2) Centre for Ice and Climate, Niels Bohr Institute, University of Copenhagen, Denmark

The abundances of the stable isotopes 18O and 2H in precipitation water vary with temperature and can therefore be used as a proxy for past climate. Ever since the 1960's, retrieving these isotope signals has been the main motivation for the drilling of deep ice cores. However, their signals in ice cores are affected by diffusion in the firn stage: the profile is smoothed mainly due to water vapour transport through the pores of the firn. This process stops after pore close-off. Although a change of the stored isotope signals is in principle highly unwanted, in this specific case the diffusion process itself carries paleo-temperature information, and can thus be put to use§. The diffusion process, expressed as a diffusion length, is a function of several parameters such as temperature, density and porosity of the firn. 18O and 2H have different diffusion lengths as a consequence of the different fractionation factors for the isotopes. The difference between them is basically a function of the temperature only. This differential diffusion therefore contains direct information about the local temperature, averaged over the firn layer, in the past. Based upon high-resolution deuterium and oxygen-18 measurements on two sections of the NorthGRIP ice core we will present independent estimates of the mean annual temperatures for the early Holocene and the little ice age. § Johnsen S.J. et al., Diffusion of stable isotopes in polar firn and ice: the isotope effect in firn diffusion, in Physics of ice core records, edited by T. Hondoh, Hokkaido University Press, Sapporo, 121-140, 2000.

William D'Andrea

Mid- to late-Holocene NAO-type variability and the impacts of climate change on Saqqaq, Dorset and Norse occupation in West Greenland based on lacustrine alkenones and compound-specific hydrogen isotopes

D'Andrea, William, J. Huang, Yongsong Fritz, Sheri Anderson and N. John

To understand the forcing and feedback mechanisms that control centennial-scale climate variability in the North Atlantic region will require quantitative climate reconstructions from throughout the North Atlantic Sector. Here we use the alkenone unsaturation index (UK37) to quantitatively reconstruct lake water temperature for the Kangerlussuaq region of Southwestern Greenland at decadal timescales over the past 6,000 yrs. We apply a temperature calibration based on new in situ measurements and previously published data to convert UK37 to °C. Major reductions in lake water temperature ca. 6-5 and 3-2.7 kyrs BP correspond to periods of decreased Meridional Overturning Circulation, expansion of the North Polar Vortex and advection of cold waters from north of Iceland into the North Atlantic Ocean. Beginning ca. 4.2 kyrs BP the alkenone record reveals centennial-scale temperature variability opposite in sign to Southwestern Ireland, suggesting centennial-scale variability in the dominant mode of the North Atlantic Oscillation (NAO). This mid- to late-Holocene transition is likely related to the waning climatological influence of the shrinking northern ice sheets and reorganization of oceanographic conditions in the North Atlantic. The timing and severity of temperature changes depicted in the Kangerlussuaq alkenone record ca. 3.0-2.7, 2.0-1.8, and 0.85-0.55 kyrs BP support hypotheses that climate and environmental change played a fundamental role in the final abandonment of SW Greenlandic settlements by the Saqqaq and Dorset cultures, and the Norse culture. D/H ratios from sedimentary short-chain and long-chain n-alkanoic acids, reflecting lake water and precipitation D/H, respectively, provide additional insight into Holocene temperature and precipitation variability in Southwestern Greenland for the past 8,000 years.

Liguang Sun

A 7500-year Oxygen and Carbon Isotope Record within the Shell Remains in Ny-Alesund, Svalbard, Arctic: Linkage with Solar Activity and Episodes of Ice-rafting in North Atlantic

Sun, L. G., L. X. Yuan, X. F. Wang, Y. H. Wang, K. X. Liu and X. H. Wu

In the present study, a 118-cm-long and well-preserved sediment profile which contained lots of shell remains in a paleo-notch from the first strandflat of Ny-Alesund, Svalbard, Arctic, was collected. AMS14C dating and stable oxygen and carbon isotope analysis were carried out on the shell remains. The results showed that the variations of stable oxygen and carbon isotope values within the shell remains preserved in the paleo-notches in present study could record the climate changes in Ny-Alesund, Svalbard, Arctic from early Holocene to mid-Holocene (11.7-4.2 kaBP). In 7500 years records, the δ18O values within the shell remains experienced 5 time periods of remarkable changes and the δ13C values within the shell remains showed 6 time periods of substantial fluctuations. Moreover, the δ18O and δ13C curves displayed coincident

fluctuation pattern (R=0.59, P<=0.01). The peaks of δ18O and δ13C profiles corresponded to getting colder climate, reducing snow melt amount and decreasing input of snowmelt water into Kongsfjorden; and the troughs of δ18O and δ13C profiles corresponded to becoming warmer climate, enhancing snow melt amount and increasing input of snowmelt water into Kongsfjorden. After comparing with solar activity and episodes of ice-rafting in North Atlantic, it was concluded that increasing δ18O and δ13C values within the shell remains corresponded to weaker solar activity and enhanced drift-ice cycles, and vice versa, which revealed the strong correlation among the variations of δ18O and δ13C in shell remains and solar activity and episodes of ice-rafting in North Atlantic.

Mikhail Ivanov
Polar Urals glaciers variability past to Future

Ivanov, M. and G. Nosenko

High-latitude alpine glaciers are sensitive climate indicators and the most greatly they respond on the Arctic's climate changing. Existing at the limit of possibility glaciers of the Polar Ural mountains are reliable object for monitoring of nature fluctuations. The study region is located between 68º10' and 67º30´N, where the maximum of glaciers is concentrated, which are the 50% of glaciation area of Polar Ural. First glaciers discovered in 1932. The static glaciological investigations were in progress in 1958–81 on IGAN and Obrucheva glaciers. In 1947, 53, 58, 60, 68, 73, 89 was made aerial survey and topographical plan for glaciers, received ASTER-2000. The DGPS survey of Obrucheva and IGAN made in 2008. The main topics of this report are the revision, generalization of collected data, making detailed diagrammatic curves of glacier's size fluctuations for the modeling task solution. Data from the 1932, 1947, 1953, 1960, 1973 1982–2008 are important for the detailed reconstruction of fluctuations line of glacier's square area, length and the surface altitude and their connection with climate. For the glacier's fluctuations estimation numerical models of the surface, based on the topoplans were made. On this numerical models the contours of glaciers for different years were overlaid. Size, square area and surface altitude fluctuations were calculated. The material of moraine research was generalized too. The photographs of glaciers from different years are collecting for the new "Catalogue of repeated images", which will represent climate and nature environment changing.

Michael Fritz
How ground ice studies may contribute to paleoenvironmental reconstructions at the easternmost edge of Beringia (Herschel Island, western Canadian Arctic)

Fritz, Michael, Hanno Meyer, Lutz Schirrmeister, Hugues Lantuit, Nicole J. Couture and Wayne H. Pollard

Herschel Island lies off the Yukon Coastal Plain in the southern Beaufort Sea as a terminal moraine resulting from the Laurentide Ice Sheet during the Early to Middle Wisconsin and represents the likely easternmost edge of Beringia. Ground ice is ubiquitous and contributes to the shaping of the landscape since deglaciation. Stable isotope analyses (δ18O, δD) have been performed on various ground ice types. Since ground ice is a valuable record of paleoclimate information it can be used for paleoenvironmental reconstructions. Ice wedges on Herschel Island have begun to form in outwash and morainic deposits during the Pleistocene after deglaciation, when dry and harsh climatic conditions supported frost cracking. These ice wedges are remarkably depleted in their isotopic signature (−29 ‰) compared to Holocene ice wedges (–24 to –21 ‰). Within ice-rich Herschel Island sediments, bodies of massive ice are exposed whose appearance and isotopic composition is completely different from all other sampled ground ice types. δ18O-isotopes are strongly depleted (−33 ‰) thus suggesting a Pleistocene origin with slope and d-excess near the global meteoric water line (GMWL), which indicate that the moisture is likely of meteoric origin without substantial alterations. Other massive ice of unknown but supposedly glacial origin was encountered adjacent to large, striated boulders. With −37 ‰ for δ18O, the ice exhibits extremely low isotopic values. The question arises, whether the ice bodies aggraded before or after deglaciation as massive segregated ice or if the ice was originally basal glacier ice buried by supraglacial till.

Reinhard Pienitz
Postglacial paleoclimates of the Foxe Peninsula, Nunavut, Canada: new insights from chironomid and sedimentological analyses

Rolland, Nicolas and Reinhard Pienitz

Climate change reports show that many High Arctic regions are affected by unprecedented environmental changes because global warming effects are amplified at high latitudes. However, paleoclimate studies completed in areas surrounding the southern Foxe Basin, Labrador and northern Quebec, suggest that

these regions experienced relatively subtle climatic and environmental changes over the recent past. These contrasting scenarios underscore the necessity to increase our knowledge of past and present environmental conditions across the Arctic in order to refine our capacity to model past, present and future environmental changes. Unfortunately, the generally short time series data available for developing regional and global climate models does not adequately capture the natural environmental variability that has affected these regions in the past. One way to extend such environmental time-series data sets is to explore the sediment archives preserved in northern lake basins. As part of a concerted study of the Foxe Basin and its surrounding regions, our research presents the Holocene evolution of two lakes located on the Foxe Peninsula, Nunavut (Canada). Combined with sedimentological analyses, changes in the composition of fossil chironomid assemblages (Insecta: Diptera: Chironomidae) provide two reconstructions of centennial and millennial-scale climate and environmental variability during the Holocene for the Foxe Peninsula region which is compared to results obtained through previous studies of sediment records from neighboring Southampton Island, Nunavut.

Larisa Nazarova

Reconstruction of Holocene Climate Variability in Yakutia, North Eastern Siberia, made with regional calibration data set and chironomid inference model

Nazarova L., B. Diekmann and L. Pestryakova

The climatic influence arising from the vast permafrost regions of Siberia is poorly understood. In particular, in Central Yakutia, North Eastern part of Eurasia that represents one of Earth's most extreme climate regions with deep-reaching frozen ground and a semiarid continental climate with highest seasonal temperature contrasts on the northern hemisphere. For the first time for Northern Russia we established a regional calibration datasets and developed 3 empirical chironomid inference models for reconstructions of mean July air temperature, Lake depth, Water salinity. The data set includes150 lakes from all Yakutia that cover a waste range of broad ecological gradients. The models were applied to a long sediment core of the lake Temja, Central Yakutia (N62o03', E129o29') in order to obtain reconstructions of Holocene climate conditions of the region. The lacustrine record spans over the last 9000 years of the Holocene. The downcore variability in composition of organic matter and the assemblages of fossil bioindicators gave evidence of climate-driven and interrelated changes in biological productivity, lacustrine trophic states, lake-level fluctuations and resulted in first reconstruction of Holocene Tjuly in Yakutia made on the basis of a regional data set. As a result of this investigation four phases of the development of paleoenvironments in Central Yakutia have been recognized. Reconstruction of a present day temperature, made with the regional model gives us an estimate within 0.9oC of instrumental record.

Aleksandra Zemskova

Ground ice and cryogenic morphology of Quaternary deposits of Yeniseyskiy bay coast and floral variety along the northern part of Yenisey river (research in the frames of IPY 2007-2009)

Zemskova A.M., M.A. Medvedeva and I.V. Kopytov

As part of International Polar Year program the field courses on geocryology for the young researchers, studying the north, took place at Western Taimyr coast in July-August 2007-2008. The purpose of the work was to study different types of permafrost ice (ice wedges, ice complex, hydrolaccoliths, massive ice) as well as to research the morphology, properties and cryolithology of Western Taimyr Quaternary deposits and to study landscape conditions and, in particular, floral variety along the northern part of Yenisey River. The complex of such methods as geological and geomorphological, cryolithological, geobotanical and landscape was applied. Samples of ice, snow, ground, soil and paleofauna for chemical, isotopic, microfaunistical, granulometrical, radiocarbon, paleomagnetic analysis were collected. The complex of landscape study included the detailed description of watershed landscapes, plant cover in sample-areas 10x10m, soils and moisture conditions for a layer of seasonal thawing. The complex description was accompanied by selection of herbarium. Obtained data allows to estimate the present-day situation in Western Taimyr permafrost zone and reconstructing conditions of permafrost evolution and formation in the past. During the expedition Pleistocene-Holocene deposits in coastal exposal of the right bank of Yenisey river and Yeniseyskiy Bay were studied. Contemporary cryogenic processes of Western Taymyr coastal zone were also explored (coastal dynamics, thermokarst, etc). It is possible to see that for the last several decades the degradation of permafrost is observed in explored region. Landscape study shows us an approximate floral zone dynamic, distribution, abundance of some arctic species; illustrate boundaries of polar vegetation zones.

Sebastian Wetterich

Late Quaternary environmental history inferred from permafrost exposures on Kurungnakh Island, Lena Delta, Northeast Siberia, Russia

Wetterich, Sebastian, Svetlana Kuzmina, Andrei A. Andreev, Frank Kienast, Hanno Meyer, Lutz Schirrmeister, Tatyana Kuznetsova and Melanie Sierralta

Late Quaternary permafrost sequences are widely distributed in the arctic lowlands of Siberia. Because the existence of permafrost has been sensitive to climate changes during the Quaternary past, such frozen deposits are regarded as an archive of palaeoenvironmental dynamics. Late Quaternary palaeoenvironments of the Siberian Arctic were reconstructed by combining data from several fossil bioindicators (pollen, plant macro-fossils, ostracods, insects, and mammal bones) with sedimentological and cryolithological data from permafrost deposits. The late Pleistocene to Holocene sequence on Kurungnakh Island (Lena Delta, NE Siberia) reflects the environmental history of West Beringia and covers glacial/interglacial and stadial/interstadial climate variations with a focus on the Middle Weichselian interstadial (50–32 kyr BP). The record mirrors the development of periglacial landscapes under changing sedimentation regimes which were meandering fluvial during the Early Weichselian, colluvial or proluvial on gently inclined plaines during the Middle and Late Weichselian, and thermokarst-affected during the Holocene. Palaeoecological records indicate the existence of tundra–steppe vegetation under cold continental climate conditions during the Middle Weichselian interstadial. Due to sedimentation gaps in the sequence between 32 and 17 kyr BP and 17 and 8 kyr BP, the Late Weichselian stadial is incompletely represented in the studied outcrops. Nevertheless, by several palaeoecological indications arctic tundra–steppe vegetation under extremely cold-arid conditions prevailed during the late Pleistocene. The tundra–steppe disappeared completely due to lasting paludification during the Holocene. Initially subarctic shrub tundra formed, which later retreated in course of the late Holocene cooling.

Alexey Lupachev

Soil-Cryogenic Complex of Russian North-east in Modern and Future Climate Conditions

Lupachev A.V. and S.V. Gubin

Due to syngenetical freezing during Pleistocene, a great volume of organic matter has been preserved in the Ice Complex deposits. Complicated climatic history and pedogenesis of Holocene formed the "soil-cryogenic complex" that consists of soil profile, transient and intermediate layers of permafrost. Such conditions determined the existence of numerous organic-rich layers within the intermediate layer (maximum SOC - 4-5%). In the modern, relatively optimal climate conditions for tundra pedogenesis, the active lateral redistribution and accumulation of coarse organic matter between the parts of soil pedonanocomplex is obtained now. This process is fully determined by the interaction of pedogenic processes and the nanorelief of permafrost border. It takes place within the super-permafrost soil horizons and in the transient layer of permafrost (maximum SOC - 10-15%). The concentration of organic carbon in these layers is frequently more, than in the soil surface horizons. Nowadays, this layer that is enriched by the coarse organic plays a role of a buffering system, preventing the lower permafrost layers from thawing due to its isolating properties. But in case of global climate warming or even short periods of significant air temperature increase and entailed increasing of the active layer thickness, it can possibly yield a carbon emission to the biosphere.

Iglovskiy Stanislav

Geocryological conditions of north of Archangelsk region (Russia)

Cryolithozone of Archangelsk region (Russia) it is submitted island and rare spread by types of distribution of permafrost last Holocene age (temperature -0,5 - -1,0 º C). Thikness - 25 m. Permafrost are dated for peat deposits. In Kanin peninsula permafrost are found out in flat-topped tundra bogs and in peat frost heave mound tundra. In north of Kanin permafrost also are dated to palsa bogs. The features spatial - temporary distributions of ice caves are subordinated to dynamic parameters of carst systems. The investigation area belongs to Kanin-Timan geocryological region and is represented by isolated patches of permafrost located at peatlands. On the territory of Mezen and Kanin tundra various cryogenic processes are represented (thermokarst, frost heaving, thermoerosion). The topography of cryolythozone is represented by frost heaving mounds, thermokarst lakes and thermoerosion formes. The height of mounds is about 3-4 m. The contemporary south boundary of permafrost is located in the south of Kanin Peninsula. The cryolythozone of Archangelsk region tundra has an unstable character.

L. X. Yuan

Striking association between North Atlantic climate and seabird populations in Ny-Alesund, Svalbard, Arctic between 12 and 4 kyr ago

L. X. Yuan1, L. G. Sun1, X. F. Wang1, Y. H. Wang1,2, K. X. Liu3, X. H. Wu4*

The historical seabird populations at Ny-Alesund, Svalbard, Arctic, from 12 to 4 kyr BP, have been estimated from the shell debris content, bio-element concentrations, total organic carbon (TOC) and total nitrogen (TN) in one well-preserved palaeo-notch sediment profile that is influenced by seabird excrements. After seabirds colonized the west coast of Svalbard around 12 kyr BP, their populations gradually increased and peaked around 10 kyr BP. In the subsequent 6000 years, the seabird populations experienced four remarkable changes with peaks around 8700 yr BP, 7000 yr BP and 4800 yr BP and troughs around 9400 yr BP, 7600 yr BP, 6000 yr BP and 4200 yr BP. These great variations are strikingly associated with North Atlantic climate: seabird populations decreased as drift ice increased and the climate deteriorated, and vice versa. Without human interference, the historical seabird populations in Arctic are likely impacted by climate-related factors such as Gulf Stream.

Session 3
The Role of the Arctic in the Global Change Process

Robert Dickson
Towards an integrated Arctic Ocean Observing System (iAOOS)

The integrated Arctic Ocean Observing System, conceived by the Arctic Ocean Sciences Board (AOSB) was designed to optimise the cohesion and coverage of Arctic Ocean Science during the IPY. Its main scientific focus was with Arctic change, including the fate of its perennial sea-ice and the climatic and social effects of its disappearance. Its task was to view the ocean-atmosphere-cryosphere system of high northern latitudes operating as a complete system for the first time. The rationale for this task was that understanding this system and testing its predictability seemed to be a direct way of extending our ability to mitigate for or adapt to its changes, including global change. Its means lay in the fact that for the first time we are technically able to measure almost any key variable at almost any place and time that we need to describe the ocean-atmosphere-cryosphere system of high latitudes. And the IPY provided the necessary stimulus for piecing together the available PIs, gear, ships and funding on a pan-Arctic scale. This talk aims first to describe the major advances that were made in our understanding of large-scale change in northern seas through the close international coordination that was achieved during the IPY. Second, to contribute to the debate on which of these efforts should be maintained into a post-IPY 'legacy phase'. This exercise is necessarily one of prioritising the observational needs of climate models and ecosystem management against the technical demands and cost of meeting these on a sustained international basis.

Lars H. Smedsrud
Barents Sea Heat - Oceanic advection and surface fluxes

Smedsrud, L.H., Ø. Skagseth, A. Sorteberg and E. Nilsen

Sensitivity of the Barents Sea towards variation in oceanic advection of heat and vertical heat fluxes is explored. Using mean monthly atmospheric forcing and oceanic advection a column model reproduce the seasonal cycle with with deep winter convection and surface warming and freshening well. Model results are compared to horizontally averaged profiles and earlier estimates of the ocean to air heat fluxes. Results indicate that the advected oceanic heat of $\sim$50\ TW is lost in the southern ~30% of the Barents Sea; latent, sensible and longwave radiation each contributing 20-25 TW to the heat loss. Solar radiation adds 25 TW in this area, as there is no significant ice production. The northern Barents Sea (~70% of the area) gets little oceanic heat advected in. This leads to a mixed layer at the freezingpoint during winter and significant ice production. The ice reflects much of the solar radiation, leading to similar input of solar radiation (28\ TW) as in the south. There is little net surface heat loss in the north, the balance is achieved by longwave loss removing the solar heating, and a sensible heat gain balancing the latent heat loss.

Igor Esau
Vertical structure of the Arctic warming: The effect of the Arctic planetary boundary layer decoupling.

Esau, Igor and Svetlana Sorokina

Studies of the vertical structure of the Arctic warming disclosed the strongest warming near the surface in the cold seasons but the strongest warming aloft in the warm seasons. These findings have caused hot debates in the research community. The vertical structure of the warming could be better understood when the effect of the vertical turbulent mixing throughout the shallow, stratified Arctic planetary boundary layer (PBL) is taken into account. Our study reveals an asymmetric response of the PBL on the cold/warm advection in the lower troposphere. The cold advective events destabilize the PBL, which cause the tight coupling between the temperature course in the troposphere and near the surface. Contrary, the warm advective events stabilize the PBL, which prevents the temperature rise near the surface. We demonstrate with simulations and observational data that on average the asymmetry of the PBL response and the PBL summertime decoupling lead to trapping of the cold anomalies near the surface in all seasons with the minimum trapping effect in the spring season of the greatest observed warming.

Florian Geyer
Dense Overflow at the Storfjorden Sill: Mean Seasonal Cycle, Variability and Wind Influence

Geyer, F., I. Fer and T. Eldevik

Brine-enriched shelf water production associated with ice formation in an annually recurrent polynya in Storfjorden, Svalbard, is the cause for the dense overflow across the Storfjorden sill. Current profile and bottom temperature data from the Storfjorden sill

from 2003 to 2007 form the longest time series collected at this site and provides a sufficient data base to study the interannual variability of the overflow and the influence of atmospheric forcing. For the first time the mean seasonal structure of the overflow can be presented. The annual average of the overflow flux across the sill was 0.026 Sv (1 $\mathrm{Sv}\equiv10^6\,\mathrm{m^3\,s^{-1}}$). The overflow starts up strongly with high volume transports early in the overflow season and then gradually diminishes, becoming increasingly intermittent during the last third of the overflow season. The comparison of four consecutive overflow seasons reveals relatively small variations of the average overflow flux. In spite of the stability of the average overflow flux there are considerable interannual variations in the onset date of the overflow and the intra-seasonal distribution of the overflow flux. Thus overflow profiles of specific months can differ substantially from year to year. Variability on the shorter scale of 1-2 weeks was strongly connected to wind forcing, indicated by the significant rotary coherence between the current at the Storfjorden sill and wind measurements at two meteorological stations on Edge{\o}ya and Hopen Island. The physical connection is the surface Ekman transport. This connection between cross-sill flow and wind forcing holds independently of the dense-water overflow and is also observed outside the overflow season.

Malgorzata Cisek

Role of the west Spitsbergen shelf and slope in the interactions between the Atlantic and Arctic type water masses in summers 2005-2008.

Goszczko, Ilona, Małgorzata Cisek and Waldemar Walczowski

Interactions between the Atlantic water (AW) and Arctic type water (ArW) masses were analysed based on measurements performed during summer Arctic Experiments by IOPAS in 2005-2008 aboard R/V Oceania. Investigated dataset makes up a series of CTD sections perpendicular to shelf-break and high resolution CTD sections in west Spitsbergen fjords: Hornsund and Kongsfjord. Presence of density compensated Arctic Costal Front (ACF) characterized by horizontal gradients of temperature and salinity was observed. Frontal zone separates warm and saline AW carried north with the West Spitsbergen Current (WSC) from colder and fresher ArW transported with the Sørkapp Current. In surface layer the freshest water originating from ice melting and river run-off occurs. Range and thickness of this water mass vary depending on intensity of summer warming. Width of the ACF shapes layering area which determines efficiency of mixing processes such as salt fingering and double diffusion. Strength of WSC has an effect upon the magnitude of AW inflow on the shelf. Shape of bathymetry diversified along the shelf break and width of the shelf region are additional factors to that. Mixing processes above shelf-break area influence heat and salt transport rates through the Fram Strait to the Arctic Ocean and are significant for the global climate. In 2006 the ACF was sharper and narrower compared to other years which indicates stronger inflow of warm AW.

Helene Reinertsen Langehaug

Changes in the Distribution and Properties of the Deep Water Masses in the Fram Strait for the period 1984-2005

Langehaug, Helene R., Eva Falck and Svein Østerhus

Changes in the distribution and properties of the deep water masses passing through the Fram Strait have been studied for the period 1984 to 2005 in an east-west section at about 79°N. The Fram Strait is the only deep connection between the Arctic Ocean and the adjacent seas, with a sill depth of approximate 2600 m. In recent years we have seen large changes in the inflow of Atlantic Water into the Arctic Ocean. In this study we turn to the deep water masses in the strait to investigate if there have been changes also here. The most important deep water masses comes from the Norwegian Sea, the Greenland Sea, the Canadian Basin, and the Eurasian Basin. The Optimum Multiparameter Analysis has been used to estimate the contribution from each of these water masses. This method requires measurements of nutrients in addition to temperature and salinity. A classical TS-analysis is also accomplished to look for alterations in both the properties and vertical extent of the different water masses. The results revealed several alterations in the deep gap. The deep water masses from the Nordic Seas have become warmer and more saline, while the most saline intermediate water mass got fresher during the study period. According to the chosen water mass definitions the Eurasian Basin Deep Water, and partly the Norwegian Sea Deep Water, have occupied the area where the Greenland Sea Deep Water dominated in the early 80's.

Vidar S. Lien

Is the Barents Sea cooling the Arctic Ocean?

Lien, Vidar S., Tor Gammelsrød, Øyvind Leikvin and Alexander Trofimov

The Barents Sea plays an important role in the transformation of warm and saline Atlantic Water into cold and dense bottom water. CTD and current

meter observations from the north-eastern Barents Sea, between Novaja Zemlja and Franz Josef Land, show that this Cold Bottom Water (CBW) is flowing into the Arctic Ocean. This water is so dense that it will sink to levels below the thresholds of the Arctic Mediterranean, and thus contribute to the Atlantic thermohaline circulation. Recent observations indicate variability on several timescales, seasonal, inter-annual and decadal. Eddies are probably causing variability on a few days timescale, thus making it difficult to interpret individual CTD sections in a long term context. Current observations show that the most important transport of CBW is in the lower layer near the northern tip of Novaja Zemlja. Some recirculation of Atlantic Water from the Arctic into the Barents Sea in the middle of the section was also observed. In total we suggest that the Barents Sea may act as a heat sink for the Arctic Ocean.

Bert Rudels

The Barents Sea inflow branch & its interactions with the Arctic Ocean water column

The inflow of Atlantic water to the Arctic Ocean over the Barents Sea, although of similar strength as the Fram Strait inflow, has received comparatively less attention. This is due to the large heat loss and the freshening of the inflow in the Barents Sea, which make it less distinct and allow it to become distributed over a larger depth range as it enters the Arctic Ocean, mainly through the St. Anna Trough. The impact of the Barents Sea branch is threefold; it provides a less saline intermediate water below the warm Atlantic layer, its less dense parts cool and freshen the warm Atlantic core of the Fram Strait inflow branch and the part which absorbs the river runoff on the shelves evolves into the low salinity shelf water that eventually enters the Arctic Ocean and forms the Polar Mixed Layer in the larger part of the Amundsen and Makarov basins. The circulation of these different inputs and their interactions with and impacts on the Arctic Ocean water column are examined and discussed.

Ole Henrik Segtnan

Cross-isotherm currents in the southwestern part of the Barents Sea: flow field derived from ocean temperature observations and surface heat fluxes

Segtnan, Ole Henrik, Tore Furevik and Alastair Jenkins

In this study we investigate the transport of Atlantic Water through the Barents Sea, which is regarded as a key region with respect to the thermohaline circulation in the North Atlantic. From the general heat equation, an expression for the cross-isotherm currents is derived. In the southwestern part of the Barents Sea, the cross-isotherm currents are computed from depth averaged temperature observations and observational based surface heat fluxes. Dependent on the choice of surface heat flux data, the annual mean throughflow of Atlantic Water is between 0.81 Sv and 1.01 Sv. In agreement with previous findings, the results show that near the Central Bank, the Atlantic Water divides into a southern and northern branch, where the northern branch continues northeastward along the Hopen Trench. The transport along this route accounts for 63 to 70 percent of the total throughflow of Atlantic Water, and is therefore the major pathway of Atlantic Water through the Barents Sea. Relatively short after entering the Barents Sea, Atlantic Water following the northern route sinks below less dense Arctic Water and becomes isolated from the atmosphere. From these results it can be drawn that characteristics of the water exiting the Barents Sea to a large extent is determined by the surface heat loss southwest of the Central Bank.

Anders Sirevaag

Upper ocean turbulence measurements during the 2008 ASCOS experiment

Sirevaag, Anders and Sara de la Rosa

As a part of the Arctic Summer Cloud Ocean Study (ASCOS), a six week long field campaign in high Arctic was launched in Aug – Sept 2008. A large fraction of the field experiment consisted of an ice drift, in which the Swedish ice breaker Oden was moored to an ice floe and drifted passively with the ice for 20 days. The drift started from 87.4 N, 2W and the average ice drift speed was about 9 cm day-1. During this period, upper ocean small scale measurements were made using two instrument systems; i) an eddy covariance instrument for measurements of turbulent fluxes deployed close to the ice/ocean interface and ii) a loosely tethered micro structure profiler to resolve the fine scale resolution of temperature and salinity as well as high resolution velocity shear in the upper 500 m under the ice. This work presents the first results of the turbulence measurements during this drift experiment. Velocity, temperature and salinity data are analyzed in order to obtain the general characteristics of the turbulent boundary layer flow; fluxes of heat, salt and momentum. In addition, estimates of turbulent fluxes, mixing and eddy diffusivity are given for the mixed layer, pycnocline and below the mixed layer based on the microstructure profiler data, are presented.

Tor Eldevik
Variability and constraints of the Arctic-North Atlantic thermohaline circulation

Eldevik, Tor, Jan Even Ø. Nilsen, Ingo Bethke and Till Kuhlbrodt

The Atlantic Ocean's thermohaline circulation (THC) is completed in the Arctic Mediterranean. The warm and saline Norwegian Atlantic Current is totally transformed by the northern heat loss and freshwater input. The return flow to the Atlantic proper is consequently fresh polar water at the surface and cold, dense overflow waters at depth. In this study we present the observed thermohaline variability associated with the northern THC for the period 1950-2005, and present a simplest model for the associated volume fluxes and their sensitivity to climate change. The observation-based estimates are in turn compared to the estimated sensitivity of the northern THC in the climate models of the recent IPCC 4th Assessment Report.

Gabriel Wolken
Snow and ice facies variability on pan-Arctic land ice, 1999-2008

Wolken, Gabriel and Martin Sharp

Temperature increases in polar regions have exceeded those elsewhere on the planet, and climate model predictions consistently indicate that this trend will continue. One consequence of continued temperature increase in these regions is the widespread reduction of glaciers, ice caps, and ice sheets and subsequent rise in global sea level. Our knowledge of the mass loss of these Arctic land ice masses is limited, however, due to sparse in situ mass balance measurements, which are typically of short duration and usually biased towards smaller ice masses. Active microwave remote sensing data can provide valuable information about land ice surface conditions over large spatial areas, and can augment our knowledge of the spatial variations in the regional mass balance of Arctic land ice. Enhanced resolution QuikSCAT (QS) scatterometer data were used to map the distribution of snow and ice facies on the major pan-Arctic land ice masses during the period 1999-2008. In this paper, we present maps of the distribution of snow and ice facies on these ice masses and analyses of facies changes over the last decade and their relationship to climatic forcings.

Waldemar Walczowski
Changes of the Thermohaline Circulation of the Nordic Seas and Climate

Walczowski, Waldemar and Jan Piechura

Flow of the warm, salty Atlantic Water (AW) in the Nordic Seas and transport through the Fram Strait are important components of the climate system. Observations of the West Spitsbergen Current (WSC) carried by the Institute of Oceanology Polish Academy of Sciences (IOPAS), show changes of the AW properties and currents pattern. Progressive warming of the WSC was observed. During summers 2004-2006 isotherm 5ºC at 100m has moved meridionally 4.5º northward. In summer 2006 temperature of AW core reached record-high values. Two branches of the WSC exist. The core flows over the Barents Sea shelf break as a prolongation of the mostly barotropic Norwegian Atlantic Slope Current. The western branch flowing over the underwater ridges is a continuation of the outer branch of the Norwegian-Atlantic current. Intensity of the flow in each branch and mesoscale activity changes over the time. Observations revealed large positive heat anomalies, advected along the western branch in 2005 and 2006. It coincided with extensive northward shifting of the ice margin. Also high correlation between the AW layer temperature and yearly mean air temperature in Hornsund (Svalbard) show importance of the thermohaline circulation variability for the climate change. In summers 2007 and 2008 the AW layer temperature has decreased.

Steingrímur Jónsson
The upstream path of the Denmark Strait overflow water through the Iceland Sea

Jónsson, Steingrímur and Héðinn Valdimarsson

A part of the deep water formed in the Arctic Ocean flows through the Nordic Seas before exiting them into the North Atlantic proper. Denmark Strait overflow water is one of the main components of the thermohaline circulation in the North Atlantic. Observations have shown that a substantial part of it is transported to the sill along the Icelandic continental slope before entering the North Atlantic's Subpolar Gyre. The water has been traced along the Icelandic slope to the Kolbeinsey Ridge. To trace it further upstream and determine whether it has connection to the East Greenland Current or is flowing along the Kolbeinsey Ridge its properties are compared to the properties of water along the two paths. This is done using data from the Greenland Sea project from 1987-1991 that covered the western part of the Iceland Sea. Also the new and more extensive data set from the ongoing project, "Ecosystem of the

Iceland Sea", initiated in 2006 by the Marine Research Institute in Iceland that covers the whole Iceland Sea, is used.

Vigdis Tverberg
Winter heat loss from the West Spitsbergen current due to eddy exchange across the shelf edge front.

Tverberg, V., O.A. Nøs, F. Cottier and F. Nilsen

Isopycnal heat flux by mesoscale eddies is likely to be of larger importance for the winter cooling of the West Spitsbergen Current (WSC) than direct heat loss to the atmosphere. Our simple heat and salt budget box model study indicates that the eddy exchange of Atlantic Water (AW) across the shelf edge front between the WSC and the shelf has been stronger during the late winter months of 2007 and 2008 than earlier years. This is probably a result of shelf water being more dense than the AW core, leading to a surface bound eddy transport of AW onto the shelf. Atmospheric cooling on the shelf acts to maintain the positive on-shelf density gradient, and consequently also the surface bound AW shelf-ward eddy flux. All earlier winter observations has detected subsurface AW exchange across the shelf edge front in this region. The reversed situation may be linked to a warmer AW core entering the region, possibly in combination with less fresh water input to the shelf water from melting sea ice entering the region from the Barents sea.

Marius Årthun
Ice-Ocean climate variability in the Barents Sea: A model study

Årthun, Marius and Corinna Schrum

A 40 year (1958-1997) hindcast simulation from the regional coupled ice-ocean model HAMSOM is used to study interannual to decadal variability in climate relevant processes in the Barents Sea. Compared to observations the model captures the variability in temperature and ice extent. Higher heat transport through the Barents Sea Opening (BSO) and less sea-ice characterizes the mid 1970s and the early 1990s, while the opposite situation dominates the 1960s and early 1980s. Clear trends are also seen in both parameters, being +16.9%/decade and -5.8%/decade, respectively. The heat input through BSO is effectively lost through intense atmosphere-ocean heat exchange within the Barents Sea; annual mean oceanic heat loss reaching more than 200 W/m2. Due to its intimate link with ocean temperature and ice cover, long term variability tracks that of heat transport and ice extent. 5 year composite means range from -36 TW (low years) to -65 TW (high years) indicating significant variability. Areas of large heat flux anomalies are identified, and the effect of different forcing mechanisms is investigated. Bottom water formation at key locations (Central Bank and Novaya Zemlya) also shows considerable quasi-decadal variability. The importance of oceanic heat loss and sea-ice formation is discussed and a link to changes in Arctic Ocean stratification is speculated.

Idar Barstad
A Modeling study of the baroclinicity and surface fronts near the ice-edge

Barstad, Idar and Muralidhar Adakudlu

Advection of cold and stable Arctic air over warm ocean generates a shallow and sharp low-level front at the ice edge. These fronts lead to the formation of sharp vertical wind shear. The horizontal temperature gradient which provides the necessary thermal wind balance for the vertical shear, is the source of potential energy for the baroclinic instabilities. This baroclinic instability coupled with an upper level disturbance is a potential cause for the extreme weather in Arctic latitudes. In this study, the formation of surface fronts and baroclinic waves is investigated in an idealized baroclinic channel by using a state-of-the-art high resolution numerical model. The investigation is carried out with various background atmospheric conditions such as horizontal temperature gradient, upper level jet conditions etc. At the initial stage, a strong inversion and low surface temperatures is found over the lower boundary. After the model simulation commences, the southern part of the domain appears warm and the inversion is thus removed. A horizontal temperature gradient is produced and a low-level jet results as a baroclinic response. Results from the investigation will be presented. These preliminary results set a stage to investigate the formation of baroclinic zones near the surface fronts. The study includes the intrusion of a realistic, upper level potential vorticity anomaly in to the model atmosphere. The advection of such an anomaly in to a region where there is a pre-existing meridional temperature gradient triggers cyclone developments (Polar lows).

Vladimir Alexeev
Polar amplification dynamics: results from an idealized model, reanalysis products and observations

Langen, P.L. and V.A. Alexeev

An aquaplanet atmospheric GCM coupled to a mixed layer ocean is analyzed in terms of its polar amplified response to a 2xCO2-like forcing and in terms of phase space trajectory of the relaxation of a free perturbation to equilibrium. In earlier studies concerned with linear stability and fluctuation-dissipation analysis of the same system we have shown that the least stable mode of the linearized operaor of the system has a polar amplified shape. We demonstrate that this shape of the least stable mode is responsible for the polar amplified shape of the response to a uniform forcing and for the manner in which the system relaxes back to equilibrium. We use reanalysis products (ERA-40, NCEP) in order to quantify the signal in the Arctic atmosphere due to the influence of lateral heat transport from the lower latitudes. Robustness of polar amplification obtained from the reanalysis products is tested against radiosonde data from dataset IGRA.

John Burkhart
Atmospheric Change in the Arctic; an update of focused campaigns under POLARCAT

Burkhart, J F, T. Bates, C.A. Brock, C. Clerbaux, J.H. Crawford, J.E. Dibb, K. Law, P. Quinn, H. Schlager, H.B. Singh and A. Stohl

The Arctic system is particularly sensitive to climate variability and filled with uncertainties. Furthermore complex feedback mechanisms are amplified in this environment. During the International Polar Year (IPY) international partnerships were formed to establish the Polar Study using Aircraft, Remote Sensing, Surface Measurements and Models, of Climate, Chemistry, Aerosols, and Transport (POLARCAT). The POLARCAT projects cooperated with support from several national funding agencies to undertake the most comprehensive assessment of air pollution impacts on the Arctic to date. In spring and summer of 2008 more than 20 institutes from ten nations participated in intensive aircraft, ship, and station-based campaigns with accompanying efforts from the satellite and modeling communities to provide near real time products for mission planning and analysis. These campaigns provided an assessment of the role that tropospheric chemistry, aerosols, and transport play in the Arctic. The spring campaigns focused on anthropogenic pollution, while the summer campaigns targeted biomass burning. During the spring of 2008, over 80 flights were flown by five different aircraft as part of the ARCTAS, ISDAC, ARCPAC, and French POLARCAT campaigns, the ICEALOT campaign commissioned the R/V Knorr to travel over 12,000 km, and numerous specialty satellite and modelling products were developed with near real time distribution. In the summer campaigns an additional 50+ flights were flown by the ARCTAS, French POLARCAT, Siberian YAK, and GRACE campaigns. Several ground based stations and the Siberian TROICA campaign also conducted intensive operating periods (IOPs). We present an overview of the individual campaigns, anticipated products, and initial "quicklooks" from these activities.

Jinping Zhao
Arctic Oscillation, a spatially varied and non-seesaw-like oscillation

Zhao, Jinping, Yong Cao and Jiuxin Shi

Arctic Oscillation (AO) is defined by a space-stationary and time-fluctuating result of Empirical Orthogonal Function (EOF) method and expresses the seesaw-like fluctuation between polar and mid-latitudinal regions, which is sometimes inconsistent with the real situation. By calculating the running correlation coefficient (RCC) between grid sea level pressure and AO index, an AO-dominant region has been identified to illustrate the spatial variation of AO. In the RCC figures of the past 54 years, the oscillation occurred not only between the polar and mid-latitudinal regions, but also between the landmasses and oceans. The North Atlantic Oscillation is addressed as a stable seesaw-like oscillation. However, AO is addressed surely an oscillation, but a spatially varied and non-seesaw-like oscillation. In recent years, the spatial structure of the AO-dominant region becomes indistinct because of Arctic warming. EOF and RCC are addressed to be mutually complementary methods by viewing the different facets of the AO process.

Svetlana Sorokina
Atmospheric energy flux across 70ºN from the International Global Radiosonde Archive

Svetlana Sorokina and Igor Esau

The Arctic plays an important role in the global energy budget. This study presents the atmospheric energy flux across 70°N. This flux is obtained on basis of the International Global Radiosonde Archive (IGRA) available from the National Climate Data Center. Measurements of wind, temperature, moisture, and geopotential height were processed at levels from the surface up to 30 hPa over 1992-2007. Spatial and seasonal variability of the flux and its components (meridional sensible and latent heat fluxes, the fluxes of potential and kinetic energy) were analyzed. The mean altitude-longitude pattern of the flux was identified. Data suggest the peak meridional transport is localized in the upper layers from the mid- to high-troposphere. There are two

prominent regions of poleward (positive) flow centered at about 170ºE and 50ºW. A region of equator wards (negative) flow lies to the west, centered at about 110ºW. The outflow also dominates a broad region from 20ºE to 90ºE with the longitude maximum varying by season. The annual mean flux derived from IGRA dataset are very similar to the results calculated from reanalysis data in previous studies.

Rasmus Gjedssø Bertelsen
Climate Change and New Security in the North Atlantic

This paper studies the effects of climate change mediated by oil/gas exploration and trans-Arctic shipping on security in the Greenland-Iceland-Faroe Islands region under eventual Faroese and Greenlandic independence. Security is broadly conceived as exercise of sovereignty, participation in, e.g., NATO and provision of environmental protection as well as search and rescue services, etc. Climate change is particularly pronounced in Arctic areas and is 'very likely' to lead to improved access for energy exploration and international shipping (Arctic Climate Impact Assessment 2004-2005). Energy exploration and trans-Arctic shipping will move Arctic communities to much more central positions in the international energy and transport systems. This development will place increased security demands on these societies. Faroese and Greenlandic independence is the stated goal of these societies and an important—and overlooked—likely long-term political development in the Arctic. Climate change, creating new possibilities for energy exploration and transport may support this political development through new economic opportunities. Eventual Faroese and Greenlandic independence will entail the security policy challenge of how micro-states with very limited absolute financial, human, etc. resources can exercise sovereignty and surveillance over vast, strategically important air and sea space. Denmark, the Faroe Islands, Greenland, Iceland and other partners need to debate and examine today a possible future scenario of independent Faroe Islands and Greenland with sovereignty over large energy resources and strategic shipping routes: How these micro-states will exercise effective sovereignty over these resource and sea lanes and supply environmental protection, search and rescue services, etc.

Gerard Duhaime
Poverty in Nunavik, Arctic Canada.

Duhaime, Gérard and Félicité Bélisimbi

Very little is known about poverty in the Arctic. This research tries to evaluate the proportion of poor people in the Nunavik region, one of the Canadian Arctic region inhabited by a majority of Inuit. Several poverty measurements are widely accepted and calculated at a national scale. Based on such measurements applied to already available data from previous research and surveys, it seems that poverty incidence is as much as three times higher in the Arctic than the national average. These preliminary conclusions call for original research in order not only to adequately measure the phenomenon, but also to identify population segments that suffer most from poverty in Nunavik.

Kjetil Lygre
Carbon uptake by the ocean, subject to biological feedback

The World oceans - especially the Arctic - are projected to undergo large changes in physical state, such as temperature, light (shrinking ice cover) and mixing climate. The ocean stores carbon by the joint effect of solubility (temperature, wind) and downward particulate transport of biogenic material. A simple box model is constructed to examine how changes in physical parameters (mainly temperature and light) alter carbon storage and the partitioning between downward transport of sinking particles and dissolved organic matter.

Jorun K. Egge
Osmotroph responds to organic-C enrichment in an arctic pelagic ecosystem

Egge, Jorun K., Frede Thingstad, Aud Larsen, Jens C. Nejstgaard and Runar Thyrhaug

In order to investigate how the carbon-flow through the microbial community is affected by mineral nutrient limitation, mesocosm experiments were carried 56' E). The mesocosm were supplied° 55' N, 11°out in Ny Ålesund, Svalbard (78 with equal amounts of nitrogen and phosphorus, +/- silicate and glucose in a gradient in order to create an increasing limitation of mineral nutrients and labile DOC, respectively. Heterotrophic bacteria were the most successful to compete for mineral nutrients when labile DOC was available, and the growth were increasing with increasing glucose addition. The effect was opposite for the phytoplankton, and total biomass measured as Chl a decreased with increasing

glucose addition. Not all groups of phytoplankton followed this general tend, as pico eukaryotes showed the same pattern versus glucose gradient as heterotophic bacteria. The responds of organic carbon addition on the whole community was strongly affected on either the phytoplankton community was dominating by diatoms or not. The carbon flow in our arctic experiment was also quit different from similar experiment in temperate waters.

Namyi Chae

Carbon dioxide emission from tundra soil in Ny-Ålesund, Svalbard

Chae, Namyi, Taejin Choi and Bang Yong Lee

To evaluate the role of soil carbon to the net ecosystem exchange of CO2 in summer season, quantifying of CO2 efflux from soil surface to atmosphere and its controlling factors were investigated in the Dasan station (78° 55´ N, 11° 55´E), Ny-Ålesund in Svalbard, Norway. Soil CO2 efflux measurement were conducted within the major footprint area of the tower CO2 flux measurements in the plot (30 m x 30 m) using a closed-dynamic chamber system for July 2007 and 2008. Spatially averaged soil CO2 efflux for 16 sampling locations ranged from mol m-2 s-1 (2007)m0.07) ±mol m-2 s-1 and means of that were 0.6(m0.3 to 0.7 0.13) mol m-2 s-1 (2008). Spatially averaged soil temperature ranged±and 0.5(C and soil water content ranged from 13 to 27% during measuring of°from 6 to 12 Rs. Based on the preliminary results on CO2 exchange, the tundra ecosystem plays a role as a week sink for the atmospheric CO2 in summer season. This study was supported by ‘Integrated research on the COMposition of Polar Atmosphere and Climate Change (COMPAC)’ of Korea Polar Research Institute.

Session 4
Evolution of Arctic Ecosystems in a Warming World

Miyuki Kondo
Isotopic Signatures of Soil Organic Carbon and its Relation to Vegetation in a Successional Glacier Foreland in Ny-Ålesund, Svalbard

Kondo, Miyuki, Masao Uchida, Masaki Uchida, Toshiyuki Ohtsuka, Shinpei Yoshitake, Hiroshi Kanda, Hiroshi Koizumi and Takayuki Nakatsubo

High-latitude soil organic carbon (SOC) stocks are of particular interest because warming is expected to be greatest at high latitudes and induce acceleration of SOC decomposition. In the deglaciated areas in the high Arctic, accumulation in soil carbon take place very slowly and the organic layer is very thin. If this thin organic layer decreases as a result of climate change, it would profoundly affect the structure and function of whole ecosystems. Thus, improving our knowledge about the dynamics of the soil organic layer is essential to predict how high Arctic terrestrial ecosystems will respond to climate change. Our objects in this study were to obtain elemental and isotopic signatures of SOC in a successional glacier foreland sites in Ny-Ålesund, Svalbard, and examine its relation to vegetation. Soil organic carbon content, nitrogen content, stable-carbon composition (δ13C) and radiocarbon age for soil profiles were measured along a primary successional series of the deglaciated area. The C and N contents of SOC at soil surface tended to increase and its δ13C values gradually decreased with the progress of succession. On the other hand, no clear trend was found at deep soils. Regardless of vegetation types, δ13C values was significantly correlated with C and N contents, suggesting relatively high contribution of carbon input from biomass at surface soil. However, it is difficult to explain the correlation only with productivity of vegetation. In this site, soil carbon storage may be related to SOC decomposition.

Dmitry Kaverin
Upper permafrost as a part of tundra soil system

Shallow underlying of permafrost affects strongly soil processes in active layer and influences on general features of permafrost-affected soils. Upper permafrost layer is often differentiated from epigenetic permafrost thickness beneath. Shur et al. (2005) developed the concept of the transient layer, a layer of ground between soil active layer and permafrost that cycles through freezing and thawing at frequencies ranging from decadal to millennial. Transient layer is considered to be the original buffer protecting permafrost from spasmodic thawing because of its high ice content. Upper layer of permafrost was studied in tundra mineral and organic soils of the European North-East of Russia. Revealed transient layer in permafrost was characterized by ataxic or layered cryostructure. In some profiles we determined an increase in ice content in the upper permafrost: gravimetric ice content - 40-70% in loamy soils, and 300-800% in peaty ones. Absence of layers with high ice content in the layer could be explained by thawing of the transient layer in recent decades. Study at CALM R2 site showed that in upper permafrost volumetric ice content could be approximated by a "normalized subsidence" index (subsidence, cm to permafrost downward retreat, cm ratio). Site averaged index was 0.46 (ice content of thawed upper permafrost was about 46%) for 1999-2008. Such quite high ice content is typical for mineral horizons of the transient layer. Surface subsidence processes caused degradation of permafrost ice reached layer. Revealed decrease in acidity in upper permafrost layer was resulted from specific decomposition of organic matter.

Lise Øvreås
Microbial diversity in Arctic tundra

Øvreås, Lise, Christopher Quince, Anders Lanzèn, Jessica Green, Steve Coulson, William T. Sloan and Thomas P. Curtis

The diversity and formation of microbial communities is a largely unexplored frontier in science. There is exciting evidence that polar tundra in general and Spitsbergen tundra in particular could be some of the most diverse microbial communities on the planet. Evidence for the high diversity in Arctic tundra are based both on fingerprinting applications using 16S rDNA genes in combination with DGGE, clone libraries, 454 pyrosequencing and reassociation analysis of community DNA extracted from tundra. DNA reassociation measures the complexity of the tundra metagenome and the number of genome equivalents relative to the genome size of E.coli can be estimated. Using reassociation analyses the total genetic diversity in Arctic tundra was found to be as high as soil from temperate climatic zones with at least 9000 genome equivalents (Øvreås 2004). Sequences derived from clone libraries and pyrosequencing of Arctic tundra showed that more than 90% of the sequences affiliated to previously uncultured and unknown microorganisms. It is evident that the diversity is large and there are extensive numbers of relatively rare species. The current level of sequence analyses (~30,000 sequences per sample) is clearly insufficient and we

estimate that sample of 100 million sequence tags or more may be required to find 90% of the taxa in a sample. For at its simplest these finding imply that this remote archipelago is as reservoir of diversity of Amazonian proportions. If this exceptional diversity reflects both the latitude and climate of these islands, this diversity may be threatened by climate changes.

Alexander Tveit
Temperature effects on arctic methane producing microorganisms

Tveit, Alexander, Lynsay Blake, Neil Gray, Ian Head, Ana María, Salgado López, TP Curtis, Lise Ovreas and Vigdis Torsvik

Models suggest that gobal warming will have most dramatic effects in Arctic regions. Based on high soil organic carbon content (14% of global), it is predicted that the warming will induce a substantial release of the potent greenhouse gases CO2 and methane (CH4) due to thawing of permafrost soils and lake sediments. Methane is an important greenhouse gas, having about 26 times the effect of CO2 on a mol to mol basis. Estimates indicate up to 1% annual increase in atmospheric methane concentration, and it has been suggested that 74% of the total annual methane release originates from recent microbial activity (Whitman 2006). Methane producing microorganisms (methanogens) from freshwater sediments from Ny Ålesund, Spitsbergen has been investigated. In microcosm experiments, the effect of changing temperature and substrate was studied. The results show that under stable low temperature conditions (5°C) a single dominating population is selected regardless of substrate input. This population differs from the dominating population in the native samples. High temperature incubations on the other hand show a clear difference in response to substrate input, and distinct, dominating populations emerge. Preliminary work, comparing methanogenesis in Arctic (Ny Ålesund, Svalbard 79oN) and temperate (Newburn, Newcastle, UK, 55oN) sediment suggests that the activity of arctic methanogens at 5oC may equal or exceed the activity of temperate or arctic methanogens at 20oC. Also, the difference between arctic and temperate temperature patterns in methanogenesis suggest the low temperature methanogens are not ubiquitous, but confined to the arctic and possibly other low temperature environments.

Ryosuke Nakai
Spore-forming halophilic bacteria isolated from Arctic terrain: Implication for tropospheric

Nakai, Ryosuke, Kise Yukimura, Takeshi Naganuma, Shiro Kohsima, Jun Uetake and Hiroshi Kanda

Organisms living in Arctic terrain such as Greenland have to deal with adverse conditions, which include low temperature, dryness, and lack of nutrients. The mechanisms by which bacteria resist such hostile conditions are largely unknown; however, one well known survival strategy of the microorganisms inhabiting the Arctic is a spore-forming. Moreover, halophilic bacteria are often resistant to dryness because high salinity may otherwise result in low availability of water to these organisms. We have attempted isolation spore-forming halophilic bacteria from Arctic terrain. We isolated 10 strains of spore-forming halophilic bacteria from the samples collected from a glacial moraine in Qaanaaq, Greenland in July, 2007. Identification was based on 16S rRNA gene sequence similarities and it revealed that the isolates were of the Oceanobacillus, Paucisalibacillus, Virgibacillus, Gracilibacillus, and Bacillus genera. Spores are non-active cells that exhibit resistance to various environmental factors, but become active when environmental conditions are suitable for them. In addition, almost all halophilic and halotolerant bacteria produce compatible solutes such as ectoin for control osmotic presser. One part of bacteria, living in Arctic, uses these strategies to resist many stresses in Arctic. Moreover, some isolates have high sequence similarities of 16S rRNA gene with strains from the desert sand in China (100% identical, near full length), the source of the so-called "yellow dust". Previous research indicated that yellow dust had been transported to Greenland by the wind. Our research implies the tropospheric transportation of these microorganisms to locations such as the Arctic.

Rik Van Bogaert
European aspen in a warming sub-Arctic—competitive interaction between aspen and birch moderated by invertebrate and vertebrate herbivores and climate warming

Rik Van Bogaert, Christer Jonasson, Morgan De Dapper, and Terry V Callaghan

In northernmost Europe, thermophilic aspen (*Populus tremula*) usually occurs as infrequent clonal stands in the extensive mountain birch forests (*Betula pubescens* ssp. *czerepanovii*). In the Torneträsk area of sub-Arctic Sweden, aspen has increased in abundance over the last century and its treeline (limit of individuals taller than 2m) has moved more than

30 km to the northwest. Increasing summer temperatures since the 20th century likely caused this shift as indicated by the positive correlation between summer temperature and both aspen seed set ($r = 0.92$, $p = 0.11$) and sucker production ($r = 0.57$, $p < 0.01$).

Repeat photography of an aspen stand for the last thirty years showed, however, surprising homeostasis despite summer warming of 0.8°C since 1988. Although aspen had 45% higher growth rates and 7 times higher recruitment numbers than birch, no range expansion was observed because of browsing by moose (*Alces alces*). Herbivory of birch also occurred but by the invertebrate autumnal moth *Epirrita autumnata.* A 100-year old birch individual has experienced on average 9.0 years of reduced growth due to moth herbivory, whereas an equally aged aspen only showed 1.0 years of growth reduction due to the invertebrate. Moreover, these insect outbreaks were found to stimulate clonal recruitment in aspen ($r = 0.41$, $p = 0.03$).

Future community development in a warmer climate is likely to result from an interaction between the number of moose (and other browsers) compared with the number of aspen recruits, while major insect herbivore outbreaks on birch facilitate the spread of aspen by reducing competition.

Qi Zhao

A primary photosynthetic study on polar plants

The ultrastructure of plants from the polar region and Russian was observed. The results showed there were big starch granules in chloroplasts of most plants, which was the adaptive characteristic to the extreme environment; the thylakoid membrane of Oxyria digyna and Medulla junci were a bit damaged, but their physiological status was good. Secondly, the results of physiological measurement of arctic plants showed their configurations were all adaptive to the extreme environment; it appeared obvious differences by measuring their chlorophyll content in whole day, the highest chlorophyll content of Silene acaulis and Deshampsia alpine were in the evening or at night, but the highest chlorophyll content of other arctic plants were in the noon. Thirdly, more photosynthetic characteristic of plants were found by measuring chlorophyll fluorescence. RLC curve showed the photosynthetic rate of Deshampsia Antarctic was the highest, the photosynthetic rate of D. Russian was the lowest; which means the photosynthetic ability of photosystem II; qP showed the photosynthetic activity of Saxifrage hieracifolia is the highest, while S. polaris is the lowest; qN showed the polar plants were more adaptive to intense light than Poa pratensis, but I. acaulis and D. alpine were less adaptive to intense light than any other arctic plants. Finally, the analysis of homology on rbcl gene showed the genetic relationship among the gramineous plants: the genetic relationship between poa pratensis and other plants were more farther, the homology between Deshampsia alpine and Deshampsia Antarctic was 85.37%, while Deshampsia alpine and Deshampsia Russian was mere 42.16%.

David Hik

Ecosystem and plant community responses to climate change: do biotic interactions matter

Koh, Saewan, Alex Jarosch, Ryan Danby, Scott Williamson, Garry Clarke and David S. Hik

A rapid shift in Arctic and alpine plant community distribution, composition and structure is likely as species respond to climate change. In northern alpine tundra ecosystems, like those found in the southwest Yukon, Canada, these movements may have significant impacts on biodiversity and habitat quality as suitable areas diminish in size at higher elevations. Bioclimatic envelope models generated by current species-climate relationships are frequently used to predict changes in species distributions in response to climate change. We used Nonparametric Multiplicative Regression Modeling to determine the relationship between climate and alpine tundra vegetation in Kluane, Yukon. The climate model was produced using the North American Regional Reanalysis downscaled from 32 km grids to 30-100 m to spatially match the ecosystem models. For precipitation, we relied on a linear model of orographic precipitation modified to track air mass and dynamically calculate nucleation and fallout timescales. Our temperature downscale calculated free-air and inversion lapse rates to adjust mid-tropospheric temperature to ground-level. Other variables in our model included solar radiation, snow-free days and topography. Recently bioclimatic models have been criticized because they fail to incorporate biotic interactions. In response we integrated multiple vegetation species/functional group layers, competition and transition rules into a spatial modeling platform to project regional vegetation distributions with and without interspecific interactions. Competition and transitions rules between species/plant functional types were developed by analyzing fine-scale spatial interactions from a 12-year Open Top Chamber experiment within the study area. Differences in species distribution between bioclimatic envelope modeling alone and with inter-specific interactions will be discussed.

Isla Myers-Smith
How will increasing shrubs alter tundra ecosystem function?

Myers-Smith, Isla H. and David S. Hik

With a warming climate, arctic ecosystems will experience shifting boundaries such as the spread of tall shrubs into tundra communities. Rapid shrub expansion has been documented in arctic Alaska and north-western Canada using repeat aerial photography, and satellite imagery. Increasing shrubs could alter the soil thermal regime and reflectance of the tundra ecosystem. In the winter, snow trapping can insulate soils, and has been proposed as a positive feedback mechanism for promoting the expansion of shrubs in the arctic. Results from our experimental manipulations in the south-western Yukon indicated that, during the growing season, the shrub canopy shades the ground surface, and in winter, snow trapping insulates the soil. These data suggest that cooler summer soils will offset enhanced nutrient cycling from warmer winter conditions. With an increasing canopy height and expansion of shrubs, albedo is likely to decline, thus generating a positive feedback to climate warming. Our results indicate that reflectance is greatest in tundra plots in the early growing season before leaf out and at in the autumn after the first snow fall. However, in the middle of the summer when the willows are fully leaved, reflectance is higher in shrub plots, suggesting that the change in albedo after shrub invasion may be less than previously projected. The results from this field study, when synthesized with other work from around the arctic, can be used to estimate the influence of increasing tundra shrub cover to regional and global climate.

Stef Bokhorst
Will winter warming counter the effects of summer warming in the sub-Arctic?

Stef Bokhorst, Jarle Bjerke, Hans Tømmervik, Jerry Mellilo, Terry Callaghan and Gareth Phoenix

The Arctic is experiencing considerable change in climate with greatest change occurring in winter and a greater frequency of extreme climate events. Especially climatic events that influence the snow pack such as rain on snow events or extreme winter warming leading to complete snow melt are of concern for sub-Arctic communities. The potential for damage to vegetation is considerable given loss of snow cover exposes plants to sub-zero ambient temperatures and large temperature fluctuations and may also lead to damage by winter desiccation, repeated freeze-thaw cycles and abrasion by windblown ice particles before the system is covered with fresh snow. Here we report findings from both observational and experimental studies to show that short-lived (<10 days) winter warming events can cause major damage to sub-Arctic plant communities at landscape scales.
With a unique experimental winter warming facility near the Abisko Research Station (Sweden), we simulate extreme winter warming events in a sub-Arctic heathland. After two such events considerable die-back occurred of dominant dwarf shrub species. In the winter of 2007/08 a natural winter warming occurred in northern Scandinavia, resulting in loss of snow cover and therefore exposure of vegetation to firstly warm temperatures and then the returning winter cold. In the following summer, extensive areas of damaged dwarf-shrub vegetation could be observed over 1400 km^2 and was supported by a NDVI reduction of 26% in comparison with the previous summer.
The similarity observed in vegetation die-back between the experimental simulation and after the natural event of extreme winter warming provide compelling evidence that winter warming events can cause considerable damage to sub-Arctic vegetation. With increasing winter temperatures predicted as a result of climate change, such damage may have major consequences for productivity and diversity of these ecosystems, in complete contrast to the greening of parts of the Arctic resulting from summer warming.

Kieran O'Donovan
Adaptive foraging behaviour of the collared pika (Ochotona collaris) and influences on the alpine tundra community in the southwestern Yukon.

O'Donovan, Kieran S. and David S. Hik

Climate models suggest that average global temperatures could rise between 1.4o C and 5.8 o C over the next 100 years, and that these effects will be most extreme in northern mountain regions. Understanding how these arctic and alpine tundra ecosystems will respond to anticipated climate change is an important challenge for ecologists to undertake. Of great interest, and the subject of extensive research, are the potential long-term changes in tundra vegetation resulting from the effects of a changing climate. In order to clarify these effects we must address the interaction between climate, the vegetation community and the herbivores which forage on that community. Collared pikas (Ochotona collaris) live in the alpine environments of Canada's Yukon and Alaska, and have exhibited sensitivity to climate variability. Research on collared pikas in the southwestern Yukon has demonstrated that the resulting grazing pressure from these herbivores directly influences composition and

productivity of the vegetation communities in which they forage. In order to develop predictive models of community response to climate change for this system, we need a more mechanistic understanding of influences on pika foraging behaviour and how they may adapt to variability in forage species availability and quality. We report on the results of an activity-budget based foraging behaviour and resource selection study of collared pikas, and the role of annual and seasonal variation in vegetation community structure and quality.

Zhenlin Yang

Topoclimate model at 50 metres' resolution and its potential applications around Abisko, Swedish Lapland

Zhenlin Yang, Edward Hann and Terry Callaghan

Ecosystem function and structure are scale-dependent: determining surface air-temperature distribution at a scale of tens to hundreds of metres can facilitate geographical research, which is currently hampered by the relative dearth of meteorological stations and complex surface temperature characteristics in mountain areas. Here we provide a novel model of surface air temperature distribution in such regions. As a new methodology, we separate the driving forces of the temperature variation into vertical and horizontal directions.

First, we compare large-scale weather station and gridded climate data in order to define the mesoclimatology around northern Sweden and obtain the vertical temperature lapse rate. Second, combined with temperature measurements obtained from transects set among complex terrain, key microclimatic characteristics of the temperature distribution are identified. Third, the key driving forces operating at different spatial and temporal scales are discriminated and defined as the basis of our final topoclimate model.

Model validation is conducted using fieldwork measurements from different seasons, which enabled our hypotheses about seasonal and diurnal mountain temperature variations to be tested. This includes the considerable moderating influence of Lake Tornetrask on temperature. We present model results of surface air temperature distribution on a 50-m grid for the Abisko region. Our topoclimate model provides a new method of estimating fine-scale temperature distribution in mountain areas.

Such a fine-resolution topoclimate model provides a fundamental framework in which to develop adaptation strategies aimed at proper management and conservation of biodiversity in this region. Ongoing discussions about its potential applications include the mapping of the detailed vegetation dynamics among the mountains, and the provision of potential habitats for the reindeer.

Larisa Frolova

Cladocera assemblages from the surface sediments of Northern Siberia (Russia) lakes and their indicative potential for palaeoclimatic research

Frolova, L., L. Nazarova, L. Pestryakova and U. Herzschuh

The 35 lakes examined in this study are located on the catchment area of Anabar river (Yakutia, Russia, north of the Arctic Circle) along a broad north–south transect. Most of the lakes are relatively shallow (1–7 m) and are characterized by specific thermal and chemical regimes, making them sensitive to recent climate changes. A total of 28 cladoceran taxa were identified, comprising predominantly littoral chydorid taxa. The most common of them were Chydorus spahericus, Eurycercus spp., Alona rectangula, Acroperus harpae, Daphnia pulex agg. Species richness ranged between 5 and 20 averaging at 9, and was not significantly correlated with any of the measured environmental variables. Distributions of the cladoceran taxa, revealed major shifts in abundance in relation to the temperature along the investigated transect. Constrained cluster analysis (CONISS), based on the structure of cladoceran communities, disclosed three groups of lakes. Interestingly, frontiers of these groups, separated along a temperature gradient completely coincided with landscape zoning based on vegetation types (typical tundra, southern tundra, forest-tundra). RDA with forward selection and Monte Carlo permutation tests (999 permutations) identified a minimal subset of four environmental variables (TJuly, water depth, SO42-, Si4+) that explained a significant ($p \leq 0.05$) amount of the variation in species data. RDA axis 1, 2 explained almost all of the relationships between the cladoceran taxa and measured environmental variables (85.8%). Importance of climate dependant physical and chemical factors in structuring cladoceran communities is similar to results obtained from other previously studied regions and suggest the Cladocera may be useful as ecological and palaeoenvironmental indicators for Russian Arctic.

Donald McLennan

The Role of Ecological Integrity Monitoring in Managing Canada's Arctic National Parks in a Changing World

National parks in Canada's arctic and sub-arctic cover an area of 166,000 km2, and are located to protect the range of terrestrial ecological variability from east to west across the Canadian north, and from treeline to

the north pole. The emerging reality of fast paced climate change in Canada's arctic provides the obvious challenges of maintaining park ecological integrity, but also brings into question the whole notion of area based protected areas as a tool for biodiversity conservation. One key to mitigating and adapting to this change is reliable information on how key ecological processes and focal populations are actually responding to ongoing changes in climate, and other ecological stressors such as increasing UV levels and bioaccumulation of long range contaminants. This information can only be derived from well-designed and nationally/internationally coordinated park-based monitoring programs that measure, assess and report key ecological responses to ongoing and future environmental change. In this presentation we outline the Parks Canada climate change strategy, and, in particular, the role of ecological integrity monitoring as a component of the strategy, and address key challenges for developing meaningful assessments that interpret biological change in the context of park ecological integrity objectives. Finally, we discuss how the results of effective monitoring can be used to prioritize management activities, address key opportunities for cooperation to ensure such programs can be feasibly implemented and widely communicated, and discuss the contribution these results will make to understanding change across the circumpolar area.

Alexandre Forest

Three-year assessment of particulate organic carbon fluxes in Amundsen Gulf (Beaufort Sea): Satellite observations and sediment trap measurements

Forest, Alexandre, Makoto Sampei, Ryosuke Makabe, Hiroshi Sasaki, David G. Barber, Yves Gratton, Paul Wassmann and Louis Fortier

As part of the Canadian Arctic Shelf Exchange Study (CASES), we assessed the importance of new production and resuspension in determining the nature and magnitude of the deep (200 m) particulate organic carbon (POC) flux from October 2003 to September 2004 in central Franklin Bay. In spring and summer, phytoplankton production was nutrient limited in the stratified surface layer and the initial spring bloom evolved into a subsurface chlorophyll maximum (SCM) at the nutricline. Large herbivorous calanoid copepods intercepted little of the initial bloom but grazed intensely on the SCM. The phytoplankton and fecal pellet fluxes culminated simultaneously in July-August (24 and 23 mg C m-2 d-1, respectively). The detrital POC flux peaked in September (52 mg C m-2 d-1), coincident with wind-induced resuspension of recently-settled POC. In the fall, detrital POC fluxes increased again to 22 mg C m-2 d-1, following the off-shelf transport of terrigenous POC carried by the Mackenzie River plume and POC resuspended by wind on the shelf. In winter, the relatively weak POC fluxes (2-7 mg C m-2 d-1, detrital at 90%) resulted from the settling down of resuspended sediments. We propose a conceptual model in which the ecosystem of Franklin Bay shifts from an algal to a detrital mode according to seasonal changes in the relative importance of fresh and old POC supplies. Based on this model, the ecosystem of southeastern Beaufort Sea could evolve towards a less productive equilibrium dominated by sediment resuspension in response to the on-going reduction of the ice cover.

Ingrid Helene Ellingsen

Primary production in a warmer Barents Sea

Ellingsen, Ingrid H. and Dag Slagstad

The Barents Sea physical and biological environment is characterized by large variability on a wide range of scales. Results from a 3D coupled hydrodynamic ice and ecological model show that interannual variability in ice cover and freshwater content is closely linked to variability of ice import from the Arctic Ocean and the Kara Sea. These properties are for instance important for the timing of the phytoplankton spring bloom. An important question is how primary production will change temporally and spatially in a warmer Barents Sea. The mean air temperature in the Arctic has increased by 2-4 °C during the last decades resulting in markedly longer summers. By the end of this century, an additional increase of 4-5°C has been projected. We have forced a model with modified atmospheric input from the ERA40 (ECMWF). The ERA40 air temperature is increased by 1 °C at 60 °N and further gradually increased, resulting in a temperature raise by 4 or 8 °C at the North Pole for two different cases, respectively. We will present results from these two scenarios with a focus on temporal and spatial changes in the primary production in the Barents Sea.

Martin Emil Blicher

Does sea ice cover affect the annual production of marine macrobenthos through bottom-up processes?

Blicher, Martin E., Mikael K. Sejr and Søren Rysgaard

The marine ecosystem off Greenland is expected to undergo dramatic changes in ecological structures in response to ongoing climate change, but due to the lack of ecological baseline studies in the past we need to look for alternative methods to study the effect of

climate variation on a long-term scale. One of the primary indicators of a general warming in the Arctic is a reduction in the seasonal sea ice cover. Sea ice has the potential to control the level of primary production by preventing light from reaching the water column. This process could potentially affect the next trophic level, e.g. benthic herbivores. Hence, we studied annual growth increments in the skeleton of sea urchins and bivalves in Greenland to: 1) estimate geographical variation in general growth patterns along a gradient of seasonal sea ice cover (64 to 77°N), and 2) estimate inter-annual variation in growth. Satellite data were used to extract estimates of seasonal sea ice cover. Our results showed that the growth performances of sea urchins and bivalves are reduced along a gradient from the sub-Arctic to the high-Arctic. We suggest that this pattern is linked to sea ice through its effect on primary production. This suggestion is supported by the fact that inter-annual variation in growth of bivalves in high-Arctic areas, where the effect of sea ice on primary production is supposed to be most pronounced, correlated significantly to year-to-year variation in sea ice cover. Thus, we expect Arctic benthos to increase production in concurrence with future reductions in sea ice cover.

Kenneth Drinkwater
Ecosystems responses to recent climate variability: Comparison of 4 Northern Hemisphere regions

Drinkwater, Ken, Franz Mueter, Kevin Friedland, Jon Hare, George Hunt, Webjørn Melle and Maureen Taylor

Results of comparative studies examining the ecosystem responses to recent climate changes in 4 high latitude regions of the Northern Hemisphere are presented. The regions include two in the Pacific (Bering Sea and Gulf of Alaska) and two in the Atlantic (Georges Bank/Gulf of Maine and the Barents/Norwegian Seas). Air temperature, heat fluxes and wind forcing over the four regions are examined their effects on the physical oceanography of the regions are compared and contrasted, including changes in ocean temperatures, salinities, stratification, and circulation. The relative roles of advection and air-sea fluxes in controlling the physical variability will also be discussed. In addition, changes in seasonal sea ice cover are compared between those regions where it occurs. The responses of phytoplankton and zooplankton to the physical changes are then discussed. Phytoplankton production is found to increase with increasing temperature in the Bering Sea, Barents Sea and the Gulf of Maine regions but not in the Gulf of Alaska or Norwegian Sea. The responses of the higher trophic levels include distributional shifts and changes in production, which are species dependent. Evidence of both bottom-up and top-down control is provided. The implication of these results for developing ecosystem responses to future climate scenarios is also discussed.

Chie Sato
Pilot study of marine planktonic archaeal distribution in the Arctic Ocean

Sato, Chie, Motoo Utsumi, Yukiko Kuroki and Masao Uchida

Ongoing Arctic warming is already melting ice, including sea-ice thinning and retreat and also enhanced melting would induce significantly ecological influences on microbial communities, especially in the shelf environment. In summer 2008, the Arctic Ocean cruise by R/V MIRAI (MR08-04) was done in the Chukchi Sea, Canada Basin and Makarov Basin. In this cruise, we collected water samples using CTD from 29 stations to investigate the distributions of bacterial population density in the water column and compare the differences of bacterial population composition by sea area. We used Catalyzed Reporter Deposition Fluorescence in situ hybridization (CARD-FISH) technique targeting archaeal and eubacterial rRNA for identifying and enumerating marine microbial cells. This approach was enhanced for the sensitivity seawater samples, allowing easy identification and enumeration of bacterioplanktonic cells. After that, we could calculate the amount of archaeal carbon biomass in the Arctic Ocean carbon cycle. These microbial and ecological data will give a useful knowledge to understand ecological influence in recent changing Arctic Ocean. The details of this study will be presented in the conference.

Kathrine Michalsen
The Barents Sea Ecosystem survey: in a historic perspective

Michalsen, Kathrine, Dimitry D. Prozokevich, Edda Johannesen, Knut Sunnanå, Thomas de lange Wenneck, Jan Erik Stiansen, Anne Berit Skiftesvik and Erik Olsen

The Barents Sea has been influenced by human activity in many decades, historically mainly involving fishing and hunting of marine mammals. More recently, transportation of goods, oil and gas industry, tourism and aquaculture have amplified in this area. The increase in activity makes it important to monitor the whole ecosystem, not only the commercially important species. Knowledge and understanding of structure and function of the

ecosystem has evolved from relying purely on catch statistics, through separate surveys for different species, up to today's combined ecosystem survey. Today this survey encompasses various surveys that previously have been carried out jointly or at national basis. Instead of covering more or less the same area 3-4 times, all these investigations are now conducted simultaneously. The survey has grown to encompass investigations on hydrography, phytoplankton, zooplankton, benthos, marine mammals, seabirds and pollution. In this way the survey is now a true 'ecosystem survey' covering all components of ecosystem. This survey is a continuation of a longstanding cooperation between Norway and Russia on monitoring and research in the Barents Sea. Given the increased ecological awareness and international focus on ecological questions, the ecosystem survey is a first large-scale practical implementation of ecosystem-based monitoring and research in the region. A survey of this magnitude in terms of ship-time, personnel, number of different investigations etc. poses large logistical challenges, but the data collected gives a lot of opportunities for interesting and valuable studies/interactions.

Elizabeth Logerwell

Beaufort Sea Survey 2008: Geographic and Historical Comparisions

Logerwell, Elizabeth A. and Kimberly Rand

During August 2008 the first survey of marine fishes in offshore waters of the Beaufort Sea since 1977 was conducted. The primary objective was to establish a baseline against which the effects of oil and gas development and climate change could be measured. The F/V Ocean Explorer was chartered for the survey. Benthic fish and invertebrate species composition, distribution and abundance were assessed with bottom trawls. Pelagic fish were surveyed with hydroacoustics and mid-water net tows. The distribution of zooplankton was sampled with bongo nets. Physical oceanographic data were collected with conductivity-temperature-depth instruments. Data on the distribution of seabirds and marine mammals were also collected. Fish made up 6% of the bottom trawl catch, and invertebrates made up the remaining 94%. A total of 38 species of fish and 174 species of invertebrates were identified at sea. The four most abundant fish species were Arctic cod, eelpouts, Bering flounder and walleye pollock. The most abundant invertebrates were brittle stars, opilio snow crab, a mollusk (Musculus niger) and a seastar (Ctenodiscus crispatus). The pelagic community was dominated by arctic cod and jellyfish. The results of this survey will be put into the context of current surveys in the Bering and Chukchi Seas and past surveys of the Beaufort Sea. The results suggest that climate change has resulted in northward expansion of some species' ranges, including commercially valuable species such as pollock and Pacific cod.

Kathrine Michalsen

The Barents Sea Ecosystem Survey: Climate impacts on pelagic species distribution and interactions

Ingvaldsen, R., M. Skern-Mauritzen, P. Dalpadado, H. Gjøsæter, E. Johannesen, T. Knutsen, P. Fauchald, E. Orlova, D. Prozorkevitch and A. Trofimov

The ocean climate has impacts on the distribution of marine species both directly through shifting the water masses, and indirectly through changing the prey and predator fields. Using data from the Barents Sea Ecosystem Survey in the years 2003-2007, we have studied how ocean climate structure the pelagic ecosystem in the Barents Sea. Furthermore, we have conducted detailed process studies on how ocean climate influences distribution of the key species capelin, and how the capelin distribution in turn determines the distribution of its prey and predators. Thus we track the impact of ocean temperature through the pelagic food web linking temperature, zooplankton, capelin, cod, marine mammals and sea birds. In recent years the Barents Sea has experienced a pronounced warming and all the years 2004-2007 have had higher annual mean temperatures than ever observed in the 1900 century. This makes the period 2003-2007 highly suitable for investigating impacts of present changes in the pelagic ecosystem. The results demonstrate that the pelagic species can be divided into southern Atlantic, frontal and northern Arctic species groups, where few species, such as the baleen whales, occur throughout the system. The observed temperature increase has induced a shift of the highest concentrations of capelin, and the distribution area has increased. This influences the distribution of baleen whales and seabirds, which forage along the capelin migration front competing with capelin for zooplankton. The presented results are crucial both for estimating future changes in the ecosystem and for an early detection of the climate induced changes.

Kim Jochum

Does the polar bear's behaviour change in relation to short-term sea ice shortage? Lessons from Data-Mining for animals with a socially complex community structure

Jochum, Kim and Falk Huettmann

In Churchill, Manitoba (Canada) polar bear (Ursus maritimus) research takes place since over three decades but free ranging behaviour studies are still rare for this species world-wide due to the polar bear's inaccessibility in the wild and limited observational possibilities. A new approach in analyzing behaviour data using latest Data-Mining techniques makes it possible to gain usable signals and results even from constrained and marginal behaviour data. In this study, social behaviour data on the Western Hudson Bay polar bear population was collected during fall 2006, 2007 and 2008 and thus represents the first and consistent three year study on metrics of social behaviour of Ursus maritimus in the wild. A second two year social behaviour study (1977, 1978) on the same population exists and will be consulted to assess how bear behaviour metrics relate to sea ice and climatic changes. Using 5 years of social behaviour metrics, we are able to obtain reliable information (i) whether social behaviour changes are detectable in a three-year period, possibly triggered through sea ice shortage following early break up and late freeze up pattern, and (ii) whether social behaviour change does occur and show adjustments during 30 years of time. Behaviour data can reveal as important information as ecological studies can when applied thoroughly and carefully interpreted. Combining available ecological long-term data with what is probably the only existing 'long-term' behaviour data time series could be crucial for defining the best possible polar bear management strategies for the near future.

Cecilie Kvamme

NEA cod in the Barents Sea: the relationship between sea temperature, cod distribution and trawl fisheries

Geir Odd Johansen, Jan Erik Stiansen, Trond Westgård and Bjørn Ådlandsvik

The distributions of many fish stocks are influenced by sea temperature. In this work the relationship between sea temperature and cod distribution in the Barents Sea, and the subsequent influence on cod trawl fisheries, are studied. The increasing average temperature related to climate change will likely reach beyond levels earlier observed, particularly in the Arctic regions. The potential effects of this include distribution shifts of marine biota and altered ecosystem functioning. Investigations into the effects of future climate change on marine ecosystems therefore pose new challenges in handling diverse data describing different components and processes of the ecosystem, spanning from physical conditions, through the trophic levels, to human activity. In the present work a spatial database capable of storing and structuring data of highly diverse origin, scale and distribution (in this case sea temperature data, cod distribution data from research surveys and catch log book data) is used to analyze relationships between data across the different levels in an ecosystem. The data are stored in an equal area grid in a spatial database developed under the FishExChange project. Three parameters were considered: sea temperature; Northeast Arctic cod (*Gadus morhua* L.) trawl survey data from research vessels (i.e. abundance of cod in the sea); and cod catch data from the Norwegian commercial trawl fisheries (i.e. amount of cod fished). The aim was to analyze the influence of temperature variation on cod distribution and the subsequent effects on spatial distribution of the cod trawl fisheries.

Peter Glazov

The Waterfowl Population Status on the Kolguev Island

Since 2006 till 2008 we carry out monitoring of waterfowl population on the Kolguev island. Waterfowls make a basis of the bird's population on the island and they are the one of the main indicators of ecosystem status. We prepared plots and routes in different landscapes. We estimated density, current status and numbers of nesting waterfowls on the island. Three species of geese nest on the island: White-fronted goose (Anser albifrons), Bean goose (Anser fabalis) and Barnacle goose (Branta leucopsis). White-fronted goose nests on the whole island and it's density of nesting is from 8 to 83 nest/km2. Nearly 150-250 thousand pairs nest on island by the preliminary estimation. During the spring period up to 400-600 thousand white-fronted geese uses territory of the island (approximately 30-40% from the European population). The greatest density of nesting Bean goose is marked in the central drained sites of the island. Some colonies of Barnacle goose are located on island. A colony in Peschanka delta can be considered as the largest at present in the world. More than 45 thousand pairs nest here. We estimated goose harvesting by local people. The result of our work was giving recommendations on protection and using of waterfowl resources. Our investigations were carried out under the Russian program IPY and "ECORA" project.

Jan Erik Stiansen/Geir Odd Johansen

Fish stocks distribution in the future: presenting the projects FishExChange and NorExChange

Stiansen, Jan Erik, Cecilie Kvamme, Bjørn Ådlandsvik, Geir Odd Johannessen, Rögnvaldur Hannesson, Bogi Hansen and Asta Gudmundsdottir

The projects will evaluate effect of future climate change on fish stocks in the Barents Sea and the Nordic Seas. Development of an ecosystem database is a key issue for both projects, and gathers available spatial data in an equal-area grid, which enables easy accesses cross-ecosystem-component analyses. FishExChange Focuses on how climate changes will influence fish stocks and their commercial stakeholders. Changes in fish distribution will not only affect the fisheries directly through changes in possible fishing areas yield because of changes in stock production, but also indirectly through changes in national quotas related to how stocks are shared between international stakeholders. The main sub-goals are: • Produce best possible scenario of the Arctic climate • Produce best possible distribution maps of the economical important fish stocks for the different climate scenarios. • Produce maps showing annual seasonal distributions of the fisheries • Investigate how these findings historically have influenced the fisheries and to assess the socioeconomic implications in the future. NorExChange A Nordic expantion of the Norwegian national project FishExChange. This component will investigate the effect of future cliamte change on distribution, growt and migration of pelagic stocks in the Atlantic part of the Nordic Seas, which is not or only partial covered by FishExChange. The key species is herring, blue whiting, saithe and mackerell, species that in the last warm years already are estabilished in the western and southern Barents Sea, or is expected to move in during future warming. The results will feed back into the sosioeconomic concequencies evaluations that will be performed in FishExChange.

Charlotte Moshøj

Temporal and spatial variations in wildlife population fluctuations in Greenland; The effect of climate, environment and man

Moshøj, C.M, M.C.Forchhammer and V.E. Forbes

Temporal and spatial variations in wildlife population fluctuations in Greenland; The effect of climate, environment and man: The underlying factors of species fluctuating population dynamics has been the dominant focus of attention in population ecology throughout much of this century. In arctic regions where a severe climate with high seasonal and annual variability and simplistic ecosystems prevail, species of fish, birds and mammals display distinct population fluctuations of varying temporal and spatial scale. In Greenland, historical records, archaeological findings and oral accounts passed on from Inuit elders all document that the presence of wildlife species and their population sizes have undergone pronounced fluctuations throughout recordable historical time. The most detailed accounts are found for the species that were harvested or had economical value. While several recent studies from northern latitudes have shown the relative roles of climate, the exogenous and endogenous environment of species and man as factors driving species population dynamics, the relative contributions and potential interactions among these factors remains unsolved. In Greenland, these fluctuations in the harvests of individual species are believed to be related to changes in climate, as well as variations in hunting pressure. Dating back 200 years, these hunting records therefore represent a unique time series for retrospective modelling of annual and decadal fluctuations in relation to long-term climatic data, environmental factors and temporal variations in social and demographic parameters in the existing society. The results of this study will model future predictions of wildlife populations under changing climate variables and human hunting pressure.

Alastair Jenkins

Entropy Production, Polar Ecology and Economics

Polar regions have been the subject of human economic activity by outside actors for several hundred years. Such activity includes transportation, whaling, fishing, sealing, fur trapping, and the extraction of coal, hydrocarbons, and other mineral resources. It has had a substantial effect on the local ecology, and on the economic systems and environment of the countries and regions involved. To quantify the local and global effects of such activity, it would be advantageous to implment a suitable coupled numerical climatic-biological-economic model. However, the large number of parameters and variables which are involved in such a model, and the difficulty in directly estimating model parameters, particularly for earlier historical periods, makes its implementation extremely difficult or impossible, and the model dynamics may be unstable or very sensitive to uncertainties in the parameters. Nevertheless, some general principles may be used to constrain such complex system behaviour, including ideas from thermodynamics and statistical mechanics. An isolated system in thermodynamic equilibrium will tend to a state of maximum entropy, subject to constraints involving the total energy, chemical composition, etc. An open coupled climate-

biological-economic system is, however in a non-equilibrium state, which favours a condition of maximum entropy production, subject, again, to appropriate constraints. Entropy production corresponds largely with energy consumption, particularly when we consider today's society, based on abundant fossil fuel supplies. A sketch is given of how these theoretical ideas may be applied to polar economic activities and their ecological consequences.

Session 5
Indigenous Cultures—Past to Future

Steven Baryluk, Lawrence Amos
Inuvialuit Observations of Climate Change and Adaptation Strategies

The Inuvialuit people of Canada's Western Arctic are the proverbial "canaries in the coal mine" when it comes to climate change. The Beaufort Delta region is expected to experience the highest levels of temperature increase in the world due to climate change – with predictions for warming as high as +6oC. This puts the Inuvialuit in a unique position of experiencing the greatest extent of change. In fact, observations of climatic changes are already being seen and recorded around the Inuvialuit Settlement Region. The Inuvialuit were the first Inuit group in the world to communicate their concerns about climate change with the now historic "Sachs Harbour Study" that was reported to the IPCC COP 6 (The Hague, 2000) and included the production of a video that was also debuted there. Traditional Knowledge is showing that there are significant changes to the sea ice in the Beaufort , less predictable weather patterns , impacts on navigation abilities and the practice of traditional activities, and on housing and infrastucture. The Inuvialuit have, and will continue to support research into climate change in their settlement region and have started to utilize various strategies for coping with these observed changes in order to maintain aspects of their traditions as well as survive in a changed arctic world.

Winfried Dallmann
Monitoring of Development of Indigenous Land Use Areas in the Nenets Autonoums Okrug, NW' Russia

Dallmann, Winfried and Vladislav Peskov

An ongoing IPY-endorsed project is presented and preliminary results are shown. The project is a cooperative project of the Norwegian Polar Institute and the Association of Nenets People "Yasavey". It has been developed out of the need of the indigenous population of the Nenets A.O. for an overview of the recent changes in the tundra. Comprehensive monitoring through regional authorities is not easily available to the public, while the situation changes quickly. A continually maintained map database, available to all relevant groups, would be an indispensable tool to track development. While a number of environmental projects are run by other institutions, none of them describes quantitatively the amount and geographical distribution of physical devaluation of the tundra. The principal objective of this project is to provide a tool for the indigenous population of the area to assess land use issues. A major source of data for the project is a questionnaire campaign directed towards traditional land users, mainly reindeer herders. Topics are all spheres of their living, their traditional occupations, and socio-economic situation. Satelllite images are used to monitor visual, physical damage of the tundra. These data are combined with relevant, publicly available data in a GIS database. The database is developed in the ArcGIS programme, but will finally be transferred to a GoogleEarth-based system, which does not require special skills or expensive software for the users. A version without sensitive and private data will be made available through the Internet.

Deanna Kingston
"Down at East End, our people were closer": Spatial Proximity as an Important Element of Community Cohesion After Relocation

The relocation and displacement of indigenous peoples due to western colonization and natural disasters is common throughout the world, generally causing detrimental effects on cultural cohesion, maintenance of tradition, and physical and psychological health. This article examines the special case of the King Island Native Community for whom displacement and relocation happened not just once, but twice in 20 years. The first was a gradual relocation from their island home in the Bering Strait to a shanty town east of Nome in the mid-20th century. The second relocation in 1974 was sudden - due to a storm surge that destroyed their homes at East End. Interestingly, while outsiders might predict that leaving of their island home was worse than moving into Nome proper, King Islanders instead remember East End as a place of community closeness and cohesion. This article examines those factors that King Islanders feel are important to their sense of community. For King Islanders, physical proximity promotes a sense of closeness that is experienced and mourned as a great loss after close physical proximity is no longer possible. This loss of physical closeness is also blamed for some of the social stresses that King Islanders experience today. In order to mitigate social disruption, we argue that policy makers should pay attention to what communities say are important elements of their "community", especially since climate change may cause displacement and relocation of many communities in Alaska, and in the world.

Elizabeth Marino

(Re)Locating Home: Contemporary Environmental Relocations in the Alaskan North

Increasingly over the past four decades, Northwestern Alaskan residents have been threatened with severe erosion and flooding due to a changing climate. Today at least four rural Inupiat villages and one rural Koyukon Athabaskan village are thought to have less than fifteen years before flooding makes permanent residence in the current village locations impossible, leading to the necessary relocation of residents. Throughout negotiations with and lobbying efforts to state and federal lawmakers, village representatives have tried to make the case for recreating small, discrete communities in areas near current village sites instead of relocating residents to larger regional 'hubs'. This paper analyzes the processes of rationalizing, essentializing, and politicizing place, culture, and lifestyle before lawmakers in order to justify the expense of recreating a rural village. We will give brief accounts of historical relocations for a perspective on state/tribe interactions during prior relocations, while focusing on current discourses between and interviews with local residents and representatives from governmental institutions. Drawing on anthropological theories of disaster and case studies of forced migration, we look critically at how extreme events bring fundamental aspects of both the state and the local into focus, and why defending the 'rural' and the 'local' can become complex, emotional, and problematic.

Joan Nymand Larsen

Human Development in the Arctic: Devising a set of indicators to track change

Arctic Social Indicators (ASI) is an IPY project that seeks to devise a set of indicators that reflect key aspects of human development in the Arctic, that are tractable in terms of measurement, and that can be monitored over time at a reasonable cost in terms of labour and material resources. The project has developed indicators within six domains that reflect aspects of human development that seem particularly prominent in the Arctic: (1) Fate control and or the ability to guide one's own destiny; (2) Cultural integrity or belonging to a viable local culture; (3) Contact with nature or interacting closely with the natural world; (4) Material Well-being; (5) Education; (6) Health & Demography. The presentation will provide an overview of the purpose, method and findings of the ASI project, including its recommendations for a final set of indicators to track human development in the Arctic, and an ASI monitoring system for the future. The presentation will place particular emphasis on the relevance of ASI for indigenous inhabitants of the Arctic.

Raila Salokangas

The Meaning of Education for Inuvialuit Youth and Families

Rapid ecological, economic, and social changes continue to take place in the Northwest Territories, Canada. Education is one of the major links to understanding the changes that impact Aboriginal family life. This case study explored how the meaning of education has changed for the Inuvialuit in the past 80 years. The study was conducted in the Inuvialuit community of Tuktoyaktuk in 2007 and 2008. The qualitative data sources included community participation field notes from three months field work, transcripts from a youth focus group, as well as interviews with key informants and diverse multigenerational families. The study found that the meaning of education has changed from "learning the Inuvialuk way of life" in the 1930s; to "best of both worlds" in the 1980s; to "becoming whatever I want" in 2000. In early 1900s attending school for a few years was beneficial for the Inuvialuit to be better adapted to the changing economy. Now students want to graduate from high school in order to a good job; continue education; have more options; and go beyond the small remote community.

Vyacheslav Shadrin

Ethnic culture of forest yukaghirs: problems of safety and adaptation in conditions of globalization

Forest yukaghirs (the self-name is odul) - an ethnic group of yukaghirs, living in a taiga zone of river Kolyma. Now live in Republic Sakha (Yakutia) and the Magadan area of the Russian Federation. Number is nearby 400 people(2002). During long ethnocultural communications with neighbour peoples Yukaghir culture have interwined together many elements of other cultures with its ancient traditions. The situation with safety of ethnic culture has sharply worsened, which major factors of steel: 1. Strengthening natural assimilation processes; 2. Destruction of the Soviet system of managing and support of an agriculture; 3. Transition to market system of managing; 4. Development of uniform information space and strengthening of information influence on youth; 5. Climatic changes as a result of global warming. Thus, the modern ethnic culture of forest yukaghirs consists their three components: 1. Relic, presented, basically, in museums, archives and individual persons of 75 years are more senior. Unfortunately, this part of culture does not function any more and is completely superseded from a life. 2. Exhibition, based on the phenomenon of secondary life on the basis of revival traditions, which can be met at school, at exhibitions, concerts, the festivals,

the revived national holidays. A basis of functioning of this culture there are internal factor of increasing of ethnic consciousness and external factors: interest of researchers, carrying out of various actions, attention of authorities of various levels, etc. 3. Traditional-economic culture, which functions only in spheres of traditional wildlife management, transformed and adapted for modern conditions.

Zoe Todd

The Impact of Participation in the Wage Economy on Traditional Harvesting, Dietary Patterns and Social Networks in the Inuvialuit Settlement Region

During the environmental assessment of the proposed Mackenzie Gas Project, Joint Review Panel members and others highlighted a lack of contemporary evidence-based research about the effect of the wage economy on Inuvialuit land-based activities including hunting, trapping, and fishing. This research aims to address this gap by studying how employment impacts harvesting activity (time spent on the land), as well as qualitative changes in the structure and use of time and the social networks and sharing arrangements associated with time on the land. The study aims to identify implications for managing the impacts of the proposed Mackenzie Gas Project and potential mineral extraction near Paulatuk, and suggest variables for consideration in a related health study. The study results will be useful for addressing gaps in knowledge about the impact of the wage economy on land-based livelihood activities in the region. Ten weeks were spent in the field in spring & summer of 2008 (April 1-May 15 and June 13-July 4); twenty in-depth interviews were conducted in Paulatuk. Food (in)security emerged as a timely and important theme and was supported by community partners. A food security workshop, developed in consultation with community partners, will take place in March 2009 to explore this component of the project. The presentation will report on the results of research carried out during the last year.

Session 6
Coastal Environments as a link between Land and Sea in the Arctic

Janet Rethemeyer
Carbon cycling and export from permafrost soils into the Kongsfjorden, Ny-Alesund: a lipid biomarker-based study

Rethemeyer, Janet and Gesine Mollenhauer

Soils of high latitudes are a large organic carbon (OC) reservoir that is linked with the Arctic Ocean through the export of dissolved and particulate OC transported by fluvial discharge. The Arctic carbon cycle and the transfer of soil-derived organic matter into marine settings will significantly change in the future due to rising global temperatures. Beside quantitative changes, radiocarbon-based studies of terrestrial organic compounds in Arctic rivers suggest compositional changes and mobilization/export of old, more refractory OC that potentially derive from greater soil depths. In order to better understand terrestrial OC dynamics and transport pathways, we study organic matter composition along a continental-marine transect in the Bayelva catchment area near Ny-Ålesund, Svalbard. Within the framework of AWIPEV project KOP 115, we analyze the distribution of several lipid biomarkers for terrestrial plants and microbial communities, e.g. long-chain fatty acids, n-alkanes, and tetraether lipids, extracted from different soil depths of the active layer, from fluvial sediments, and surface sediments from the Kongsfjorden. We will present data on biomarker assemblages from the sampled locations of the transport transect. First results indicate large differences in soil organic matter composition at different soil depths and in parts with different cryogenic structures. Relative abundances of diagnostic biomarker groups will used to characterize OC mobilization from Svalbard soils.

Anna Urban
Palsas on Kurungnakh-Sise Island, the Lena river delta

The Delta Lena region occupies the northeastern part of Russia. The surface morphology in the area is strongly controlled by permafrost and related processes, particularly frost heaving. One of frost heave manifestations is a frost mound of palsa type. Geocryological conditions in the area are poorly known. Frost heave investigations initiated recently are important for understanding mechanisms for the formation of heave-related landforms, as well as associated permafrost characteristics, such as ground ice distribution, upper permafrost temperatures, and active layer dynamics.

Antonina Chetverova
Hydrochemical characteristics of Arctic Rivers in West Siberia. Characteristic of dissolved matter run-off

Chetverova, Antonina A. and Tatjana M. Potapova

The northern part of West Siberia is the region of oil and gas recovery. However, this region is not well investigated. The problem has become on the second part of 20 century, when hydrochemical regime of rivers was changed and fishery was lost. Deficit of oxygen is causes this problem. The Pur, the Taz, the Nadim and the Poluy are main rivers in Arctic zone of the West Siberia. For analyze of an anthropogenic loading two periods were chosen for study. The first is a period of natural background - before of oil and gas output (1950-1973 years), the second - period of industrial exploration (1970 – 1992 years). So, in all rivers increase of mineralization for about15-20% on account of increase of concentrations of a natrium and chlorine ions were available. Acidification of river's water can be recognized as a human impact on marsh ecosystems of rivers catchments. Decrease of oxygen concentrations was available in an ice-covered period. It is a cause of additional charge of oxygen for oxidation of technogenic organic matter. Heavy increase of concentration of oil-products was available. Smoothed within-year variability of biogenic element's concentrations shows a low biological productivity in the north conditions. Comparison River's dissolved matter run-off in two different periods allows giving regularities of increase of dissolved mineral and organic matter run-off, and showed that dissolved mineral matter run-off depend up to dryness of year, and dissolved organic matter run-off depend up to concentration.

Karen Frey
Impacts of terrestrial permafrost degradation on biogeochemical fluxes to the Arctic Ocean

Over the next century, near-surface permafrost across the circumpolar Arctic is expected to degrade significantly, particularly for land areas south of 70°N. This is likely to cause widespread impacts on the riverine delivery of organic matter, inorganic nutrients, and major ions to the Arctic Ocean. These interacting processes can be highly complex and undoubtedly exhibit spatial and temporal variability associated with current permafrost conditions, sensitivity to permafrost thaw, mode of permafrost degradation, and/or environmental characteristics of watersheds. Here, measurements of biogeochemical

constituents from nearly 100 streams and rivers across West Siberia are presented, a region that contains the world's largest stores of peat carbon, exports massive volumes of freshwater to the Arctic Ocean, and is warming faster than the Arctic as a whole. These measurements show that cold, permafrost-influenced watersheds release little dissolved organic carbon (DOC), dissolved organic nitrogen (DON) and total dissolved phosphorus (TDP) to streams, regardless of the extent of peatland cover. However, considerably higher concentrations are found in warm, permafrost-free watersheds, rising sharply as a function of peatland cover. This suggests that by the year 2100, impacts of warming and permafrost degradation may cause ~29-53% increases in DOC, DON, and TDP fluxes to the Arctic Ocean. Additionally, measurements of total inorganic solutes (TIS) in permafrost-free watersheds currently exhibit six times higher concentrations than in permafrost-influenced watersheds, suggesting that should permafrost in the region completely disappear, TIS export from the West Siberian region to the Arctic Ocean would increase by ~59%.

Carolyn Wegner
Land-Shelf-Ocean Interaction - Seasonal Sediment Transport Dynamics on the Laptev Sea Shelf (Siberian Arctic)

Wegner, Carolyn, Jens Hoelemann, Igor Dmitrenko, Sergey Kirillov, Heidemarie Kassen and Leonid Timokhov

Models for the next 100 years project an increased input of sediments onto the Arctic shelf seas associated to increased mean annual riverine discharge of 10 to 25% for Arctic rivers, and increased coastal erosion due to increased thawing of coastal permafrost, higher sea levels, and the increased potential for severe coastal storms during the extended open water season. A detailed knowledge of the pathways of SPM and the possible response to climate change is of critical importance to understand and to forecast the impact of environmental changes on the land-shelf-ocean interaction. The Laptev Sea Shelf is one of the largest Siberian shelf seas having several rivers discharge onto the shelf, which transport a substantial load of suspended particulate matter (SPM). Four seafloor observatories equipped with Acoustic Doppler Current Profilers (ADCPs) and Conductivity Temperature Depth meters (CTDs) were deployed on the inner, mid- and outer shelf each for the period of one year (August 1998-September 1999; September 2005-August 2007) to monitor the seasonal variability of SPM concentration. In combination with detailed process studies during summer and winter conditions these unique data sets have given new insights into sediment dynamics on the Laptev Sea shelf and its complex land-shelf-ocean interactions. The data provided the basis for a conceptual model for sediment transport on the Laptev Sea shelf.

Hans-Wolfgang Hubberten
Evolution and current state of sub-sea permafrost and the zone of gas-hydrate stability in rifts on the Arctic shelf of eastern Siberia

Hubberten, H.-W, P.P. Overdui,, H. Lantuit, N. Romanovskii, and M. Grigoriey

The environmental conditions and the geological and tectonic features of rift zones on the Arctic shelf of eastern Siberia were analyzed using information obtained from field studies as well as model calculations. For the rift zones, a tectonic model is suggested in which the properties of the shelf sediments were considered. A paleogeographic scenario is proposed for the formation of neotectonic structures in the area. On the basis of the paleogeographic scenario and the suggested model, a mathematical simulation of the long term dynamics of permafrost and the gas hydrate stability zone on the shelf has been performed for the last 400.000 years. As a result of the long-term evolution of permafrost within the rift zones, pocket-like (dome-shaped) structures similar to anticlines have been formed at the base of permafrost as well as open endogenic subsea taliks. It is assumed, that the anticlinal structures act as traps for sub-permafrost gases and their hydrates, whereas the open taliks serve as channels for their emission. With the results obtained it is possible to predict the conditions of formation of anticlinal traps and open taliks in the rift zones and their relation to the periodical drying or submergence of the shelf. The results obtained in this study are discussed in the context of recent geophysical studies on subsea permafrost and measurements of methane fluxes from the East Siberian shelf areas.

Donald Forbes
State of the Arctic Coast 2009: Scientific Review and Outlook

Forbes, Donald, Lantuit Hugues, Rachold Volker, Kremer Hartwig and Floesser Goetz

The coast is a key interface in the Arctic environment, a locus of human activity, a rich band of biodiversity, critical habitat, and high productivity, and among the most dynamic components of the circumpolar landscape. A very large proportion of Arctic residents live on the coast and many derive

their livelihood from marine resources. The coast is a region exposed to natural hazards and particularly sensitive to climate change; it is thus a high priority for change detection and awareness acknowledged by the Arctic Climate Impact Assessment (ACIA) and the Arctic Human Development Report (AHDR). Under the patronage of Land-Ocean Interaction in the coastal zone (LOICZ), the International Arctic Science Committee (IASC), the Arctic Monitoring and Assessment Programme (AMAP) and the International Permafrost Association (IPA), a new initiative was formed to fill the gap observed in existing reports and assessments and to highlight the uniqueness of Arctic coasts. Its objective is to produce the first review on the state of Arctic coasts and to provide an outlook on the fate of coastal biophysical and societal environments, underlining the complex interactions at work at the land-Ocean interface. This presentation provides an update on the progress of this report and a few excerpts from the document.

Kathleen Parewick
Climate Change and the Built Community: Practical Lessons for Adaptation Governance

Parewick, Kathleen, N. Catto, D. L. Forbes, S. Solomon and E. Edinger

Climate and coastal changes have been monitored in four small communities across the Canadian Arctic. The most pressing physical hazards were observed in Tuktoyaktuk, Northwest Territories (NWT) where erosive storm action and floods act on low-lying thermokarst terrain and shoreline infrastructure. Sachs Harbour, NWT is also experiencing rapid coastal erosion and permafrost ablation, although risks are moderated by the greater elevation of the townsite. Relatively few physical hazards were identified in Gjoa Haven, Nunavut (NU) but a sudden reservoir failure above the townsite in 2005 highlighted latent risks in infrastructure engineered to suit former climatic norms. Preliminary assessment of Hall Beach, NU places it in a moderate physical hazard category, with several residences and other buildings subject to shoreline erosion. In concert with local physical hazard evaluations, community resilience assessments have been undertaken in three of the coastal communities. They reveal many cross-scale interactions that ongoing physical changes are precipitating in tandem with globalizing economic and social influences on northern populations, as well as significant community adaptation challenges stemming from human resource, organizational and relational factors. Rapid changes in ice-rich terrain have raised concerns in relation to traditional Inuvialuit and Inuit livelihoods, knowledge and practises, but significant implications for northern community governance must also be recognized. Differences in resiliency among communities have practical adaptation policy implications. They suggest mechanisms to strategically enhance or restore critical capacities (e.g. countering losses of institutional memory) and so build greater adaptability into every aspect of the community - "built" and otherwise.

Lawson Brigham
Coastal Arctic Environments and Future Marine Operations

The Arctic coastal environment is the locus of nearly all current and future marine transport systems related to Arctic natural resource development and linkages to the global economy. These coastal waters are also experiencing increased marine access due to the unprecedented retreat of Arctic sea ice. Although there is modest, summer ship traffic in the central Arctic Ocean for exploration and tourism, it is the Arctic coastal zone that has attracted new and expanded marine uses including the presence of large cruise ships from the global tourism industry. Marine transport systems today support the world's largest producers of zinc, nickel and palladium ~ all large industrial complexes located in the Arctic. Oil & gas developments in offshore Norway and onshore in northwest Russia now have fully functional systems using tankers and carriers on regional and global trade routes. Based on the work of the Arctic Council's Arctic Marine Shipping Assessment, this review will focus on key marine uses such as oil & gas, hard minerals, fishing, marine tourism, exploration, and summer sealifts. Future marine operations will be primarily influenced by global commodities markets, but a host of other long-term drivers will be at work. Several 'wildcard' issues will also be significant factors: multiple use conflicts, new resource discoveries, coastal governance issues, new ship technologies (allowing longer seasons of ice navigation), and changing marine ecosystems. All will have future impacts on the Arctic coastal environment and its people.

Falk Huettmann
Protecting Coastal and Marine Arctic as one protected Park and in times of Climate Change and Intense Development: A MARXAN and GIS application.

Huettmann, Falk and I. Irving

The Arctic represents a precious region of the globe affected by climate change, human disturbance and natural variation. It is considered one of the last remaining wilderness areas, but major development

plans are currently being proposed on land as well as at sea. A public discussion on the protection and management of this unique zone has not happened, and would be difficult to implement globally. Here I present for the first time a MARXAN optimization modeling analysis taking into account over 50 circumpolar GIS layers and model predictions for marine and terrestrial ecosystems. This method represents Strategic Conservation Planning, and is widely applied for Marine Protected Areas (MPAs) elsewhere. Using scenarios, our models help to find the best available distribution of protected zones for the Arctic. However, such tools are only a first step and require to be further fine-tuned and approved by various governments, stakeholders and legislation. Due to a wider lack of Arctic data, the pre-cautionary principles outlined by IUCN and others apply, indicating that developing the Arctic involves loss of species, habitats, and sustainability detrimental to existing legislation. We are proposing that the real Legacy of the International Polar Year (IPY) is indeed a large protected circumpolar park well balanced between land and sea.

Kate Wedemeyer
Arctic Fisheries Research Related to Offshore Energy Development in Alaska

Rising energy usage has increased prices and demand for oil and gas production offshore of the Alaskan Arctic. The US Minerals Management Service has conducted over $300 million in oceanographic, biological, and socio-economic research since 1970 to provide information to evaluate and mitigate potential effects of offshore oil and gas development on all aspects of the coastal environment. Two of the most important and controversial potential effects evaluated include the unlikely but potentially catastrophic effect of aproduction related oil spill and the potential effects of seismic exploration. The potential effects are evaluated in the context of climate change and other indirect and cumulative factors. Examples of fisheries studies include 1) a suite of studies on Arctic cisco, an important subsistence fish resource; 2) a Beaufort Marine Fish Survey; and 3) an Arctic Fish Ecology Catalog. Recent innovations include efforts to establish new methods to successfully merge western science and traditional knowledge, mining existing data to test for correlations between physical and biological factors, and combining genetics and otolith chemistry to understand the biological changes due to changing climate. The marine fish survey combined fish and oceanography GIS mapping for use in oil spill analyses and an under-ice fish sampling methods workshop. The Arctic Fish Ecology Catalog will synthesize knowledge by both species and ecological topic and develop GIS mapping layers for environmental analyses.

Hugues Lantuit
An update on circumarctic rates of coastal erosion

Lantuit, Hugues Overduin, Paul Pollard, Wayne Grigoriev, Mikhail Couture, Nicole Atkinson, David Hubberten, Hans-Wolfgang Grosse, Guido

The erosion of Arctic coasts has received considerable attention from the media over the last two to three years, resulting in the generalization of yearly rates of erosion captured locally over short amount of time to longer periods and to the entire Arctic coastline. In reality, coastal erosion in the Arctic is a complex and highly variable spatially and temporally. In this study, we used rates from the Bykovsky Peninsula (Russia) and from Herschel Island (Canada) to highlight the difficulty of capturing erosion over long sretches of coast. We show that erosion has often been increasing and/or decreasing in connection with events occurring in the backshore zone such as thermokarst and/or the longshore movement of sedimentary features, both above and under water. We also show for the first time a recent update on some of these rates of erosion, suggesting a dramatic increase potentially associated with the sea ice extent lows of the recent years. We highlight the need for an integrated approach to coastal dynamics at the Arctic scale to refine the current diagnostic and provide better boundary conditions parameters to modellers attempting to create predictive models of erosion.

Paul Overduin
The first circumarctic map on coastal erosion

Lantuit, Hugues, Paul Overduin, Nicole Couture and Rune Odegard

Arctic coasts are particularly vulnerable to climate change because they lie at the interface between terrestrial systems dominated by permafrost and marine systems dominated by sea ice. An increased rise in sea level and degradation of sea-ice as observed recently in the Arctic will likely result in greater rates of coastal retreat. An increase in coastal erosion would result in dramatic increases in the volume of sediment, organic carbon and contaminants to the Arctic Ocean. These in turn have the potential to create dramatic changes in the geochemistry and biodiversity of the nearshore zone and affect the Arctic Ocean carbon cycle. Despite these alarming threats, little is known about the current pace of erosion along the Arctic coastline. The remoteness of the area, the changing nature of erosion, and the complex interaction of processes acting upon the shore make such assessment a challenge. To solve this issue, a group of regional experts brought together by the Arctic Coastal

Dynamics project attempted at gathering current knowledge on erosion to produce the first circum-Arctic map of coastal sensitivity to climate change. We present the results of this effort and provide a few baseline numbers related to coastal change in the Arctic realm.

Mateusz Strzelecki

The cold coast of warm uncertainty - why to focus on polar coast geoecosystem from a perspective of young researcher

In the annals of geomorphology the subject of cold region coasts, which amount to at least 30% of the world coasts, has been somehow neglected. Not only number of professional papers connected with high-latitude coastal environments is smaller than from lower-latitude regions, but also their qualitative and quantitative subject seems to be insufficiently documented. It is interesting to ask why such important for geoecological, economical and geopolitical situation areas of the Arctic and Antarctic are often blank pages in our cognition? Whereas coasts of Alaska, Canada, north-eastern States, Greenland, Svalbard and other European Arctic archipelagos, northern Norway, Sweden, Finland, Russia and finally the whole coast of Siberia, right up to Kamchatka and border with Manchuria and on the southern hemisphere coasts of Antarctica, sub-Antarctic archipelagos, southern Chile, southern Argentina, are extremely vulnerable to predicted environmental changes and anthropogenic impacts. These natural boundaries, in the contact point between marine, cryogenic, terrestrial, atmospheric processes are probably first to experience climatic and sea level changes. That's why during our meeting in Bergen we are going to land on the cold coasts and focus on some important questions to be asked in the field of coastal polar geomorphology and challenges which are waiting for new generation of researchers.

Irina Streletskaya

Current Coastal Research of Western Taymyr, Russia

Streletskaya, I.D. and A.A. Vasiliev

As a part of activities of the International Permafrost Association's (IPA) during the International Polar Year (IPY), a field course for students on "Permafrost and Periglacial Geomorphology (PPG) of western Taymyr" took place along the Taymyr coast in July-August 2008. Pleistocene-Holocene deposits in coastal exposures from the right bank of the Yenisey River and Yeniseyskiy Bay were studied. Upper part of coastal deposits consists of weakly laminated loess-like silt or sandy silt with fine plant debris (Corg=0.6 – 1.2%). The volumetric ice content of sediments is more than 60-80%. Ice-rich permafrost includes polygonal ice wedges of up to 10-12 m thickness and 4-5 m width. These sediments related to so-called «Ice Complex», or Yedoma, have been extensively studied in Siberia and Alaska. Coastal bluffs of Yeniseyskiy Bay with ice-rich sections formed by the Ice Complex are rapidly retreating due to increase of summer temperature and decrease of duration of the ice-free period. Retreat rate for such sections reaches 2-3 meters per year. After strong storms, retreat of bluffs due to thermal erosion can reach 10 meters and even more. The results from stable isotope analyses (oxygen 18 and heavy hydrogen) of the younger Holocene ice wedges in this region (-19.8‰ and -146.2‰ correspondingly) are clearly different from those of the older ice wedges (-26.1‰ and -200.1‰). Ice-wedge formation occurred simultaneously with syngenetic freezing of fluvial, slope, and eolian sediments in Late Weichselian (Sartan) period, when the average temperatures for January reached 35-40 degrees centigrade below zero.

Alexander Vasiliev

Coastal Environment and Thermal Regime of Permafrost in the Transit Zone of Western Yamal

This presentation describes temporal changes in the coastal environment including climate (diurnal, monthly and annual average air temperatures, winter and summer precipitation, snow cover) and Kara Sea parameters (temperature and salinity of the sea water, duration of the ice-free period, seasonal sea-ice dynamics, height and period of waves). Monitoring of permafrost temperatures in the transit zone has been performed, and the data for two years of observations have been obtained. Analysis of data on the near-bottom temperature of sea water at depths less than 60 meters showed that the raise of temperature in 1925-1995 reached approximately 0.2-0.3^{o}C. This raise has triggered degradation of the off-shore permafrost. Since 1998, formation of seasonal sea ice occurs every year later than previous one, and its maximal thickness has decreased from 150 cm to 125-130 cm. Increase of the ice-free period duration has reached 10-12 days. In 2006-2008, amount and activity of sea storms increased sufficiently, but we failed to find a certain connection between storms activity and climate change. Monitoring of temperature regime of permafrost in the transit zone shows that transition of permafrost from the on-shore type to the off-shore one results in sharp increase of annual average temperatures of soils. The sediments are unfrozen to the depth 1.8 meters, though their temperature reaches - 0.8 oC. It is related to the low freezing point of saline clays, which is - 0.9^{o}C. Transition of sediments into a frozen state occurs during the winter season only.

Mario Neves

Shore platform evolution by intertidal ice erosion. First results from South Shetland Islands (Antarctica)

Neves, Mário, Gonçalo Vieira, Miguel Ramos, Vanessa Batista, Miguel Hidalgo and David Tomé

The evolution of shore platforms on sub-polar regions in areas sheltered from wave action, has been imputed to erosion caused by the movement of floating ice. However, its erosion consequences were not yet been accurately quantified. The purpose of this research is to identify shore platforms evolving by floating ice erosion process and assess the downwearing rates. We used a TMEM (Traversing Micro-Erosion Meter), one of the few field equipments that can supply very precise erosion data of rock surfaces. We choose two experimental areas in Deception and Livingston islands (South Shetland – Maritime Antarctica). Deception has a horseshoe shape that almost totally encloses a bay where the sea wave's action is meaningless. A TMEM station was installed in January 2007. Locally, the shore platform shows well consolidated stratified lapilli tuffs forming an almost flat, but very irregular in the detail, rock surface. A TMEM station was also installed at Livingston, in the procteted NW sector of the Hurd Peninsula, on a very smooth rock surface cut in quartzites, in February 2007. The 2008 campaign achieved the first comparative data. The TMEM Deception station presents very high downwearing rates (average 6,528mm year-1), a result that is consistent with the minor resistance of the outcrops. At Livingston, although the quartzite has a very high resistance, we obtain a downwearing rate of 0,053mm year-1. The results achieved justifies the installation of new TMEM monitoring areas and a more detailed shore platform study, aims that we want to accomplish in the following Antarctic campaigns.

Leif Anderson

High pCO2 levels in Siberian Shelf Seas caused by decay of terrestrial organic material

Anderson, Leif G., Sara Jutterström, Sofia Hjalmarsson, Irene Wåhlström and Igor Semiletov

The Siberian Shelf Seas are highly dynamic with large transformation and fluxes of carbon. Organic matter is added both through coastal erosion and discharge by several great Russian rivers. During the International Siberian Shelf Study (ISSS08) cruise, extensive sampling in the waters of the Laptev, East Siberian and Chukchi Seas were undertaken, including measurements of alkalinity, pH and dissolved inorganic carbon. These data are used to assess the carbon dynamics and fluxes. Elevated concentrations of nutrients, pCO2 and low oxygen concentration as a result of decay of organic matter was observed in most bottom waters. Extremely high pCO2 values (more than 1000 µatm) were observed and depth integrated deviation from CO2 saturation show extensive excess of dissolved inorganic carbon in much of the studied region. In the western East Siberian Sea and the Laptev Sea this excess includes the surface mixed layer while the other regions show deficit in the surface mixed layer that is more than compensated for by the bottom water. This excess of dissolved inorganic carbon can not be a result of decay of marine produced organic matter as primary productivity is too low. Hence it must be terrestrial organic matter that is the source. These results thus illustrate that much organic matter is added to the shelf seas where it is mineralized with a resulting flux of CO2 to the atmosphere. A first estimate gives a mean escape in the order of 10 g C /m2 and yr.

Kirill Egorov

The structure of the surface layer and fluxes from the ocean in the presence of ice floes

The investigations concern the problem of computing of area-averaged values of the fluxes of momentum, heat and water vapor from the sea surface in the presence of small-scale temperature and moisture heterogeneity due to ice floes. To compute the average fluxes it is necessary firstly to decide the problem of mathematical description of horizontal and vertical structure of the wind speed and temperature in the surface layer of the atmosphere over the small-scale heterogeneous of sea or land surface. In this case the heat and water vapor exchange depends on the fluctuations of temperature and humidity which are caused by two reasons: usual turbulence and vertical convective plumes formed by the temperature contrasts. These fluctuations produce the additional heat and water vapor fluxes over the surface. We have proposed that small-scale buoyancy force is a dominant one which induces the vertical convective movements. We used a rather simple model for vertical profiles of mean wind velocity and eddy viscosity to get analytical solution and visual dependence of the fluxes from the physical parameters of the process. The numerical estimations to be obtained gives a ground to make a conclusion that the investigated effect is a value of the same order of magnitude as a usual turbulent heat and momentum fluxes. We have shown that the effect of buoyancy on the additional surface stress is much more than the effect of horizontal divergence due to the surface roughness variations. The computed results are compared with the data of observations.

Gisle Nondal

Optimal evaluation of the surface CO2 system in the northern North Atlantic using data from Voluntary Observing Ships

Nondal, Gisle, Richard G. J. Bellerby, Are Olsen, Truls Johannessen and Jón Olafsson

The northern North Atlantic Ocean is considered to be an important uptake area for atmospheric carbon dioxide. Unfortunately the number of carbon system measurements available in the region presently limits our understanding. This situation has been alleviated by autonomous systems that measure sea surface CO2 fugacity (fCO2) that have been installed on board Voluntary Observing Ships (VOS). This work evaluates whether an accurate calculation of the entire CO2 system in the northern North Atlantic can be carried out using a combination of in situ fCO2 and ancillary data often measured on VOS, i.e. sea surface temperature (SST) and sea surface salinity (SSS), as well as Nitrate (NO3-). Two approaches where tested: (I) determination of total alkalinity (At) from SSS and then calculating total inorganic carbon (Ct) from measured fCO2 and estimated At; and (II) determination of Ct from SSS, SST, and NO3- and then calculating At from measured fCO2 and estimated Ct. As At is affected by high alkalinity river water from the Arctic Ocean, a single At(SSS) relationship is not valid for the northern North Atlantic, and two relationships will be presented: one for Atlantic Influenced water and ice melt water; and one from Arctic Influenced water in the East Greenland Current. The optimal approach was determination of At from SSS (mean bias of -1.8 µmol kg-1 and root mean square deviation 6.2 µmol kg-1) and then calculating Ct from measured fCO2 and estimated At (mean bias of -1.0 µmol kg-1 and standard error of calculation of 7.4 µmol kg-1).

Alexey Pavlov

Seawater optical properties in West Spitsbergen coastal waters

Pavlov A.K, B.V. Ivanov, P.F. Wassmann, S. Falk-Petersen, E.N. Hegseth, K.H. Sperre and H. Svendsen

During the past decades the negative mass balance of many Svalbard glaciers has been observed. As a consequence, an increase in inorganic suspended matter input through meltwater discharge from glaciers has occurred. The presence of suspended particulate matter (SPM) in the surface brackish layer within fjords influences underwater light regime that is of great importance for the local marine ecosystem. Investigations of inherent and apparent optical properties have been carried out after three years of field observations on Svalbard: the expedition of Arctic and Antarctic Research Institute (2006) in Gronfjorden, the ALBERT field campaign (RV Jan Mayen, 2007) in Isfjorden, Kongsfjorden and on the continental shelf, and the iAOOS cruise (RV Jan Mayen, 2008) on the continental shelf. A set of in situ and laboratory studies was performed: direct measurements of photosynthetically active radiation (PAR), sampling for SPM determination, indirect estimations of SPM using turbidity meter, fluorescence measurements (as a part of standard CTD profiling) and Secchi depth measurements. Euphotic zone depth and extinction coefficients (Kd) are parameters calculated from PAR measurements. High spatial variability of all seawater optical properties was found. The lowest euphotic zone extent, as well as the highest Kd values and SPM concentrations, are associated with inner part of the fjords, where suspended inorganic matter from melting glaciers and river run-off prevails.

Sue Moore

Impact of inter-annual variability in ocean conditions on bowhead feeding near Barrow, Alaska

Ashjian, Carin J., Robert G. Campbell, J. Craig, George Sue E. Moore Stephen R. Okkonen Barry F. Sherr and Evelyn B. Sherr

The coastal region near Barrow, Alaska is a critical feeding area for bowhead whales, particularly during the fall migration. The ocean here is particularly sensitive to ongoing climate warming and inter-annual variability. Oceanography and bowhead whale distributions near Barrow were sampled during August and September of 2005-2008 as part of an ongoing study to identify conditions that produce a favorable feeding environment for the whales, and to document short term and inter-annual environmental variability. Multiple water masses were observed, with close coupling between water mass and biological characteristics. Both 2005 and 2007 were characterized by little sea ice and warm Pacific-origin water (~11°C in 2007), while there was melting sea ice, colder water, and a reduced amount of Pacific Water in 2006 and 2008. Shorter-term variability in conditions on the shelf was intimately tied to the direction and strength of the wind. We advance a conceptual hypothesis regarding the availability of prey for the bowhead whale near Barrow. Krill and copepods are upwelled onto the Beaufort Shelf from Barrow Canyon or the Beaufort Sea when winds are from the E or SE. A favorable feeding environment is produced when these krill and copepods are retained and concentrated on the shelf near Barrow by the prevailing westward Beaufort shelf currents that converge with the strong Alaska Coastal Current that flows to the northeast along the eastern side of

Barrow Canyon. Despite high inter-annual variability over the four years, the region persisted as a favorable feeding environment for bowhead whales.

Oleg Dudarev

New Data about the Semenov Shoal Morphosculpture as Island Relict on the Laptev Sea Shelf

Dudarev, O. V., A.I. Charkin, I. P. Semiletov and A.V. Kruchmalev*

The shoal surface is complicated by the northern Semenovya Bank and the southern Vasil'ev Bank. These structures discovered as islands in 1815 were already located in the underwater position by 1950 (Gakkel, 1958). Along the longest axis of the shoal (230o) in the traverse, the minimal depth of 4.2 m was measured near the southeastern slope of the Semenov Bank, where terrace-type surfaces up to 5-6.5 km wide were distinguished at levels of -5.6 and -6.6 m. Three V-shaped depressions 0.9-1.3 m deep were recorded within the traverse. They could form as the result of thermokarst subsidence. Owing to the geographic position, the southern slopes of shoal zones are preferentially subjected to the impact of the predominant wave agitation and the heat flow of the Lena River. On the Semenov Shoal, which is open for waves, the lower boundary of the nonsedimentaion zone shifts down to the depth of 10 m, and well-rewashed and moderately graded fine psammites are exposed on the shoal surface. It is likely that they facially replace coarser varieties of elevated areas. Aleuritic mictite and psammitic aleurite, which are typical of erosion-accumulation conditions, are widespread below the 10-m isobath on slopes and hollows. The vertical stratification of watermass at the depth exceeding 15 m enhances the steady sedimentation of suspended material. Typical sediments of the accumulation zone are pelitic aleurite, aleuritic pelite, and pelite, which replace successively each other toward the shoal bottom and the plain framing.

Session 7
Risks to Human Health from a Changing Arctic

Jon Øyvind Odland
Human Health and Climate Change -Effects and Adaptation Processes in a Sustainable Development Perspective

The presentation will focus on effects and adaptation mechanisms related to human health and living conditions in the frame of a Sustainable Development Strategy. The following topics will be discussed and new data presented on selected topics: health effects of climate change, contaminants impact on humans, mechanisms, adaptation, social effects, equity and recommendations.

Natalia Belisheva
The Cosmic Ray Intensity Dependence of Human Health in the High Latitude

There are several sources of risks to human health in the Arctic, including the ozone hole and cosmic ray intensity. The effects of exposure of human organism to cosmic rays are not enough studied. Ozone depletion over the poles is thought to be a cause of increased global levels of skin cancer. Cosmic rays may be enlarging the hole in the ozone layer. A strong correlation was found between cosmic ray intensity and ozone depletion. The damage done by cosmic rays could be millions of times larger than anyone previous believed (Q.-B. Lu and L. Sanche. Phys. Rev. Lett. 87, 078501 (2001)). Our research were carried out on human organism at the solar cycle maximum and in the epoch of minimum. We demonstrate the cosmic ray intensity dependence of state of cardio-vascular systems and peripheral blood in the high latitude. In the epoch of the solar cycle minimum and the drastic increase of cosmic ray intensity, the human health are stronger modulated by cosmic rays than in the epoch of maximum. Because the cosmic rays may be enlarging an Arctic ozone hole and promote to exposure of UV rays of human organism, the human health are ran the dual risk in the epoch of minimum: by exposure to UV and cosmic rays intensity. The risks to human health from a cosmic rays are stronger in the high latitude and in the Arctic, than the middle latitude.

Sergey Chernouss
Dependence of Heart Rate Variability on variations of Space Weather parameters in Arctic

Chernouss, Sergey and Natalia Belisheva

The aim of the report is to pay attentions of officials to the Space Weather hazard for human health in the North. The experiments on studies of the Heart Rate Variability (HRV) response on stress factors connected with local and global geomagnetic activity are under discussion. Volunteers of the Kola Science Centre RAS, students of the Apatity universities and staff of the Northern Fleet aviation have been used as people under testing. Measurements of HRV parameters were carried at Kola Peninsula and Spitsbergen. Geophysical data for the same dates were obtained from the Polar Geophysical Institute observatories and Space Weather data. Simultaneous time series data of HRV and geomagnetic field and cosmic rays variations were under analysis. The results are interpreted by classical point of view on the basis of the adaptation concept. Features of the auroral disturbances impact on the HRV are under discussion. An individual response of HRV to Space Weather factors was found. Reaction of an autonomic nervous system (ANS) and redistribution of the spectral power of HRV between sympathetic and parasympathetic branches of the ANS during natural disturbances are shown.

Bjørnar Ytrehus
Weather related disease outbreaks in Arctic ungulates – a warning of changes to come?

Global warming is proposed to cause population declines or extinctions of arctic ungulates through changes in the timing and abundance of forage availability and reduced habitat availability. Disease has received less attention, though several researchers have hypothesised that global warming will affect host-pathogen interactions by (1) increasing pathogen development rates, transmission, and decreasing generation interval; (2) relaxing overwintering restrictions on pathogen life cycles; and (3) modifying host susceptibility to infection. Arctic species have evolved under severe seasonal and environmental constraints and the life history patterns of these species can be dramatically altered by even minor climatic perturbations. To recognize alterations in the association between hosts and pathogens that may result from global change, knowledge of baseline disease and pathogen occurrence is critical. The lack of long-term monitoring programs for wildlife diseases is hence an inherent challenge in the study of the impacts of environmental change on animal health. However, some observations of disease in wildlife may indicate the direction of

change: The ectoparasitic deer ked is currently expanding its distribution west – and northwards and seem to reach the home ranges of reindeer in Western Eurasia, the first recorded cases of clinical elaphostrongylosis in wild reindeer has been detected in Western Norway and an episode of fatal pneumonia killed a large proportion of the introduced musk ox population of Dovrefjell in Norway. These cases of disease may be seen merely as the results of accidental coincidences of harmful conditions. However, increased temperature and humidity may also be the driving force behind these incidences.

Maarten Loonen

Dynamics of bird diseases and their risk for human health

Loonen, M.J.J.E and J. Prop

Migratory birds move between locations which differ in pathogen load. The risk of infection from the birds is not constant over the annual cycle. The Arctic is an area with low pathogenic load and the birds save costs on the activity of the immune system and are able to grow faster. The implications for spreading diseases during migration are further discussed.

Session 8
History of Arctic Sciences

Erki Tammiksaar
IPY (1882–1883): difficulties in the preparation, solutions, budget

While it is well known that the originator of the plans for the (First) International Polar Year was Carl Weyprecht, and that Georg Neumayer was important in guiding the project in early stages and to eventual fruition, the pivotal role of Heinrich Wild, who became chairman of the International Polar Commission, has been largely overlooked in this context. The report will be focused on an analysis of the contribution of Weyprecht, Neumayer and, in the first place, Wild to the organization of IPY during the initial stage (1875–1882), having been impeded as by the political circumstances as well as by the lack of knowledge in the field of the organization of international scientific collaboration. All these obstacles were removed as a result of important compromises in different questions which enabled to elaborate organizational principles for successful realization of later international projects, including the organization of IPY II in the thirties of the last century.

James Overland
The Birth of Arctic Climate Science: the Synoptic Research Program of the First International Polar Year (1882-1883)

Wood, KR and J.E Overland

The first International Polar Year (IPY) took place in 1882-1883 and was largely due to the advocacy of the Austrian naval officer and scientist Carl Weyprecht. A key insight of Weyprecht was that point measurements collected by individual expeditions could "only furnish a picture of the extreme effects of Nature, but leave us completely in the dark with respect to their causes." Synoptic observations were essential as "the entire Meteorology of our day rests upon comparison." In an 1875 address entitled Fundamental Principles of Scientific Arctic Investigation, Weyprecht appealed for nations to set aside their unprofitable competition for mere geographic discovery and cooperate to obtain at least one year of synchronous observations using a defined sampling protocol and similar high-quality and well-calibrated instruments. Eleven nations joined in implementing Weyprecht's plan. The field program was successfully completed, with one expedition led by A.W. Greeley enduring tremendous personal hardship and sacrifice to safeguard their observations. Perhaps due to Weyprecht's own untimely death in 1881, the data fell into obscurity with little analysis completed. Today these data provide a window on the arctic climate of the past. The present authors have analyzed the synoptic pressure and temperature data from the first IPY and found similar patterns of temporal and spatial variability as in recent decades. These data reflect the large-scale atmospheric climate patterns now identified as the Arctic Oscillation/Northern Annular Mode and Pacific-North American pattern. Weyprecht's early call for synoptic observations represents a major milestone in the development of modern arctic climate dynamics.

Jörn Thiede
The First German Expeditions Towards the North Pole

Thiede, Jörn and Reinhard A. Krause

Politics were tense in the later part of the 19th century because of wars between Germany and Denmark and a variety of other European nations, and hence it was not a given thing that a number of people interested in the Arctic were trying to organize expeditions to the high latitudes of the Northern hemiisphere. Driven by geographic and commercial interests, however, a highly variably composed group of partners succeeded to organise the „"1st and 2nd German North Pole Expeditions" in 1868 and 1869, under the intense influence of a publisher (Petermann) and a Captain Coldewey (with close connections to the Hanse City of Bremen, Bremerhaven, part of the federal German country of Bremen, is today the home or the central German Polar Research Institute, the Alfred-Wegener-Institute of the Helmholtz-Association).
The „1st German North Pole Espedition" was conducted in 1868 on the sail ship „GRÖNLAND" (still sailing under the auspices of the German Ship Museum in Bremerhaven), from Bergen (Norway) to Svalbard via Greenland and returned safely in the fall of 1868. The „2 nd German North Pole Expedition" in 1869 was conducted on 2 ships, namely „HANSE" and „GERMANIA"., a sail- and a teamship. Both ships parted early during the expedition, with no kowledge of the fate of the other one, one of them was crushed by the ice leaving the crew to drift on an ice flow southwards for months under miserable concditions, but they finally succeeded to rescue themselves into one of the „Herrenhuter Colonies" in Southern Greenland where they where hosted in the home of a Greenland merchant named Motzfeldt.Many more details in the diaries of the expedition.

Sergey Chernouss
Auroral studies by the Russian-Swedish expedition to Spitsbergen 1899-1900

Sandahl, Ingrid and Sergey Chernouss

Instrumental and visual observations of aurora at Spitsbergen carried out by joint Swedish-Russian expedition during 1899-1900 years are under consideration. Auroral observations took place in frame of great bilateral Arc-of-Meridian expedition, which was pathroned by the Swedish Royal Family and the Russian Imperial Family. The Russian-Swedish Arc-of-Meridian measurements were closely coordinated but auroral measurements were almost independent in two points of the Spitsbergen Archipelago. The reports of the Russian astronomer J.Sykora and the Swedish geophysicist J.Westman are the basic auroral data for our presentation. Detailed descriptions of the optical devices and the system of spectral calibration are presented. We present a comparative analysis of auroral data from the Russian and Swedish stations in three directions: visual observations of aurora describing features of auroral forms and giving us statistical data on aurora occurrence and heights of aurora, photos of aurora, auroral spectra. It seems to be that observations of both teams contain enough data to construct an auroral oval and determine heights of aurora. The presented auroral photos are the first photographic observations in the Arctic. The auroral spectra demonstrate a high spectral resolution and show not only the main auroral emissions in the blue-green spectral range but also some weak emissions in the violet and utraviolet region. All data are interpreted from the modern point of view. We believe that the Russian-Swedish 1899-1900 expedition carried out the first complex auroral investigations in the Arctic using photographic optical instruments and presented well documented data and new results. Biographies of J.Sykora and J.Westman are presented. optical instruments and presented well documented data and new results. Biographies of J.Sykora and J.Westman are presented.

Susan Barr
100 years of Norwegian institutionalised research in Svalbard

The development of institutionalised scientific research in Svalbard and its responses to the IPYs.

Urban Wråkberg
Functions and Meanings of Polar Research Field Stations

Western science retains its knowledge position in the post-colonial world as agent to unlock the wealth of the Polar Regions but also as the dependable stewards of its use. Facilitated in recent times by the assistance of the social sciences, indigenous Arctic groups have entered into the expanding circle of stakeholders who find themselves summoned to guide, evaluate and control polar research. Science has also since long played a role as a means by which nations, organisations and various groups can show their interests in some part of the polar regions.
Early scientific stations in the Arctic were mainly organised for logistical purposes. Contemporary IPY stations have been numerous and are still part of the standard resources needed to operate polar research in the field. Research stations are in many regards ideal laboratories for reflections on the interplay between science, politics, industry, environmentalism and international law in the polar regions.
The presentation aims to focus on polar research stations, their traits, and their meaning in the surrounding landscape and in international politics. Such seemingly straightforward parameters as the location, design and layout of polar research stations are in many ways shaped by political concerns for specific social purposes. Polar stations are laden with cultural values and have proven to be useful tools for a variety of political interests and contexts. Interpretations will be exemplified over an extended time to facilitate observations on related international political issues. While most attention will be concentrated on Spitsbergen, polar stations elsewhere will also be considered.

Shuo Li
Research on the Arctic Ocean with the new concept of underwater vehicle

Li, Shuo, Baoju Wu, Junbao Zeng and Yuechao Wang

North Pole region is one of the weakest places that affected by the global warming. Sea ice is one of the most important characteristics to reflect the climate change. The Arctic Science will make great progress with the support of the new technology. The project was supported by Chinese government to monitor the Arctic Ocean parameters by underwater vehicle. Based on our past knowledge, a new concept of underwater vehicle (Polar ARV) is designed, which combine the AUV and ROV techniques. As an underwater motion platform, several different kinds of parameters will be monitored synchronously in the real time. ARV has two working modes as AUV and ROV. The most important thing is that the vehicle knows its position relative to the sea ice based onboard sensors. The ARV was applied in the 3rd Chinese Arctic Ocean expedition. The technologies

were demonstrated in the real North Pole environment. The paper will be organized as follows: Firstly, this paper discusses the increased great necessaries of Polar ARV for North Pole exploration, the basic conception and traits of the Polar ARV are introduced, and the advantages of North Pole application are also presented. Secondly, the key technologies related to the design of Polar ARV are demonstrated. The navigation relative to the sea ice will be explained in detain. Thirdly, the specification of Polar ARV is demonstrated in the lake test and Arctic Ocean application in 2008.The science data and the underwater frame will be shown. Finally, the possible further application in the Arctic Ocean will be discussed.

Rupert Wienerroither

The marine fish diversity in the area of Jan Mayen Island, NE Atlantic

Wienerroither RM, K.H. Nedreaas, F. Uiblein and J.C. Christiansen

The Arctic island Jan Mayen is of volcanic origin and surrounded by deep basins of the Norwegian, Iceland and Greenland Seas. The Norwegian Exclusive Economic Zone (NEEZ) Jan Mayen borders the Greenland zone in the west, the Icelandic zone in the southwest and an International area in the east. The Jan Mayen zone will be included in the update of the 2010 Norwegian Red List, which as a first step requires a comprehensive account on the occurrence, distribution, and abundance of all fish species. First oceanographic investigations in the area of Jan Mayen Island were already conducted in 1877 and at irregular intervals afterwards, but historical data on the ichthyofauna are scarce. Fish species occurrences are only partly documented by museum specimens and taxonomic revisions as well as new species descriptions since that time make it difficult to evaluate the records. Furthermore, these investigations cover mainly the closer surroundings of the island, but not the entire NEEZ. These early years of biodiversity-related research are followed by a series of investigations on commercially targeted species which treat by-catch only qualitatively at best. It was not before the late 1970's when investigations started to cover the whole area and records included all fish species caught. Our current compilation based on museum collections, literature data and the IMR database includes 89 species recorded from the NEEZ Jan Mayen, with an increase of registered species beginning in the late 1970's, reflecting investigations on fish biodiversity in the area and possibly also faunal shifts in distribution.

Marty Bergmann

Arctic aircraft and field logistics in Canada - Polar Continental Shelf Program's involvement with international research initiatives in the Canadian Arctic

The Polar Continental Shelf Program (PCSP) provides logistical support to Canadian Arctic researchers from Canadian and foreign government departments, universities, and non-government groups. The main service provided is efficient and cost-effective air transportation by fixed-wing and rotary-wing aircraft to and from remote field camps located throughout the Canadian Arctic. Aircraft operations are conducted out of key northern locations, with Resolute, Nunavut, representing the primary area of operations from February to September each year. Most of the PCSP's logistical support is provided to Canadian researchers, but foreign scientists are supported on a cost-recovery basis. The PCSP has been involved with international projects in the Canadian Arctic since at least the early 1970s, through studies such as the Arctic Ice Dynamics Joint Experiment and Lomonosov Ridge Experiment. The number of foreign scientists leading or collaborating on PCSP-supported projects has increased over time and more countries are now represented. During the past five years, the PCSP has supported researchers from Denmark, France, Germany, Japan, the U.K. and the U.S.A. Additionally, the PCSP has supported many projects during the International Polar Year, including many involving foreign researchers. The PCSP is the Canadian representative in the Forum of Arctic Research Operators and it facilitates the Canadian Arctic-Antarctic Exchange Program. The PCSP celebrated its 50th anniversary in 2008 and is developing its support for international activities through partnerships with Canadian researchers. The PCSP continues to work with many international arctic research groups to ensure effective delivery of logistical support to scientists working in the Canadian Arctic.