The 22nd International Symposium on Polar Sciences

The Future of the Arctic: Science and Governance

May 10-11, 2016
Korea Polar Research Institute, Songdo, Incheon
Republic of Korea

Organized by
Korea Polar Research Institute

Symposium Program at a Glance

	May 09	May 10	May 11
08:30 - 09:00		*Registration & Opening Ceremony*	
09:00 - 09:40			*Plenary Lecture: Arnold GORDON*
09:40 - 10:00		*Plenary Lecture: Susan HUBBARD*	Sea Ice Networks for Observation and Prediction
10:00 - 10:20			
10:20 - 11:00		Observations of the Changing Arctic Atmosphere	
11:00 - 11:30			
11:30 - 12:00			*Lunch & Poster Session (Korean Early Career Scientists Gathering)*
12:00 - 12:30		*Lunch & Poster Session*	
12:30 - 13:00			
13:00 - 13:20		*Invited Lecture: Takashi YAMANOUCHI*	*Plenary Lecture: Evan BLOOM*
13:20 - 13:40		Modeling the Physical Processes of Arctic Climate System	
13:40 - 14:00			Science, Law and Arctic Future
14:00 - 14:40			
14:40 - 15:00		*Coffee Break & Poster Session*	
15:00 - 15:30			*Coffee Break & Poster Session*
15:30 - 16:00		Climate Change and Arctic Terrestrial Ecosystems	Social and Human Science research on the Arctic and East Asian Contribution
16:00 - 16:30			
16:30 - 17:00			
17:00 - 17:30			
17:30 - 18:00			
18:00 - 20:00	*Icebreaker (Holiday Inn Incheon) Songdo)*	*Dinner (Own Arrangment)*	*Banquet (KOPRI Hall)*

Symposium Program

May 10 (Tuesday)	
08:30 - 09:15	***Registration & Coffee Break***
Opening Ceremony	*Auditorium*
09:15 - 09:30	***Welcome Address***
09:30 - 09:40	***Group Photo***
Plenary Lecture	*Auditorium*
09:40 - 10:20	**Susan HUBBARD** ***Geophysical Characterization of Arctic Ecosystem Behavior***
Sessions	**Observations of the Changing Arctic Atmosphere** *Auditorium*
10:20 - 10:40	**Roberto UDISTI** ***Size Distribution and Chemical Composition of Polar Aerosol : The Italian Experience and Future Prospects***
10:40 - 11:00	**Ki-Tae PARK** ***Atmospheric Dimethyl Sulfide in Arctic Ocean***
11:00 - 11:20	**Masataka SHIOBARA** ***Challenging the New Remote-Sensing of Aerosols and Clouds from Surface at the Polar Sites***
11:20 - 11:40	**Jeong-Han KIM** ***Upper Atmospheric Research Activity at Northern High Latitude***
11:40 - 12:00	**Alexander MAKSHTAS** ***Investigations at the new Russian Research Station "Ice Base Cape Baranov" in 2013 – 2015 years***
12:00 - 13:00	***Lunch & Poster Session***
Invited Lecture	*Auditorium*
13:00 - 13:20	**Takashi YAMANOUCHI** ***Overview of GRENE Arctic Climate Change Research Project and its Successor***

Sessions	Modeling the Physical Processes of Arctic Climate System *Auditorium*
13:20 - 13:40	**Hanna LEE** ***Parameterizing Permafrost Thaw Induced Wetland Dynamics and its Effects on CH4 Dynamics in the Community Land Model (CLM)***
13:40 - 14:00	**Hyungjun KIM** ***Land Surface, Snow and Soil Moisture in Land-Climate Feedback and Model Diagnosis***
14:00 - 14:20	**Jin-Ho YOON** ***Surface Measured Cloud Properties for Improving Cloud Parameterization***
14:20 - 14:40	**Yongwon KIM** ***Continuous Measurement of Soil Carbon Efflux with Forced Diffusion (Fd) Chambers in a Tundra Ecosystem of Alaska***
14:40 - 15:30	***Coffee Break & Poster Session***
Sessions	**Climate Change and Arctic Terrestrial Ecosystems** *Auditorium*
15:30 - 16:00	**Christelle MARLIN** ***Estimate of the Water Balance of a Deglaciating Catchment on the Western Coast of Spitsbergen (Austre Lovén Glacier Catchment, Svalbard)***
16:00 - 16:30	**Claudia CZIMCZIK** ***Carbon Cycling in the New Arctic***
16:30 - 17:00	**James BRADLEY** ***Characterisation of Arctic Soil Development Using the New Biogeochemical Model: SHIMMER***
17:00 - 17:20	**Alexander Tøsdal TVEIT** ***Regulatory and Evolutionary Temperature Adaptations in Globally Important Methane Oxidizing Bacteria of the Genus Methylobacter***
17:20 - 17:40	**Hojeong KANG** ***Wawrming May Not Increase Methane Emission from Arctic Ecosystems***
17:40 - 18:00	**Mincheol KIM** ***Shifts in Taxonomic and Functional Structure of Bacterial Communities During a Short-Term Succession in the High Arctic***

May 11 (Wednesday)	
Plenary Lecture	*Auditorium*
09:00 - 09:40	**Pablo CELEMENTE-COLON** ***Sea-Ice Satellite Observation and International Buoy Networks***
Sessions	**Sea Ice Networks for Observation and Prediction** *Auditorium*
09:40 - 09:55	**Melinda WEBSTER & Ignatius RIGOR** ***Evolution of Melt Ponds on Arctic Sea Ice as Observed from the Ice, Air, and Satellites***
09:55 - 10:10	**Marcel NICOLAUS** ***Snow Depth on Arctic and Antarctic Sea Ice Derived from Autonomous (Snow Buoy) Measurements***
10:10 - 10:25	**Craig M. LEE** ***Evolution of the Beaufort Sea Marginal Ice Zone: Results from Autonomous Observations Collected during 2014 MIZ Program***
10:25 - 10:40	**Christopher J. ZAPPA** ***Marginal Ice Zone Processes Observed from Unmanned Aerial Systems***
10:40 - 10:55	**Alexander FORREST** ***Drift, Drag and Deterioration: Mapping the Fate of Large Ice Hazards***
10:55 - 11:10	**Jeremy WILKINSON** ***The Need for Cross-Disciplinary International Research on Arctic Change***
11:20 - 13:00	***Lunch & Poster Session*** *(Korean Early Career Scientists Gathering)*
Plenary Lecture	*Auditorium*
13:00 – 13:40	**Evan T. BLOOM** ***U.S. Arctic Science Policy and the Role of the Arctic Council in Promoting Polar Science***
Sessions	**Science, Law and Arctic Future** *Auditorium*
13:40 - 14:00	**Timo KOIVUROVA** ***Arctic Exceptionalism***
14:00 - 14:20	**Long ZHAO** ***The Future of Arctic Legal Orders: A Chinese Perspective***

14:20 - 14:40	**Yong Ahn PARK** ***UNCLOS Article 76 and SOU and Some Understanding of the CLCS Activities***
14:40 - 15:00	**Won-Sang SEO & Dongmin JIN** ***Precautionary Principle : Common Issue of Law and Science for the Arctic Environmental Protection***
15:00 - 15:30	***Coffee Break & Poster Session***
Sessions	**Social and Human Science research on the Arctic and East Asian Contribution** *Auditorium*
15:30 - 15:50	**Gail FONDAHL** ***Agenda Setting for Arctic Social Sciences: AHDR-II, IASC SHWG and ICARP-III***
15:50 - 16:10	**Anne-Marie BRADY** ***China as a Polar Great Power***
16:10 - 16:30	**Hiroki TAKAKURA** ***Co-Design Project of the Environment Education in/for the Siberian Indigenous Communities***
16:30 – 16:50	**Jong Kun CHOI** ***Korea's Arctic Interests in Formation and Prospects for Cooperation with Greenland***
16:50 - 17:10	**Jong-Man HAN** ***The Current Situation and Task of the Domestic Human and Social Science Researches on the Arctic Region***
17:10 - 17:30	**Jong Deog KIM** ***Activities of the Korea Maritime Institute in the Arctic***
17:30 - 17:50	**Dongmin JIN & Bang-Yong LEE** ***Korean Arctic Policy and the KoARC***
18:00 - 20:00	***Banquet***

Symposium Poster Session

May 10-11 (Tuesday-Wednesday)		
Observations of the Changing Arctic Atmosphere (PS-O00)		
PS-O01	Namyi CHAE	*Soil CO_2 Efflux from Semi-Arid Tundra and Moist Tundra in the Arctic*
PS-O02	Jisu CHOI	*New Noble Gas Laboratory at KOPRI: A Progress Report of Meteorite Analysis*
PS-O03	Hiroshi KOBAYASHI	*Development of a New Shipborne Aureolemeter to Measure the Direct-and Circum-Solar Radiation*
PS-O04	Aleksander MAKAROV	*Paleo Reconstructions in the Russian Arctic Coastal Zone and Islands*
PS-O05	Young-Gyun KIM	*Marine Heat Flow Measurements in the Subsea Permafrost Degradation Area of the Eastern Mackenzie Trough, Canadian Beaufort Sea*
PS-O06	Masaki KANAO	*Characteristic Atmosphere and Ocean Interactions in the Coastal and Marine Environment Inferred from Infrasound Data at Teranova Bay, West Antarctica*
PS-O07	Yongcheol PARK	*P-Wave Velocity Structure Beneath Greenland Using Local, Regional, and Teleseismic Events*
Modeling the Physical Processes of Arctic Climate System (PS-M00)		
PS-M01	Kazutoshi SATO	*Impact of Radiosonde Data Over the Arctic Ice on Forecasting Winter Extreme Weather Over Mid Latitude*
PS-M02	Hanna LEE	*A Continuous Observation of Tundra Warming Effects on CO_2 Efflux at a High Arctic Tundra in Svalbard*
PS-M03	Christine DOW	*Examining Recovery Ice Stream Subglacial Lakes Using a 2D Hydrology Model*
PS-M04	Jun INOUE	*Japanese Contribution to the Polar Prediction Project (PPP)*

Climate Change and Arctic Terrestrial Ecosystems (PS-C00)		
PS-C01	Se-eun KIM	*Vegetation Mapping on the Midtre Lovénbreen, Svalbard Using Remote Sensed Images*
PS-C02	Sungjin NAM	*Molecular Characterization of Soil Organic Matter Along a Soil Chronosequence in Midtre Lovénbreen Foreland in Svalbard*
PS-C03	Ji Young JUNG	*Estimation of Soil Organic Carbon Stock in the Glacier Foreland of Midtre Lovénbreen, in the High Arctic*
PS-C04	Jane LEE	*Spatial Variability of Canopy Structure and Function in the Moist Acidic Tundra*
PS-C05	Hye Min KIM	*Prokaryotic Diversity and Community Structure in Arctic Tundra Soil, Alaska*
PS-C06	Woo-Suk CHANG	*Temporal Regulation of Photosynthesis and Nitrogen Fixation in Novel Soil Bacteria*
PS-C07	Yong-Hoe CHOE	*A Comparative Study of Endolithic Microbial Communites Between Different Types of Rocks in the Norwegian High Arctic*
PS-C08	Jae Eun SO	*The Diagnostic Characteristics are Highly Homoplasious Used in Cladonia gracilis and Cladonia cornuta*
PS-C09	Kyuin HWANG	*Unexpected Effect of Quality Filtering: Bias of Taxon Abundance in 16S rRNA Microbial Community Analysis*
Sea Ice Networks for Observation and Prediction (PS-I00)		
PS-I01	Chang-Uk HYUN	*Measuring Arctic Sea Ice Motion Using High-Spatial-Resolution Optical Satellite Image*
PS-I02	Eunho KO	*The Variability of Surface Chlorophyll-A Associated with Sea Ice Extent in the Western Arctic Ocean*
PS-I03	Kyoung-Ho CHO	*An Introduction to KOPRI's Collaborative Activities for Sea Ice Observations in the Arctic*
PS-I04	Mario HOPPMANN	*Ice-Based Measurement Platforms in the Arctic Ocean: A Contribution by the FRAM Infrastructure Program*

PS-I05	Eun Yae SON	*Observation of Vertical Heat Flux from Pacific Summer Water to Surface Using Ice-Tethered Moorings*
Science, Law and Arctic Future / Social and Human Science Research on the Arctic and East Asian Contribution (PS-S00)		
PS-S01	Néstor CAMPOS	*The Future of the Arctic: Consequences of Melting*
PS-S02	Jong-Man HAN	*The Current Situation and Task of the Domestic Human and Social Science Researches on the Arctic Region*
Arctic, Antarctic and Other Related (PS-E00)		
PS-E01	Seung-Goo KANG	*Estimaton of Submarine Permafrost in the Canadian Shelf of Beaufort Sea, Arctic*
PS-E02	Eun Jae KIM	*Studies of Arctic Chlamydomonas sp. KNM0029C for Biodiesel Production*
PS-E03	Jinyoung JUNG	*Characteristics of Dissolved Organic Carbon in the Western and the Eastern Arctic Ocean*
PS-E04	Yusuke KAWAGUCHI	*Enhanced Diapycnal Mixing Due to Near-Inertial Internal Waves Propagating Through an Anticyclonic Eddy in the Ice-Free Chukchi Plateau*
PS-E05	Jae-Ryong OH	*Preliminary Report of Late Paleozoic Oncoids from the Brøggerhalvøya, NW Svalbard*
PS-E06	Sookwan KIM	*Evidence for the Late Cenozic Antarctic Ice Sheet Evolution and Bottom Current Dynamics in the Central Basin, Ross Sea (Antarctica)*
PS-E07	Ji-Hoon KIHM	*Ontogeny of the Furongian (late Cambrian) trilobite Proceratopyge cf. P. lata Whitehouse, 1939 from Northern Victoria Land, Antarctica, and the Evolutions of Metamorphosis in Trilobites*
PS-E08	Changwoo LEE	*Structural Basis for the Ligand-Binding Specificity of Fatty Acid-Binding Proteins (pFABP4 and pFABP5) of the Gentoo Penguin*
PS-E09	Young-Hwan G. KIM	*Cyclic Deposit of the Channelized Debris Flows in the Spurs Formation, the Mariner Group (Cambrian), Northern Victoria Land, Antarctica*

SOCIAL EVENTS

All participants are kindly invited to the social events hosted by KOPRI. Please mark it when you make a registration at the symposium website (http://symposium.kopri.re.kr).

Icebreaker	**Banquet**
18:00 - 20:00, May 9	18:00 - 20:00, May 11
Holiday Inn Incheon Songdo Hotel	KOPRI Hall

FOR POLAR EARLY CAREER SCIENTISTS

KOPRI wishes to encourage the participation of early career scientists at this symposium.

KOREAN Early Career Scientists Gathering

Date & Time: May 11th, 11:20-13:00
Meeting Place: Seminar Room (KOPRI Main Building 3rd Floor)

Young Scientist Awards

Young Scientist Awards will be presented to the outstanding poster presentations and the award ceremony will take place as a part of the banquet on May 11th.

For further information, please contact the symposium secretariat or visit the symposium website (http://symposium.kopri.re.kr).

TRANSPORTATION INFORMATION

Between Incheon International Airport and Holiday Inn Incheon Songdo Hotel

If you are staying at the Holiday Inn Incheon Songdo Hotel, you can reach the hotel by taking the KAL Limousine Bus No. 6707B. Further information will be additionally given or posted on the symposium website (http://symposium.kopri.re.kr).

Between Holiday Inn Incheon Songdo Hotel and KOPRI

A shuttle bus between Holiday Inn Incheon Songdo Hotel and KOPRI will be provided during May 10th-11th. You can find the time table below;

Hotel ⇨ KOPRI	
Hotel	KOPRI
08:20	08:40

KOPRI ⇨ Hotel	
KOPRI	Hotel
18:20	18:40
20:20*	20:40*

* A shuttle bus to the hotel will be provided at 20:20 only on May 11th

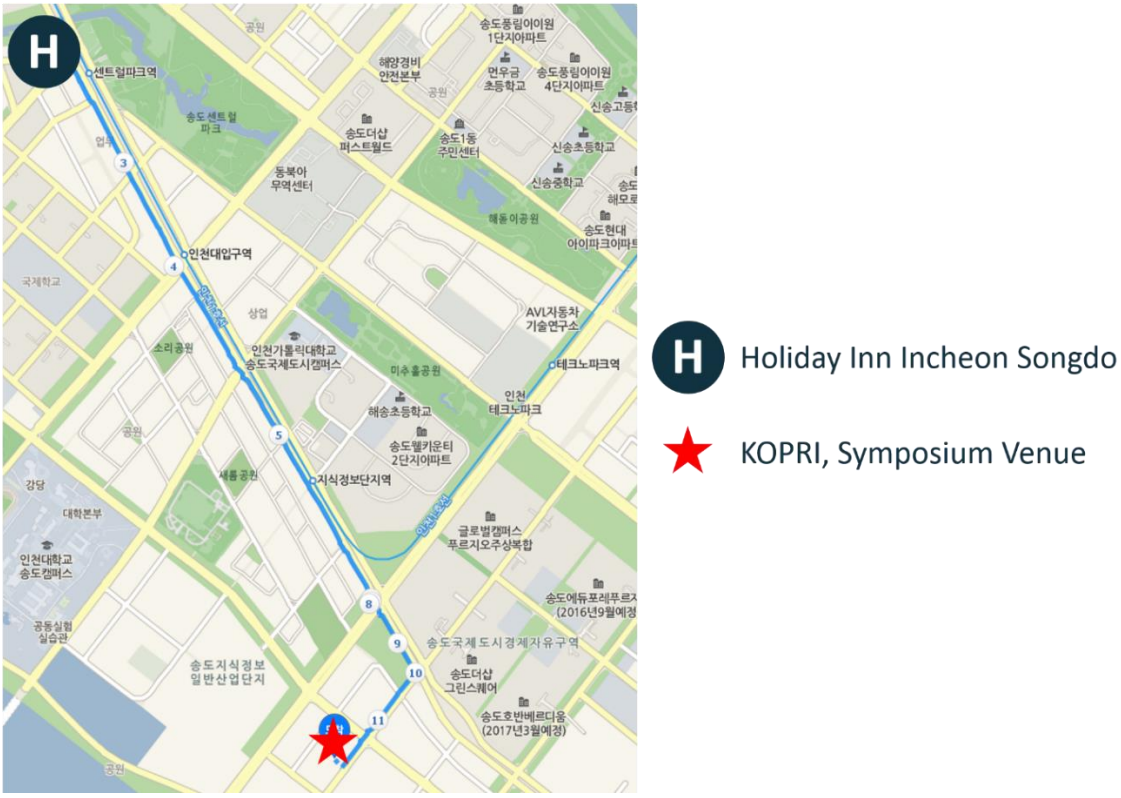

Table of Contents

PLENARY LECTURE

GEOPHYSICAL CHARACTERIZATION OF ARCTIC ECOSYSTEM BEHAVIOR

Susan S. Hubbard[1], Baptiste Dafflon[1], Haruko Wainwright[1], Anh Phuong Tran[1]
Emmanuel Leger[1] and Stan Wullschleger[2]

[1]Lawrence Berkeley National Laboratory, Berkeley CA
[2]Oak Ridge National Laboratory, Oak Ridge, TN

sshubbard@lbl.gov

ABSTRACT

Quantifying bedrock-through-canopy ecosystem dynamics that contribute to climate feedbacks is challenging due to the wide range of relevant and coupled processes that are active over different spatial and temporal scales. The Next-Generation Ecosystem Experiments (NGEE-Arctic) seeks to address this challenge by quantifying the physical, chemical, and biological behavior of terrestrial ecosystems across scales and by developing process-rich ecosystem models, in which the evolution of Arctic ecosystems can be modeled at the scale of a high resolution Earth System Model grid cell. NGEE-Arctic is initially focused on two study sites in Alaska: a flat ice-wedge polygon tundra ecosystem near Barrow, AK and ecosystems on the Seward Peninsula – a region that is relatively warmer and that has more topographic, vegetation, permafrost and bedrock variability.

SEA-ICE SATELLITE OBSERVATION AND INTERNATIONAL BUOY NETWORKS

Pablo Clemente-Colón

U.S. National Ice Center, Washington, DC, USA

ABSTRACT

The long-term monitoring of the Polar Regions by satellite systems has provided us with an understanding of the evolution of pan-Arctic and circumpolar Antarctic sea ice cover, changes in glacial ice volume, snow seasonal cover, and high-latitude atmospheric processes and weather patterns. The quality and observing capacity of these tools and their combined spatial and temporal coverage has steadily increased throughout the last several decades. As important as these remote sensing observations are, they still require of in-situ field observations from a variety of platforms that can provide validation information as well as ancillary data required for the calibration and proper interpretation of the spaceborne data.

For example, the U.S. National Ice Center (NIC) utilizes a variety of spaceborne observations from active and passive microwave to visible and infrared imagery combining them with additional information from buoys and ships, airborne and field campaigns, and forecast model output to produce our sea ice and snow analyses. These and other research and operational products have captured the significant reduction of the Arctic sea ice extent cover and a remarkable reduction in the percentage of thicker and older multi-year ice. At the same time, if anything, spaceborne sea ice extent observations around Antarctica have shown a slight increasing trend, albeit not uniform around the continent, clearly in contrast to the observed Arctic sea ice retreat. Regional warming, albedo feedback mechanisms, ocean and river interaction are among the factors at play in the Arctic responsible for changes to sea ice, snow cover, and the extent of permafrost, while processes such as katabatic wind forcing and even the location of circumpolar ocean fronts dictate the persistence and the limit of the Antarctic sea ice extent. In spite of some challenges securing continuity of critical passive microwave imaging sensors used for climate monitoring of the sea ice cover, increasing availability of other sensor data, along with open data policies, is still providing and expanded and positive outlook for monitoring of both Polar Regions.

In addition to spaceborne remote sensing observations, in-situ observations that are key to both sea ice analysis and numerical weather prediction are provided by the International Arctic Buoy Programme (IABP). Participants of the IABP have worked together for over 25 years to maintain a network of drifting buoys in the Arctic Ocean to provide meteorological and oceanographic data for real-time operational requirements and research purposes including support to the World Climate Research Programme (WCRP) and the World Weather Watch (WWW) Programme. The IABP observations are used for research in Arctic climate and climate change, forecasting weather and ice conditions, validation of satellites, forcing, validation and assimilation into numerical climate models, and tracking the source and fate of sea ice. The U.S. contributions to the IABP are coordinated through the U.S.

Interagency Buoy Program (USIABP), which is co-managed by the NIC and the University of Washington Applied Physics Laboratory Polar Science Center (PSC). Similarly, more recent parallels efforts have been established to coordinate buoy deployments around Antarctica, namely, the International Programme for Antarctic Buoys (IPAB) and the associated U.S. Interagency Program for Antarctic Buoys (USIPAB).

An important international effort that supports key sea ice and other cryosphere remote sensing and in-situ observations is the World Meteorological Organization's Global Cryosphere Watch (GCW) project. The GCW mechanism provides linkage observation, monitoring, assessment, product development, prediction, and research to meet the needs of WMO Members and partners in delivering services and seeks to .as the purveyor of authoritative, clear, and useable data, information, and analyses on the past, current and future state of the cryosphere. WMO intends for the GCW to provide a framework for reliable, comprehensive, sustained observing of the cryosphere through a coordinated and integrated approach on national to global scales to deliver quality-assured global and regional products and services. GCW organizes analyses and assessments of the cryosphere to support science, decision-making and environmental policy. Through the WMO Integrated Global Observing System (WIGOS) and the WMO Information System (WIS), GCW is expected to provide a fundamental contribution to the Global Earth Observation System of Systems (GEOSS). Other international efforts of note that will impact sea ice observing networks in the Arctic or Antarctic regions are, 1- the Sustaining Arctic Observing Networks (SAON) initiated by the Arctic Council (AC) and sponsored by the AC Arctic Monitoring and Assessment Programme (AMAP), WMO, and the International Arctic Science Committee (IASC), 2- the Climate and Cryosphere (CliC) project sponsored by WCRP and hosted at the Norwegian Polar Institute (NPI), and 3- the Southern Ocean Observing System (SOOS) initiative of the Scientific Committee on Antarctic Research (SCAR) and the Scientific Committee on Oceanic Research (SCOR).

Dr. Clemente-Colón serves as NIC chief scientist of the U.S. National Ice Center (NIC), an agency that brings together the Department of Defense - Navy, Department of Commerce – National Oceanic and Atmospheric Administration (NOAA), and the Department of Homeland Security – U.S. Coast Guard (USCG) to support coastal and marine sea ice operations and research in the Polar Regions. The NIC provides specialized strategic and tactical ice analyses to meet the operational needs of the U.S. government and is the only operational ice service in the world that routinely monitors sea ice in both the Arctic, Antarctic regions as well as in subpolar ice infested waters. In addition, the NIC provides daily global monitoring of land snow cover.

U.S. ARCTIC SCIENCE POLICY AND THE ROLE OF THE ARCTIC COUNCIL IN PROMOTING POLAR SCIENCE

Evan T. Bloom

Office of Ocean and Polar Affairs, Department of Ocean Sciences, Bureau of Oceans and International Environmental and Scientific Affairs, U.S. Department of State

ABSTRACT

The United States National Strategy for the Arctic Region sets forth the U.S. Government's strategic priorities for the Arctic region. It is designed to meet the reality of a changing Arctic environment, while simultaneously pursuing the global objective of combating the climatic changes that are driving these environmental conditions. The strategy is built on three lines of effort, namely advancing U.S. security interests, pursuing responsible Arctic region stewardship, and strengthening international cooperation. A key tenant of this strategy is that across all lines of effort, decisions need to be based on the most current science and traditional knowledge.

INVITED LECTURE

OVERVIEW OF GRENE ARCTIC CLIMATE CHANGE RESEARCH PROJECT AND ITS SUCCESSOR

Takashi Yamanouchi[1, 2]

[1]*National institute of Polar Research, Japan*
[2]*Graduate University for Advanced Studies (SOKENDAI)*

yamanou@nipr.ac.jp

ABSTRACT

Green Network of Excellence Program (GRENE) Arctic Climate Change Research Project "Rapid Change of the Arctic Climate System and its Global Influences" (funded by the Ministry of Education, Culture, Sports, Science and Technology, Japan: MEXT) had been conducted from Fy 2011 to 2015, and was the first Japanese interdisciplinary and model-observation collaborating project, advanced by many participants under a system that encompasses nearly all of Japan. Four Strategic Research Targets were set by MEXT:

1. Understanding the mechanism of warming amplification in the Arctic,
2. Understanding the Arctic climate system for global climate and future change,
3. Evaluation of the impacts of Arctic change on weather and climate in Japan, marine ecosystems and fisheries,
4. Projection of sea ice distribution and Arctic sea routes.

In order to analyze these targets, seven bottom up Research themes were selected among 23 applications:

1. Modeling Theme; 2. Terrestrial Theme; 3. Atmosphere Theme; 4. Cryosphere Theme;
5. Greenhouse Gas Theme; 6. Marine Ecosystem Theme; 7. Sea Ice and Arctic Sea Routes Theme.

Through a network of universities and institutions in Japan, this 5-year Project involves more than 300 scientists from 39 institutions and universities. The National Institute of Polar Research (NIPR) works as the core institute and The Japan Agency for Marine- Earth Science and Technology (JAMSTEC) joins as the supporting institute. It was such a unique structure that bottom up research themes answer the top down strategic research targets. Also the project supported activities of Japan Consortium for Arctic Environment Research (JCAR). In the project, field observations were conducted at pan-Arctic sites such as Svalbard, Russian Siberia, Northern Canada, Greenland and Arctic Ocean. A high precision Cloud Profiling Radar (95 GHz) was established at Ny-Ålesund, Svalbard and intensive atmospheric observation campaigns had been held. In the Arctic Ocean, research cruises by RV "Mirai" and other ice breakers were conducted and mooring buoys were deployed. Observational data were collected in the Arctic Data archive System (ADS: https://ads.nipr.ac.jp/) and opened to the public with interfaces for the analysis. Modeling studies have been promoted from fundamental process model to the general circulation model.

The successor of the project, ArCS (Arctic Challenge for Sustainability), which lays delivering emphasis on robust scientific information to stakeholders for decision making and solving problems, was started in FY2015. Within this project, a cooperative observation of black carbon are planned to be

started at Cape Baranova Station (AARI, Rusia), Severnaya Zemlya, and new activities including emphasizing aerological observations are also planned to be started for contributing to “Year of Polar Prediction (YOPP)” of Polar Prediction Project (PPP/ WMO).

SESSION

Observations of the Changing Arctic Atmosphere

CHEMICAL COMPOSITION OF POLAR AEROSOL. THE ITALIAN EXPERIENCE AND FUTURE PROSPECTS.

Robert Udisti

Robert Udisti, on behalf of the Italian Aerosol Research Group

Dept. of Chemistry, University of Florence, 50019 Sesto F.no (FI), Italy.

udisti@unifi.it

ABSTRACT

The aerosol plays a key role in the complex feedback processes between climate forcings and environmental responses, through the interaction with the solar irradiation (scattering and absorption processes) and as CCN sources. Although these processes are well known, the quantitative and qualitative impact of the aerosols in the Polar Regions is affected by a large uncertainty. The main uncertainties include the relative cloud/snow surface albedo and the scarce spatial coverage of chemical composition of aerosol at high latitudes. In order to improve our knowledge on the atmospheric load and chemical composition of Polar aerosol, several measurements and sampling campaigns were carried out in Antarctica and in the Arctic.

In Antarctica, a continuous all-year-round sampling of size-segregated aerosol were carried from 2005 to 2013 at Dome C (East Antarctica). Aerosol was collected by PM10 samplers and by multi-stage impactors. In the Arctic, a continuous all-year-round PM10 sampling campaign is ongoing since 2010 at Thule (North Greenland). At Ny Alesund (Svalbard Islands, Norway; 78°56' N, 11°56'E; 50 m asl), aerosol was collected, every year from 2010, in March to September period by using several systems (PM10 samplers, multi-stage impactors) and on different substrates (Teflon filters, quartz filters, polycarbonate and Teflon membranes). Besides, shorter measurement and sampling campaigns were carried out by using a tethered balloon, in order to study the effect of the PBL dynamics on the aerosol load and chemical composition.

Aerosol filters were analyzed for: ions composition (inorganic anions and cations and selected organic anions, including light carboxylic acids and MSA), elemental composition (by PIXE analysis), main and trace metals (including Rare Earth Elements - REEs, by ICP-HR-MS), Pb isotopic ratios (by ICP-QMS) and Elemental/Organic Carbon fractions (EC/OC, by Sunset thermo-optical analysis). Besides, continuous measurements of particle size-distribution (TSI-SMPS and TSI-APS; 6 nm – 20um; 10 min resolution) and Black Carbon (by Particle Soot Absorption Photometry – PSAP) were carried out during the sampling periods. Specific chemical markers (such as REEs elements for dust, MSA for biogenic emissions, selected heavy metals for local and long-range anthropic sources), Positive Matrix Factorization (PMF) statistical analysis, and Back-Trajectory Cluster Analysis were used in order to identify the aerosol source areas and to evaluate reliable source apportionment.

The most relevant results are here shown, with particular attention to: 1. nucleation (by SMPS measurements) and long range transport (by APS measurements) events; 2. intra- and inter-annual

trends of the most relevant markers for anthropogenic and natural sources; 3. Characterization of long-range or local dust deposition; 4. evidences of phytoplanktonic blooms by specific marine biogenic markers; 5. reconstruction of the different contributions (anthropogenic, sea spray, crustal, biogenic) to the sulphate budget.
Future prospects for aerosol studies in the Arctic and in Antarctica (including possible activity at the Korean Antarctic base Jang Bogo Station) are also presented.

ATMOSPHERIC DIMETHYL SULFIDE IN ARCTIC OCEAN

Ki-Tae Park

Ki-Tae Park[1], Kitack Lee[2], Young Jun Yoon[1], Bang-youg Lee[1], Ove Hemansen[2]

[1]Arctic Research Center, Korea Polar Research Institute, Incheon, Korea
[2]School of Environmental Science and Engineering, Pohang University of Science and Technology, Pohang, Korea
[3]Norwegian Institute of Air Research, Kjeller, Norway

ktpark@kopri.re.kr

ABSTRACT

Quantifying the relationship between oceanic emissions of dimethyl sulfide (DMS) and ocean biology presents a major challenge. We analyzed the atmospheric DMS mixing ratios in an Arctic region (Svalbard, 78.5°N, 11.8°E) during the phytoplankton growth periods in 2010, 2014, and 2015, and found regionally and temporally varying relationships between the atmospheric DMS and the strength of the DMS source in the ocean surrounding the observation site. Our analysis showed that atmospheric DMS mixing ratio was strongly correlated to potential DMS source strength ($r = 0.6–0.8$, $P<0.05$) during the phytoplankton bloom period. Moreover, the DMS production capacity of the Greenland Sea was estimated to be approximately 5 times the capacity for the Barents Sea, whereas phytoplankton biomass in the Barents Sea was 4 times that in the Greenland Sea during the bloom periods. These results indicate a higher abundance of DMS-producing phytoplankton in the Greenland Sea than in the Barents Sea during the phytoplankton bloom period. However, during the periods following the bloom, atmospheric DMS mixing ratio was not significantly related to the source strength of DMS ($P>0.05$), possibly because of the growing importance of DMS production by grazing and bacterial activity with the decreasing contribution of the direct DMS production by phytoplankton. This approach is a potentially useful tool for detecting changes in the regional and temporal DMS production capacity of Arctic Ocean and identifying unique associations between atmospheric DMS mixing ratio and phytoplankton abundance as a consequence of warming across the Arctic environment.

CHALLENGING THE NEW REMOTE-SENSING OF AEROSOLS AND CLOUDS FROM SURFACE AT THE POLAR SITES

Masataka Shiobara

Masataka Shiobara[1,2], Masanori Yabuki[3], Toshiaki Takano[4], Hajime Okamoto[5], Makoto Kuji[6], Hiroshi Kobayashi[7] and Akihiro Uchiyama[8]*

[1]National Institute of Polar Research, Japan
[2]The Graduate University for Advanced Studies, Japan
[3]Kyoto University, Japan
[4]Chiba University, Japan
[5]Kyushu University, Japan
[6]Nara Women's University, Japan
[7]University of Yamanashi, Japan
[8]National Institute for Environmental Studies, Japan

shio@nipr.ac.jp

ABSTRACT

Aerosols and clouds are key elements having a potential to change climate by their radiative effects on the energy balance in the global climate system. In order to monitor the optical properties and vertical structures of aerosols and clouds in the polar atmosphere, ground-based remote-sensing measurements using Sky-radiometer, Micro-pulse Lidar (MPL) and All-sky camera have been performed continuously at Ny-Alesund (78.9N, 11.9E), Svalbard in the Arctic and at Syowa Station (69.0S, 39.6E) in the Antarctic on a long-term basis since early 2000's.

Further in addition to such regular measurements, new active remote-sensing measurements have started in Ny-Alesund with a Polarized MPL (PMPL) in August 2013 and a 95GHz Doppler cloud radar (FALCON-A) in September 2013 for cloud microphysics and phase classification. Lidar/radar combined data analysis is now available since the collocated measurements of PMPL and FALCON-A have acquired successfully in Ny-Alesund.

Aerosol optical thickness (AOT) is one of essential parameters for estimating the direct effect of aerosols. AOTs, however, cannot be obtained for polar night as far as we employ sun photometry at the polar site. The moon could be alternative to the sun as a light source. To obtain AOTs during the polar night season, a moon photometer was developed with modification of an existing instrument, that is, the Prede POM-02 Sky-radiometer. We plan to deploy the modified Sky-radiometers to Ny-Alesund and Syowa Station.

These measurements are also expected to contribute ground validation of the EarthCARE (Ear th Clouds, Aerosols and Radiation Explorer) retrievals for aerosols and clouds over the polar region. The E-CARE satellite is scheduled to launch in 2018.

UPPER ATMOSPHERIC RESEARCH ACTIVITY AT NORTHERN HIGH LATITUDE

Jeong-Han Kim

Jeong-Han Kim[1], Changsup Lee[1], Jieun Kim[1], Geonhwa Jee[1], John W. Meriwether[2], Devin Wyatt[3], and Trond Trondsen[3]*

[1]Korea Polar Research Institute, Korea
[2]Department of Physics, Clemson University, USA
[3]Keo Scientific Ltd., Canada

jhkim@kopri.re.kr

ABSTRACT

KOPRI has been operating Fourier Transform Spectrometers (FTS) at Kiruna, Sweden (68°N, 21°E) and Dasan Station (79°N, 12°E) since its installation in 2002 and 2003, respectively, in order to measure the upper atmospheric temperatures at around 90 km altitude. In addition, we recently installed Fabry-Perot Interferometer (FPI) that measures upper atmospheric wind and relative temperature, at Light-free Cabin in Ny-Alesund to investigate the interaction between the ionosphere and thermosphere in the polar cap region. In this presentation, we introduce the upper atmospheric research activities conducting by KOPRI, including the optical and radar observations for the ionosphere and thermosphere in the auroral oval and polar cap region, and some application studies using the obtained data will also be presented.

INVESTIGATIONS AT THE NEW RUSSIAN RESEARCH STATION "ICE BASE CAPE BARANOV" IN 2013 – 2015 YEARS

Aleksander Makshtas

A.Makshtas, V. Sokolov, P. Bogorodskii, V. Borodkin

Arctic and Antarctic Research Institute, St.Petersburg, Russia

ABSTRACT

Research Station "Ice base “Cape Baranov" of Arctic and Antarctic Research Institute (AARI) had been opened in the fall 2013 on the Bolshevik Island, Archipelago Severnaya Zemlia. Now it is going as the integrated observatory, conducting comprehensive studies in practically all areas of Earth Sciences: from free atmosphere to sea ice and sea water structure in the Shokalsky Strait, from glaciers to permafrost, from paleogeography to ornithology. Overview of activities together with some preliminary results of field works at the station, performing in 2014 - 2015 years, is presented with especial attention to investigations of fast ice formation and destruction in the Strait Shokalski in vicinity of Research station "Ice Base “Cape Baranov”. During field measurements, executed in winter – spring the role of snow cover in the formation of ice, characteristic for both the Arctic and Antarctic Seas, was revealed. Also some peculiarities of fast ice structure transformation during summer are described.

SESSION

Modeling the Physical Processes of Arctic Climate System

PARAMETERIZING PERMAFROST THAW INDUCED WETLAND DYNAMICS AND THE EFFECTS ON METHANE DYNAMICS

Hanna Lee

Hanna Lee[1], Sean C. Swenson[2], David M. Lawrence[2]

[1]Uni Research Climate/Bjerknes Centre for Climate Research, Bergen, Norway
[2]Climate and Global Dynamics Division, National Center for Atmospheric Research, Boulder, Colorado, USA

hanna.lee@uni.no

ABSTRACT

Projecting permafrost carbon climate feedback largely depends on model representation of permafrost, permafrost thaw-associated local hydrological change, and the link between biogeophysics and biogeochemistry. Our previous work showed the effects of incorporating 'excess ice' in the Community Land Model (CLM) and how excess ice and subsequent melting of excess ice under warming climate affects energy and hydrological cycles within the model. Here, we develop permafrost affected wetlands with melting of excess ice by using gridcell microtopography to better link permafrost thaw and subsequent methane (CH4) dynamics.

Production and oxidation of CH4 is a function of gridcell inundated fraction within the model. The functioning version of the CH4 model parameterizes gridcell inundated fraction using water table depth and surface runoff. Unfortunately, this method contains problems in representing dynamic seasonality of the gridcell inundated fraction and is not compatible with some of the recent model developments to represent permafrost thaw related processes. The future model development plan is to parameterize inundated fraction based on precipitation and river channeling to capture seasonal dynamics of hydrological cycles. Here, we investigate how different model parameterization of inundated fraction affect Arctic hydrological cycles. In addition, we quantify the rate of CH4 production and oxidation under changes in inundated fraction using different parameterization methods. We used CLM4.5BGC to understand the behavior of hydrology as well as CH4 production and oxidation. The results show that using water table depth and surface runoff to parameterize inundated fraction result in unrealistic seasonality especially in the high latitude region. For instance, winter freezing, spring thaw, and summer increase in inundated fraction were not manifested using water table depth and surface runoff to parameterize inundated fraction. The two other methods simulated these processes more realistically throughout the season except that precipitation based parameterization underestimated and river channeling based parameterization overestimated the overall high latitude inundated fraction compared to satellite based estimation. Despite the large difference in inundated fraction estimation, total CH4 production and oxidation simulated in the high latitude region were similar across the three different parameterization of inundated fraction.

Our development will allow more realistic simulations of permafrost thaw related processes within the Earth System Model by global scale simulations such as permafrost thaw, thermokarst formation, Arctic wetland formation and seasonal cycles, and CH4 dynamics. Finally, the coupled framework of our model will provide a more accurate simulations of permafrost carbon-climate feedback cycles.

LAND SURFACE, SNOW AND SOIL MOISTURE IN LAND-CLIMATE FEEDBACK AND MODEL DIAGNOSIS

Hyungjun Kim

Hyungjun Kim[1]*

[1]Institute of Industrial Science, The University of Tokyo, Japan

hjkim@iis.u-tokyo.ac.jp

ABSTRACT

The solid and liquid water stored at the land surface has a large influence on the regional climate, its variability and its predictability, including effects on the energy and carbon cycles. Notably, snow and soil moisture affect surface radiation and flux partitioning properties, moisture storage and land surface memory. Recently, the Land Surface, Snow and Soil-moisture Model Intercomparison Project (LS3MIP) was initiated as an intercommunity effort between Global Energy and Water Cycle Exchanges Project (GEWEX) and Climate and Cryosphere (CliC) to contribute to the 6th phase of Coupled Model Intercomparison Projec (CMIP). It was designed to provide a comprehensive assessment of land surface, snow, and soil moisture feedbacks on climate variability and climate change, and to diagnose systematic biases in the land modules of current Earth System Models (ESMs). In this presentation, the details of the project will be introduced which includes the experiment structure, land forcing data generation, and preliminary results of long-term (1901-2010) land surface estimation and known problems.

SURFACE MEASURED CLOUD PROPERTIES FOR IMPROVING CLOUD PARAMETERIZATION

Jin-Ho Yoon[1], K. Sunny Lim[2]*

[1]Gwangju Institute of Science and Technology (GIST), Gwangju, Korea
[2]Pacific Northwest National Laboratory, Richland, WA, USA

ABSTRACT

Cloud radiative forcing varies significantly depending on cloud types. An accurate classification of cloud-type is an important step forward to understand the impact of clouds on the energy budget and hydrological cycle in a regional and global scale. In order to provide a long-term database of cloud types over the Atmospheric Radiation Measurement (ARM) Southern Great Plains (SGP) site, we developed cloud-type classification algorithm based on typical values of the cloud top, cloud base, and the physical thickness of cloud layers, which vary according to the different cloud types, using the cloud layer information from Active Remote Sensing of Clouds (ARSCL).

Classified low clouds using the cloud-type classification algorithm can be further categorized into shallow cumulus clouds using the cloud fraction information from the Total Sky Imager (TSI) and a ceilometer. We automate the selection of shallow cumulus period during spring and summer seasons to complement the Large Ensemble Simulation (LES) ARM Symbiotic Simulation and Observation (LASSO) project. The produced dataset of shallow cumulus period have been compared with the manually selected dataset (Berg and Kassianov, 2008; Zhang and Klein, 2013) and showed the promising results with 70 percent hit, 20 percent false-positives, 10 percent missing rates.

CONTINUOUS MEASUREMENT OF SOIL CARBON EFFLUX WITH FORCED DIFFUSION (FD) CHAMBERS IN A TUNDRA ECOSYSTEM OF ALASKA

Yongwon Kim[1], Sangjong Park[2], Bangyong Lee[3], and David Risk[4]

[1]International Arctic Research Center (IARC), University of Alaska Fairbanks (UAF), USA
[2]Division of Polar Climate Research, Korea Polar Research Institute (KOPRI), Korea
[3]Arctic Research Center, Korea Polar Research Institute (KOPRI), Korea
[4]Department of Earth Sciences, St. Francis Xavier University, Canada

kimyw@iarc.uaf.edu

ABSTRACT

Soil is a significant source of CO2 emission to the atmosphere, and this process is accelerating at high latitudes due to rapidly changing climates. In order to investigate the sensitivity of soil CO2 emissions to high temporal frequency variations in climate, we performed continuous monitoring of soil CO2 efflux with Forced Diffusion (FD) chambers at an interval of a half hour, within three representative Alaskan soil cover types with underlying permafrost. These sites were established during the growing season of 2015 located on the Seward Peninsula in western Alaska. The chamber system is conceptually similar to a dynamic chamber, but the FD is more durable, water-resistant and consumes less power, which lends itself to remote deployments. We first conducted methodological tests, testing different frequencies of measurement, but did not observe a significant difference when collecting data at 30-min measurement intervals, or at 10-min measurement intervals (averaged half-hourly) ($p<0.001$). At the study sites, we observed cumulative ecosystem respiration of 62.0, 126.3, and 133.5 gC m-2 for the growing period, at sphagnum, lichen, and tussock, respectively, corresponding to 83.8, 63.7, and 79.6% of annual carbon emissions. All sites showed strong sensitivity to air temperature rather than soil temperature. Growing season soil carbon emissions extrapolated over the region equated to 0.17 ± 0.06 MgC over the measurement period, which is 47% higher than previous estimates from coarse-resolution manual chamber sampling, presumably because it better captured high efflux events. This finding demonstrates how differences in measurement method and frequency can impact interpreted seasonal and annual soil carbon budgets. We conclude that annual CO2 efflux-measurement with FD chamber networks would be an effective means to quantify growing and non-growing season soil carbon budget, and would optimally be paired with time-lapse imagery to track local and regional changes in environment and climate in a warming Arctic.

SESSION

Climate Change and Arctic Terrestrial Ecosystems

ESTIMATE OF THE WATER BALANCE OF A DEGLACIATING CATCHMENT ON THE WESTERN COAST OF SPITSBERGEN (AUSTRE LOVÉN GLACIER CATCHMENT, SVALBARD)

Christelle Marlin

Christelle Marlin[1], Mélanie Quenet[1], Madeleine Griselin[2], Florian Tolle[2], Jean-Michel Friedt[3] and Eric Bernard[2]

[1] UMR 8148 GEOPS, Université Paris-Sud-CNRS, Orsay, France
[2] UMR 6049 THEMA, Université de Franche-Comté-CNRS, Besançon, France
[3] UMR 6174 FEMTO-ST, Université de Franche-Comté-CNRS, Besançon, France

christelle.marlin@u-psud.fr

ABSTRACT

The Austre Lovénbreen is a 4.5 km^2 land-based temperature glacier along the west coast of Spitsbergen, that experience shrinking like other glacier along the Brøgger peninsula. The glacier is monitored for annual and winter mass balances since 2008. In addition to mass balance measurements, we used geodetic methods and GPS data for surveying the glacier change over the last decades. The results show the glacier is retreating in length (-16.4 ± 0.3 m a^{-1}) and in area (-0.027 ± 0.002 km^2 a^{-1}) and in volume (-2.3 ± 0.1 x 10^6 m^3 water equivalent per year or -0.22 ± 0.01 m w.e. a^{-1}. In order to estimate the water balance, discharge and air temperature were also measured since 2008. In addition, ground temperature and suprapermafrost groundwater potentiometric level are also measured (since 2010). The average total discharge is 1 m a^{-1} with respect to the catchment area. The time series of discharge (June-October) may be divided into three periods: an early melt season (1–5% of total annual runoff), a peak flow period (70–90%) and a late melt season (10–30%). Based on our measurements and climatic data provided by the meteorological station of Ny-Ålesund, we computed the contribution of each component of the water balance: meltwater from the glacier (52% divided into 32% snowmelt and 20% icemelt), 18% effective summer precipitation, 7% proglacial area snowmelt, 3% subglacial, perennial water. The remaining 20% corresponds to the contribution of both slopes snowmelt and suprapermafrost groundwater to the water balance. The active layer temperature measurements and suprapermafrost groundwater potentiometric level monitoring show that a water-table does take place above the frozen ground in the proglacial area when the active layer thaws to a depth of 2.5 m. The proglacial groundwater takes part of the hydrological system. During summer, the suprapermafrost aquifer undergoes multiple recharge episodes during the main rainwater events and snowmelt period. The potentiometric level monitoring shows that groundwater contributes to stream water flows by restituting belatedly part of summer precipitation and snowmelt. Hydrochemical data and isotopic contents (δ^{18}O and δ^2H) values of river water are consistent with a model of mixing that implies snowmelt, summer precipitation, subglacial water and suprapermafrost groundwater. The isotopic compositions in ^{13}C and

^{14}C of river water indicate a multiple source of dissolved C, including old C from soil or carbonated rocks.

CARBON CYCLING IN THE NEW ARCTIC

Claudia Czimczik

Earth System Science, University of California, Irvine, USA

ABSTRACT

Rapid warming, increasing precipitation and a reduction in snow cover duration are releasing constraints on carbon (C) cycling in the Arctic. Critical uncertainties in future climate projections today are (1) how much and how quickly microorganisms may decompose vast amounts of ancient organic C that were previously disconnected from the active C cycle in permafrost, and (2) what fraction of permafrost C will be transferred to the atmosphere as carbon dioxide (CO2) as opposed to the more powerful greenhouse gas methane (CH4). At the same time, multiple lines of evidence suggest that the terrestrial Arctic is undergoing substantial increases in plant productivity, facilitated through the expansion of shrub biomass and at the expense of graminoid-dominated tundra. The implications of this "greening" on permafrost thaw, accumulation of shrub-C in soils, and the ability of microorganisms to decompose permafrost C further challenge our ability to forecast the New Arctic's carbon feedback to climate change.

We use measurements of land-atmosphere CO2 and CH4 exchange and inventories of soil C stocks and quality (stable & radio isotopes, C/N, n-alkanes) at long-term climate manipulations and along natural gradients of shrub density to assess the impacts of climate and vegetation change on ecosystem C dynamics. Further, we quantify the concentration and mean age of whole-lake CH4 emissions on the Arctic Coast Plain of Alaska to understand the role of thaw lakes in transferring terrestrial permafrost C to the atmosphere.

We find that together with warming, precipitation exhibits a key control on magnitude and sources of permafrost C emissions. While warming alone accelerates loss of older C pools from high arctic soils, warming and wetting strongly increases plant productivity and dampens the loss of older C, and thus the strength of the Arctic C feedback to climate change. Second, we show that thaw depth is shallower in shrub than in graminoid tundra, and that mineral soils from shrub tundra have higher C content and quality than graminoid tundra. And, in laboratory incubations, additions of labile C (mimicking shrub root exudation) do not stimulate the decomposition of in situ mineral soil C. Third, we demonstrate that Northern Alaska's thaw lakes currently emit predominantly biogenic CH4 with a mean age of less than 2,500 years BP, and that surface geology is the dominant predictor of the age of lake CH4 emissions.

Our findings suggest that shrub expansion may augment soil C storage in the Arctic because a greater proportion of soil C is frozen in permafrost, soil C under shrubs turns over more slowly, and existing C in mineral soil does not appear to be vulnerable to loss via priming. And, thaw lakes are not currently landscape hotspots for transferring ancient terrestrial C to the atmosphere. Taken together, our results indicate that current projections of the Arctic's C-climate feedback may be too large. Future work should focus on building scalable, quantitative relationships between plant productivity and ecosystem and soil C storage, quantify the role of winter-time C emissions and explore how the long-term dynamics of thaw lakes are related to their C emission.

CHARACTERISATION OF ARCTIC SOIL DEVELOPMENT USING THE NEW BIOGEOCHEMICAL MODEL: SHIMMER

James Bradley

James Bradley[1], Alexandre Anesio[1], Sandra Arndt[1], Marie Sabacka[1], Gary Barker[1], Liane G. Benning[2,3], Joshua Blacker[2], Joy Singarayer[4], Martyn Tranter[1] and Marian Yallop[1]*

[1]University of Bristol, UK
[2]University of Leeds, UK
[3]GFZ, Research Centre for Geosciences, Potsdam, Germany
[4]University of Reading, UK

j.bradley@bristol.ac.uk

ABSTRACT

Soils exposed following glacier retreat exhibit successional characteristics in microbiology and geochemisrty over timescales of decades to centuries. Here we used the new biogeochemical model SHIMMER alongside empirical observations and measurements from a chronosequence from the forefield of Midtre Lovénbreen, Svalbard (78˚N), to investigate the first 120 years of soil development. We show that biomass accumulates with soil age, and that the bacterial production is dominated by autotrophy (rather than heterotrophy). Heterotrophic production in young soils (0-20 years) is supported by labile substrate, whereas carbon stocks in older soils (60-120 years) are more refractory. Nitrogen-fixing organisms are responsible for the initial accumulation of available nitrates in the soil. We also infer that allochthonous deposition of organic material may play a significant contributory role that could accelerate or facilitate further microbial growth. This integrated model-data approach provides a quantitative evaluation on the dynamics of glacier forefield systems that have previously largely been explored through qualitative interpretation of datasets.

REGULATORY TEMPERATURE ADAPTATIONS IN GLOBALLY IMPORTANT METHANE OXIDIZING BACTERIA OF THE GENUS *Methylobacter*

Alexander T. Tveit

Alexander T. Tveit[1], Alena Didriksen[1], Hans-Jörg Hellinger[2], Thomas Rattei[2], Mette M. Svenning[1]

[1]Department of Arctic and Marine Biology, UiT The Arctic University of Norway, Post Box 6050 Langnes, 9037 Tromsø, Norway
[2]The Division of Computational Systems Biology, Department of Microbiology and Ecosystem Science, University of Vienna, Althanstrasse 14, Vienna, Austria

alexander.t.tveit@uit.no

ABSTRACT

Methylobacter tundripaldum and closely related Methylobacter species are the dominant methane oxidizing bacteria (MOB) in many exposed Arctic and temperate ecosystems. Efficient regulation to keep the cell in tune with changing temperatures is crucial in these environments. We aimed to identify the relationship between temperature, gene expression and function in M. tundripaludum, combining growth, CH4-oxidation and transcriptomic experiments at 8, 15, 21 and 27 °C.

WARMING MAY NOT INCREASE METHANE EMISSION FROM ARTIC ECOSYSTEMS

Hojeong Kang

Hojeong Kang[1], Juyoung Seo[1], and Jaehyun Lee[1]*

[1]Yonsei University, Korea

hj_kang@yonsei.ac.kr

ABSTRACT

Ecosystems in arctic region are expected to experience the strongest effects of global warming over the coming century, resulting in thawing permafrost and thickening of the perennially frozen ground's active layer. Soils of the circumarctic-region contain up to 300 Pg of carbon, which is around a quarter of the world's soil carbon pool. It is widely believed that the warming of these cryopreserved carbon stocks will lead to the release of greenhouse gases including methane.

SHIFTS IN TAXONOMIC AND FUNCTIONAL STRUCTURE OF BACTERIAL COMMUNITIES DURING A SHORT-TERM SUCCESSION IN THE HIGH ARCTIC

Mincheol Kim[1], Ji Young Jung[1] and Yoo Kyung Lee[1]*

[1]Korea Polar Research Institute, South Korea

mincheol@kopri.re.kr

ABSTRACT

Primary succession after glacier retreat has been widely studied in plant communities, but bacterial succession is still poorly understood. Here, we investigated the shift in bacterial community structure and soil development along a 145-year old chronosequence in Austre Lovénbreen glacier foreland on Svalbard.

SESSION

Sea Ice Networks for Observation and Prediction

EVOLUTION OF MELT PONDS ON ARCTIC SEA ICE AS OBSERVED FROM THE ICE, AIR, AND SATELLITES

*Ignatius Rigor**

Melinda A. Webster[1], Ignatius G. Rigor[1], Donald K. Perovich[2,3], Jacqueline A. Richter-Menge[2], Christopher M. Polashenski[2], and Bonnie Light[1]

[1]Polar Science Center, Applied Physics Laboratory, University of Washington, Seattle, Washington, USA
2US Army Corps of Engineers, Engineer Research and Development Center, Cold Regions Research and Engineering Laboratory, Hanover, New Hampshire, USA
3Thayer School of Engineering, Dartmouth College, Hanover, New Hampshire, USA

ignatius@uw.du

ABSTRACT

The seasonal evolution of melt ponds has been well documented on multiyear and landfast first-year sea ice, but is critically lacking on drifting, first-year sea ice, which is becoming increasingly prevalent in the Arctic. Using 1 m resolution panchromatic satellite imagery paired with airborne and in situ data, we evaluated melt pond evolution for an entire melt season on drifting first-year and multiyear sea ice near the 2011 Applied Physics Laboratory Ice Station (APLIS) site in the Beaufort and Chukchi seas. A new algorithm was developed to classify the imagery into sea ice, thin ice, melt pond, and open water classes on two contrasting ice types: first-year and multiyear sea ice. Surprisingly, melt ponds formed 3 weeks earlier on multiyear ice. Both ice types had comparable mean snow depths, but multiyear ice had 0–5 cm deep snow covering 37% of its surveyed area, which may have facilitated earlier melt due to its low surface albedo compared to thicker snow. Maximum pond fractions were 53 +/-3% and 38 +/-3% on first-year and multiyear ice, respectively. APLIS pond fractions were compared with those from the Surface Heat Budget of the Arctic Ocean (SHEBA) field campaign. APLIS exhibited earlier melt and double the maximum pond fraction, which was in part due to the greater presence of thin snow and first-year ice at APLIS. These results reveal considerable differences in pond formation between ice types, and underscore the importance of snow depth distributions in the timing and progression of melt pond formation.

SNOW DEPTH ON ARCTIC AND ANTARCTIC SEA ICE DERIVED FROM AUTONOMOUS (SNOW BUOY) MEASUREMENTS

Marcel Nicolaus[1], Stefanie Arndt[1], Stefan Hendricks[1], Georg Heygster[2], Mario Hoppmann[1], Marcus Huntemann[1,2], Christian Katlein[1], Danielle Langevin[3], Leonard Rossmann[1], Sandra S chwegmann[1]

[1]Alfred-Wegener-Institut Helmholtz-Zentrum für Polar- und Meeresforschung (AWI), Bremerhaven, Germany
[2]Institut für Umweltphysik (IUP) der Universität Bremen, Germany
[3]MetOcean Data Systems, Halifax, Canada

ABSTRACT

The snow cover on sea ice received more and more attention in recent sea ice studies and model simulations, because its physical properties dominate many sea ice and upper ocean processes. In particular; the temporal and spatial distribution of snow depth is of crucial importance for the energy and mass budgets of sea ice, as well as for the interaction with the atmosphere and the oceanic freshwater budget. Snow depth is also a crucial parameter for sea ice thickness retrieval algorithms from satellite altimetry data. Recent time series of Arctic sea ice volume only use monthly snow depth climatology, which cannot take into account annual changes of the snow depth and its properties. For Antarctic sea ice, no such climatology is available. With a few exceptions, snow depth on sea ice is determined from manual in-situ measurements with very limited coverage of space and time. Hence the need for more consistent observational data sets of snow depth on sea ice is frequently highlighted.

EVOLUTION OF THE BEAUFORT SEA MARGINAL ICE ZONE: RESULTS FROM AUTONOMOUS OBSERVATIONS COLLECTED DURING 2014 MIZ PROGRAM

Craig M. Lee [1] and the ONR Marginal Ice Zone Team*

[1]Applied Physics Laboratory, Univ. of Washington

ABSTRACT

The observed reduction of Arctic summertime sea ice extent and expansion of the marginal ice zone (MIZ) have profound impacts on the balance of processes controlling sea ice evolution, including the introduction of several positive feedback mechanisms that may act to accelerate melting. Examples of such feedbacks include increased upper ocean warming though absorption of solar radiation, elevated internal wave energy and mixing that may entrain heat stored in subsurface watermasses (e.g. the relatively warm Pacific Summer (PSW) and Atlantic (AW) waters) and elevated surface wave energy that acts to deform and fracture sea ice, all of which grow in importance with increasing open water extent.

Investigations of MIZ dynamics must resolve the short spatial and temporal scales associated with the processes that govern the exchange of momentum, heat and freshwater near the atmosphere-ice-ocean interface while also achieving the spatial scope and temporal persistence required to characterize how the balance of processes shifts as a function of evolving open water fraction and open water fetch to the south. The recent Office of Naval Research (ONR) Marginal Ice Zone program employed an integrated system of autonomous platforms to provide high-resolution measurements that extend from open water, through the MIZ and deep into ice-covered regions while providing persistence to quantify evolution over an entire summertime melt season. This talk will provide an overview of the strategy developed by the ONR MIZ team and results from the 2014 field program.

MARGINAL ICE ZONE PROCESSES OBSERVED FROM UNMANNED AERIAL SYSTEMS

Christopher J. Zappa

Christopher J. Zappa[1], Scott M. Brown[1], Sophia E. Brumer[1], Deborah A. Le Bel[1], and Tejendra Dhakal[1]*

[1]Lamont-Doherty Earth Observatory, Ocean and Climate Physics, Columbia University, P. O. Box 1000, 61 Route 9W, Palisades, NY 10964, USA

zappa@ldeo.columbia.edu

ABSTRACT

Recent years have seen extreme changes in the Arctic. Marginal ice zones (MIZ), or areas where the "ice-albedo feedback" driven by solar warming is highest and ice melt is extensive, may provide insights into the extent of these changes. Furthermore, MIZ play a central role in setting the air-sea CO2 balance making them a critical component of the global carbon cycle. Incomplete understanding of how the sea-ice modulates gas fluxes renders it difficult to estimate the carbon budget in MIZ. Here, we investigate the turbulent mechanisms driving mixing and gas exchange in leads, polynyas and in the presence of ice floes using both field and laboratory measurements.

DRIFT, DRAG AND DETERIORATION: MAPPING THE FATE OF LARGE ICE HAZARDS

Alexander Forrest[1,4], Derek Mueller[2], Bernard Laval[3], Andrew Hamilton[3], Isak Bowden-Floyd[4], Peter King[4], Damien Guihen[4], Vanessa Lucieer[4,5]*

[1]University of California – Davis, California, United States of America
[2]Carleton University, Ontario, Canada
[3]University of British Columbia, Vancouver, Canada
[4]Australian Maritime College, University of Tasmania, Tasmania, Australia
[5]Institute for Marine and Antarctic Studies, University of Tasmania, Tasmania, Australia

alforrest@ucdavis.edu

ABSTRACT

Floating ice hazards are a risk to safe navigation in both the Arctic and the Southern Ocean as a result of changing ice conditions and increased marine traffic in recent years. These hazards include icebergs and ice islands (a type of iceberg in the Arctic that is tabular in shape and up to several km in length). Under the influence of climate change, calving (break-off) rates of tidewater glaciers, floating glacier tongues and ice shelves, the source of icebergs and ice islands, appear to be increasing, particularly in the Arctic. Understanding the drift and deterioration of these ice features is a key challenge to the ice community and tends to be limited by a paucity of observational data from around Newfoundland and Labrador, where water temperatures are significantly warmer and interaction with sea ice is less common than in Arctic waters. Observations of drifting ice islands that calved from the Petermann Glacier in NW Greenland were attempted in 2011 in the Canadian High Arctic (69-75ºN) to examine draft, surface roughness and basal features using an Autonomous Underwater Vehicle (AUV) to help improve numerical ice hazard drift models. The AUV was successfully deployed under a grounded ice island, yet key challenges for future deployments involve mapping ice that is both drifting and rotating. Acoustic localization, combined with terrain-relative navigation, is proposed to deal with this motion, enabling accurate in situ measurements of the underside and sidewalls of the ice. This data is required to help understand the drift, deterioration and ultimate fate of these ice hazards in a changing global climate.

THE NEED FOR CROSS-DISCIPLINARY INTERNATIONAL RESEARCH ON ARCTIC CHANGE

Jeremy Wilkinson

British Antarctic Survey

ABSTRACT

One of the most visible aspects of climate change is the dramatic loss of Arctic sea ice; both sea ice extent and thickness. The striking loss of sea-ice in recent summers reflects profound changes in the Arctic system. However these climate driven changes in sea ice are not the only pressures on the region as the increase in the demand for natural resources are providing opportunities for investment, with estimates of $100bn or more coming in to the Arctic region over the next decade. However the environmental, socio-economic, and geopolitical consequences associated with Arctic change bring opportunities and possibilities, but also far-reaching change amidst the potential conflicts and risks for human activities right across the Arctic and the globe. To better understand the complexities of Arctic Change a multi-sectorial approach is needed. This innovative multi-sector approach has gained traction over recent years as it transcends disciplinary boundaries, advances knowledge of Arctic change within a regional and global context, has a sharp eye to policy-relevance, and builds strong partnerships with northern communities. We highlight various examples of cross-disciplinary international research programme on Arctic Change.

SESSION

Science, Law and Arctic Future

ARCTIC EXCEPTIONALISM

Timo Koivurova

Arctic Centre, University of Lapland

timo.koivurova@ulapland.fi

ABSTRACT

The relationships between Russia and the West are at their lowest point after the Crimean annexation and Ukraine conflict in general. Sanctions have been imposed by the Western powers against Russia, and Russia laid its own counter-sanctions. One would think that this has affected Arctic co-operation, given that Russia and the Western powers are the members of the Arctic Council. The presentation will demonstrate that in effect peaceful co-operation via many international agreements has reigned the development in the region.

THE FUTURE OF ARCTIC LEGAL ORDERS: A CHINESE PERSPECTIVE

Long ZHAO

Shanghai Institutes for International Studies

ABSTRACT

The changing environment of the Arctic has created great impact on the global ecosystem and socio-economic activities. Arctic issues have widely attracted global attention in recent years, largely due to the increasing ice-melting rate. Natural sciences usually focus on geographical, climatic and ecological issues of the Arctic region, while social scientists are discussing the evolution of Arctic governance from prospective of history, culture, geopolitics and geo-economics, analyzing policies of Arctic states towards the region. For a long period of time, comprehensive studies on the international treaty system of the Arctic, legislation process and legal orders of the Arctic have not attracted attentions of researchers.

With development of institutionalized governance structure in the Arctic, issuing legal-binding agreements under current governance bodies like Arctic Council (AC) is becoming the new priority for all parties. During the Nuuk meeting of AC held in 2011, Agreement on Cooperation on Aeronautical and Maritime Search and Rescue in the Arctic was passed as the first legal-binding agreement since its founding, the international code of safety for ships operating in polar waters (Polar Code) was also adopted by International Maritime Organization. Thus, issues related with international legal status of the Arctic, the Arctic applicable legal system, national jurisdiction on Arctic sea routes, legal bases of scientific management and environmental protection, development of Svalbard treaty create next hotspot of Arctic governance studies.

In recent years, establishment of territorial sovereignty over portions of the Arctic and its seabed has become increasingly attractive to many nations for military purposes or as a source of minerals. From perspective of Chinese scholars, the general legal system of the Arctic should not be founded on Terra nullius (No Man's Land) or Sector principle, which traces longitudinal parallels from borders of countries adjacent to the Arctic Circle to the North Pole. The legal order of the Arctic should be determined by existing institutional framework provided by the United Nations Convention on the Law of the Sea (UNCLOS). Coastal States of the Arctic Ocean are entitled rights to claim its internal waters, territorial sea, exclusive economic zone (EEZ) and the continental shelf. It is noteworthy that portions of the Arctic Ocean belong to high seas or international seabed area, which applies the principle of freedom of the high seas under the UNCLOS and the common heritage of mankind regulated by the International Seabed Authority. In addition, two special features of the international legal status of the Arctic should be also noted. First, the special international legal regime over Svalbard archipelago; Second, the outer continental shelf claimed by Russia and Norway.

The future trends of the legal order of the Arctic has direct impact on depth and wideness of different actor's participation, involve great concerns and attentions from Arctic states and AC's observers as China and Korea. Generally speaking, it can be divided into three hypothesizes as follows:

Svalbard Model. The first model advocates the establishment of a similar legal pattern in the Arctic to the Svalbard Treaty, which regulates the demilitarization of the archipelago and the signatories are given equal rights to engage in commercial activities (mainly coal mining) on the islands, provides a guideline for the parties of conflict to solve problems: shelving disputes and seeking common development. Svalbard model is calling for special agreement signed by all stakeholders of the Arctic, regulates that the Arctic is always used exclusively for peaceful purposes, freezing territorial claims in the Arctic, providing citizens of the party states free access in the Arctic for business activities, recognize the Arctic is a common heritage of mankind and etc.

Arctic Treaty Model. The second model is seeking to sign the Arctic Treaty and establish Arctic Treaty System, including following provisions: 1. Together with recognition of the Arctic coastal state's rights of internal waters, territorial sea, the EEZ and the continental shelf, freeze or cancel the provision of the outer limits of continental shelf applies in Arctic waters. 2.Establishing legal status of waters outside national jurisdiction of Arctic coastal states, including high seas, international seabed areas as common heritage of mankind; 3. Establishment of consultative procedure of party states similar with Antarctic Treaty, jointly develop a common legal institutions related with Arctic expedition, environmental protection, natural resource development and other activities.

IIulissat Model. As a typical example, Ilulissat model was started from Ministerial meeting of five Arctic coastal states in 2008. At that meeting, states representatives discussed climate change, marine environment, safety of navigation among others, and signed Ilulissat on the end. All five countries declared that there is no need to develop a new comprehensive international legal regime to govern the Arctic Ocean. Coastal states are committed to settle possible conflicts under the legal framework of UNCLOS. The limits of UNCLOS as fundamental legal system of the Arctic are that its Article 234 is the solely provision which regulates the Arctic. This article authorizes coastal states to develop and administer special non-discriminatory regulations dealing with human activities in ice-covered waters.

In general, establishment of new treaty system, freezing the territorial claims of Arctic states and seeking for demilitarization of the Arctic are common features of Svalbard Model and Arctic Treaty Model, also there are difficulties to be implemented. Unlike Antarctica, which is an uninhabited landmass administered by the Antarctic Treaty System, there is no single regulatory regime covering the entire Arctic region. The Arctic land masses are sovereign territories, while the Arctic Ocean is covered by national legal regimes, safeguard national interests will be the first priority of Arctic state before to reach consensus of establishment of such treaty, which will inevitably encounter all kinds of conflicts of interest among them, the Arctic does not have necessary political and geographical environment for establishment the Arctic treaty.

Besides, under the current situation, the competition over territorial and maritime jurisdiction among coastal states of the Arctic Ocean has far exceeded the scope of legal settlement, some countries even took drastic measures together with military activities, therefore the demilitarization of the Arctic is also difficult to be achieved.

A unified approach towards Arctic issues has not been identified. Whether in a global context or in the circle of Arctic states, scholars have not reached a consensus on basic principle, forms, channels and shares of Arctic governance, the path of governance is still in debate with varies options. Meanwhile, in addition to dialogues and cooperation between developing and developed countries, between Arctic and Non-arctic countries, disagreements still exist on the establishment of mechanism, deviation of responsibility and transfer of interests.

The future concerns of the Arctic not only include the well-being of the Arctic countries and people, but also the overall interests of the entire international community. In this increasingly globalized world, it is more important for parties to jointly explore, understand and utilize the Arctic. With further deepening cooperation in the Arctic, the primary task is to leave the contemporary system of the regulation by general international treaties without specification, which will not reflect the actual needs of the Arctic. Future Arctic legal order should make full use of the existing institutional framework of the UNCLOS, seeking legal-binding agreements on Arctic expedition, climate change and environment protection, shipping, fisheries and other specific areas will gradually provide a multilateral governance paradigm standing on international and regional co-operation, soft law instruments leaning on the common binding international legal framework as a possible solution of Arctic legal framework.

UNCLOS ARTICLE 76 AND SOME UNDERSTANDINGS OF THE CLCS ACTIVITIES

Yong Ahn Park

Seoul National University, Korea

yap@snu.ac.kr

ABSTRACT

DISCLAIMER - The views expressed herein are solely those of the speaker and do not necessarily reflect the views of the Commission on the Limits of the Continental Shelf.

It is generally understood the so-called Truman Proclamation made by President Truman of the United States in 1945 as the first clear assertion of the idea that the resources of the continental shelf belong to the coastal State. The Truman Proclamation stated that the Government of the United States regards the natural resources of the subsoil and seabed of the continental shelf (up to 200m water depth) as appertaining to the United States, subject to its jurisdiction. In fact, it is recognized that the Truman Proclamation is the first clear legal claim and assertion that the natural resources of the subsoil and seabed of the continental shelf belong to the coastal State.

The 3rd UNCLOS article 76 defines the law-science integrated concept of continental shelf by which science integrated concept of continental shelf by which a coastal State may establish the outer limits of its continental shelf beyond 200 nautical miles. And also, the Statement of Understanding (SOU) contained in Annex II to the Final Act of the Convention may be applied to establish the outer limits of its continental shelf beyond 200 nautical miles. In short,
There are two provisions for the legal definition of the continental shelf, that is, basis for establishing of the outer edge of the continental margin:
1. Article 76 paragraph 4(a)(i) and (4)(a)(ii) – for ordinary continental margin.
2. Annex II, Final Act, 3rd UNCLOS – for special continental margin.

PRECAUTIONARY PRINCIPLE: COMMON ISSUE OF LAW AND SCIENCE FOR ARCTIC ENVIRONMENTAL PROTECTION

Won-Sang SEO & Dongmin JIN

ABSTRACT

Protection of the Arctic environment is a key agenda of Arctic governance. Lawyers and scientists continue to debate each other for Arctic environmental protection. Science provides an objective basis of legal regulations necessary for the protection of the environment. If, however, a causal relationship between certain behaviors and environmental pollution has not been scientifically proven, should we choose to do the forbidden and neglect? This question is boils down to a discussion of the precautionary principle or precautionary approach. The precautionary principle is a concept that encompasses moral, legal, political, and scientific issues. I want it dealt with the precautionary principle to protect the Arctic environment from a legal point of view as a jurist.

SESSION

Social and Human Science research on the Arctic and East Asian Contribution

AGENDA SETTING FOR ARCTIC SOCIAL SCIENCES: ICARP-III, IASC SHWG AND AHDR-II

Gail Fondahl

Gail Fondahl[1]*

[1]University of Northern British Columbia, Canada

ABSTRACT

As biophysical, socio-economic and cultural changes in the Arctic accelerate, and as interest in the Arctic grows on many fronts, numerous research organizations and projects have recently initiated exercises to identify key areas that need research attention. In this paper I review three such international initiatives and the priorities they enumerate for arctic social sciences research: the Third International Conference on Arctic Research Planning (ICARP-III), the Social and Human Sciences Working Group (SHWG) of the International Arctic Science Committee (IASC), and the second Arctic Human Development Report (AHDR-II). I underscore the common findings of these initiatives, and how they might inform Korea's interest in expanding its Arctic social sciences research portfolio. I also note key overarching leitmotifs in current discourses on arctic social sciences research approaches.

CHINA AS A POLAR GREAT POWER

Anne-Marie Brady

Anne-Marie Brady[1]*

[1]University of Canterbury, New Zealand

ABSTRACT

In the last five years China has emerged as a member of the unique club of nations who are powerful at both poles. Polar states are global giants, strong in military, scientific, and economic terms. The concept of a polar great power is relatively unknown in international relations studies. Yet China, a rising power globally, is now widely using this term to sum up its aspirations and symbolise the significance of the polar regions to China's national interests.

CO-DESIGN PROJECT OF THE ENVIRONMENT EDUCATION IN/FOR THE SIBERIAN INDIGENOUS COMMUNITIES

Hiroki Takakura

Hiroki Takakura[1], Tetsuya Hiyama[2], Yoshihiro Iijima[3], Vanda Ignat'eva[4]

[1]Tohoku University, Japan
[2]Nagoya University, Japan
[3]Mie University, Japan
[4]Institute of Humanities and the indigenous Peoples of the North, SBRAS, Russia

ABSTRACT

The presentation is a report of research planning and its purpose is to develop the project more feasibly and effectively through the exchange of views in the conference. The project is a part of the Japanese Arctic Project recently launched. The purpose of the project is to make the teaching materials of environment education related to local history, and to explore the application to the public, in order to return the scientific knowledge on environment change to the related stakeholders including indigenous peoples. The materials will be produced by the collaboration of Japan-Russian researchers with local peoples. Heretofore, Japan and Russian scientists has accumulated the longer collaboration both in social and natural scientific fields in Sakha Republic, Russia. The project expands the collaboration in a transdisciplinary way. By the participatory research methods we create the chance for people to excavate local memories to rediscover their own values of local culture and environment.

KOREA'S ARCTIC INTERESTS IN FORMATION AND PROSPECTS FOR COOPERATION WITH GREENLAND

Jong Kun Choi

Associate Professor, Dept. of Political Science & International Studies and Director, the Nordic Research Program, the Institute of East and West Studies, Yonsei University, Seoul, Korea

ABSTRACT

I will introduce why South Korea's interest in the Arctic has been emerging from the perspectives of political economy. I will identify what will be the economic, political, technological and scientific barriers. In so doing, I will ask if the Arctic could be South Korea's Middle East in the 1970s that provided economic and natural resources. I will also introduce Yonsei University's network efforts to link with particularly with Greenland. Expansion of South Korea's foreign policy domain is factored into explaining Seoul's approaches to the Arctic region.

THE CURRENT SITUATION AND TASK OF THE DOMESTIC HUMAN AND SOCIAL SCIENCE RESEARCHES ON THE ARCTIC REGION

Jong-Man Han

Pai Chai University

jmhan@pcu.ac.kr

ABSTRACT

ACTIVITIES OF THE KOREA MARITIME INSTITUTE IN THE ARCTIC

Jong Deog (Justin) Kim and Jihye Kim

Korea Maritime Institute, Korea

ABSTRACT

Korea became an Observer in the Arctic Council in May 2013, and as the primary intergovernmental forum for Arctic governance, Korea places high importance in the participation of its meeting and activities. Korea Maritime Institute (KMI), a national think-tank for oceans and fisheries issues, has been involved in shaping and implementing Korea's Arctic policy since 2011 and supports the Government in its Arctic Council related endeavors primarily through organizing the Korea Arctic Experts Network (KAEN) meetings, participating to a project with Permanent Participant of the Arctic Council and co-hosting academic exchange program with UArctic.

KMI utilizes KAEN (Korea Arctic Experts Network) to coordinate Korean experts' attendance in Arctic Council Subsidiary Bodies, and periodically convenes their gathering to share and discuss meeting outcomes. KMI also promotes Korea's involvement in the Arctic Council activity by partnering with AIA in its Arctic Marine Use Mapping project. It is Korea's first Arctic Council Working Group project. Another notable Arctic Council activity of KMI includes the Korea Arctic Academy, which was launched in 2015 with UArctic which is another Observer, and its week-long program promotes friendship and understanding between Arctic students mainly from indigenous community and Korean students. These are some of the ways that KMI is involved in the Arctic affairs, and it is only one aspect of how KMI supports the Government by building a platform for carrying out Korea's Arctic policy.

KOREAN ARCTIC POLICY AND THE KOARC

Dongmin Jin

ABSTRACT

The first research project on the Arctic in Korea was "A preliminary on the Arctic 1993-95" which was done KORDI. Since a KOPRI scientist on board of the first Arctic research cruise of Chinese icebreaker Xuelong, some bilateral field studies organized and conducted in the Arctic. Opening of Arctic Dasan station in NyAlesund in 2002, the first research cruise of Korean Icebreaking research vessel Araon in 2010, entitlement of observer of the Arctic Council in 2013 and the Korea Arctic Master Plan were the cornerstones for Korean Arctic Activities.

When did Korea start to have interests in the Arctic? Some publications on the Arctic in Korea will be introduced.

As a Non-Arctic state, why has Korea interested in the Arctic. It is to enhance national profile through contributing to and participating in the global matters, climate change affecting the weather of the East Asia, sustainable development of natural resources in the Arctic, shipping and ship building, and scientists' interests in the Arctic sciences.

2013 Arctic Master Plan which was approved at the ministerial meeting in December 2013. With the vision of becoming "a country contributing to the sustainable future of the Arctic" the plan has four goals: i) strengthening scientific research, ii) exploring new opportunities, iii) promoting international cooperation, iv) establishing an institutional base. Who is the leading players of the 31 specific projects in the master plan? And what's the effects of the master plan on KOPRI, the leading polar research institute? will be discussed.

POSTER SESSION

Observations of the Changing Arctic Atmosphere

SOIL CO_2 EFFLUX FROM SEMI-ARID TUNDRA AND MOIST TUNDRA IN THE ARCTIC

Namyi Chae

Namyi Chae[1], Sang-Jong Park[2], Yongwon Kim[3], Hojeong Kang[4], Young Jun Yoon[2], Taejin Choi[2], Soon Gyu Hong[2], Larry Hinzman[3] and Bang yong Lee[2]*

[1]Korea University, Seoul Korea
[2]Korea Polar Research Institute, Incheon Korea
[3] International Arctic Research Center, University of Alaska Fairbanks, USA
[4]Yonsei University, Seoul Korea

cnamyi@korea.ac.kr

ABSTRACT

Response of the Arctic to global warming is seen as a high-sensitivity indicator of climate change. Considering that 25% of Earth's terrestrial surface is underlain by permafrost, warming permafrost may play important roles in carbon cycle of the Arctic. The soil CO_2 efflux from representative tundra ecosystems in the Arctic should be monitored in order to evaluate the potential future sensitivity of the carbon cycle to climate change. We measured soil CO_2 efflux of two different tundra ecosystems which are a semi-arid tundra in high-arctic and moist tundra near treeline in subarctic. The study sites were Ny-Ålesund (78° 55´ 24" N, 11° 55´ 15" E), Svalbard archipelago, Norway and Council, Alaska (64° 50.63´ N, 163° 42.64´ W) on the Seward Peninsula. We examined relationship between soil CO_2 efflux and various controlling factors and contribution of vegetation. Response of soil CO_2 efflux to environmental factors was compared in two type tundra ecosystem. This study was supported by a National Research Foundation of Korea grant funded by the Korean government (MSIP) (NRF-C1ABA001-2011-0021063 and NRF-2015R1C1A1A02037763).

NEW NOBLE GAS LABORATORY AT KOPRI: A PROGRESS REPORT OF METEORITE ANALYSIS

Jisu Choi

Jisu Choi[1], Jong Min Baek[1], Changkun Park[1], Keisuke Nagao[1], Mi Jung Lee[1], and Jong Ik Lee[1]*

[1]Korea Polar Research Institute, Incheon, Korea

jisu@kopri.re.kr

ABSTRACT

Introduction: Noble gases (He, Ne, Ar, Kr, and Xe) are chemically inert and are generally rare in natural samples. Concentrations and isotope abundance ratios of 23 stable isotopes in planetary solid materials such as meteorites and cosmic dust particles show wide variations, because several noble gas components of different origins exist in these materials. The noble gas components are roughly classified as; 1) gases trapped in solids during cooling from high temperature (trapped components), 2) isotopes produced from radio-isotopes (radiogenic component), 3) isotopes produced from nuclear fission of heavy radioactive isotopes (fissiogenic component), 4) isotopes produced in space by spallation reactions induced by energetic cosmic rays and by secondary neutrons (cosmogenic), and exotic isotopes trapped in presolar grains. Noble gas isotopes are therefore useful as sensitive cosmochemical tracers. For study of extraterrestrial materials using these noble gas isotopes, a noble gas mass spectrometer of high performance is essential.

Installation of noble gas mass spectrometer: A system for noble gas mass spectrometry had been relocated in Korea Polar Research Institute (KOPRI) from the University of Tokyo in May, 2015. After the installation of the machine in our noble gas laboratory, we continued tuning of the system to attain a high performance applicable to small meteorite samples. The system is equipped with three different types of furnaces for noble gas extraction from meteorites by heating; 1) a furnace with Mo crucible heated by electric resistance Ta-heater applicable to relatively larger samples (≥mg), 2) a miniature furnace using a W-heater applicable to small samples (μg–mg), and 3) a laser heating system using Nd-YAG CW laser applicable to small samples such as cosmic dust particles (≤μg). Released gases can be purified by using two Ti-Zr getters and two SAES getters (NP10), and then be separated into five elements, i.e., He, Ne, Ar, Kr, and Xe, before admitting into the mass spectrometer for analysis. Two charcoal traps and a cryogenically cooled porous sintered stainless-steel trap are used for the separation. Temperature of the latter trap is controllable from ~15K to 400K. The mass spectrometer was a commercially produced VG5400 in 1988, but modified afterward in laboratory by replacing with a computer system and software controlling the mass spectrometer, an ion-counting detector of own design, low-noise Daly-multiplier detector, and low-noise amplifiers.

Performance examination of the mass spectrometer: We started performance examination of the system by measuring meteorites with low noble gas concentrations such as diogenite and high

petrologic type chondrites. Here we present preliminary results on chondrites of petrologic type 6, which are suitable to investigate blank level of the vacuum line, background spectra which may interfere with noble gas isotope spectra, mass resolution, long term stability in sensitivities and mass discriminations, etc.

At present, the line for the gas extraction, purification, and separation is kept at ultra-high vacuum condition in the range of 10-10 Torr. Mass resolving power is about 600 (M/ΔM), enough to measure most noble gas isotopes. Blank levels at 1800°C heating of Mo crucible are <1×10-10, <3×10-12, 1×10-9, 7×10-14, and 1×10-14 cm3STP for 4He, 20Ne, 40Ar, 84Kr, and 132Xe, respectively. Back ground at mass of 36, equivalent to about 3×10-12 cm3STP 36Ar, shows a small effect to the isotope ratios of 38Ar/36Ar and 40Ar/36Ar. Sensitivity estimated with intensity of 132Xe spectrum is ~1×10-3 A/Torr, high enough to measure noble gases in meteorites weighing less than 1 mg. It takes about 4 hours to measure all stable 23 isotopes, including sample heating for gas extraction, purification, separation among He, Ne, Ar, Kr, and Xe, and isotope analysis with the mass spectrometer.

Here we present preliminary results obtained for 20 meteorites classified as L6 chondrites, which were collected in a same area of blue ice field in Antarctica. Concentrations of trapped 84Kr and 132Xe are plotted in Fig. 1. Concentrations of these isotopes are known to be correlated with petrologic types of ordinary chondrites, i.e., concentrations decrease with increasing petrologic type from 3 to 6. All the meteorites are plotted in the area for type 6 chondrites, which agree with the classification based on mineralogical investigations. These meteorites, however, may be divided into two groups, group 1 and group 2, as clearly shown in Fig. 2, where 36Ar/132Xe ratios are plotted against 84Kr/132Xe ratios. Most meteorites are plotted in or close to an area for Q-gas, the most abundant heavy noble gases trapped in Q-phase of chondrites. Contrastingly, two meteorites show much higher 36Ar/132Xe ratios as shown in Fig. 2. The component is known as "subsolar gas" discovered for the first time in enstatite (E-) chondrites, and thought to be a remnant solar gas originally trapped in meteorite parent asteroids in the early stage of solar system formation.

K-Ar ages calculated assuming an average concentration of 860 ppm K for L-chondrites are 3.8–4.5 Gy. No systematic difference between the two groups was observed. On the other hand, (U,Th)-He ages calculated using average concentrations of U (13 ppb) and Th (43 ppb) for L-chondrites show clear difference between the two groups, i.e., the ages for group 1 are in the range 0.4–1.7 Gy, much younger than the K-Ar ages, but older ages of 2.5 and 3.6 Gy were obtained for group 2. Many L-chondrites show young gas retention ages around 0.5 Gy, which is supposed to indicate an occurrence of large scale impact event for L-chondrite parent asteroid. Cosmic-ray exposure ages calculated for the meteorites based on the concentrations of cosmogenic 3He, 21Ne, and 38Ar are in narrow range without systematic difference between the two groups, and average value is 35 3 My. Noble gas data we have now begun to accumulate for the large numbers of KOPRI meteorite collections will be a powerful data base for identifying paring of meteorites (meteorite fragments delivered from a single meteoroid during passage through the atmosphere), identifying rare and important meteorites such as Martian and Lunar meteorites, and for study of formation and evolution of our solar system.

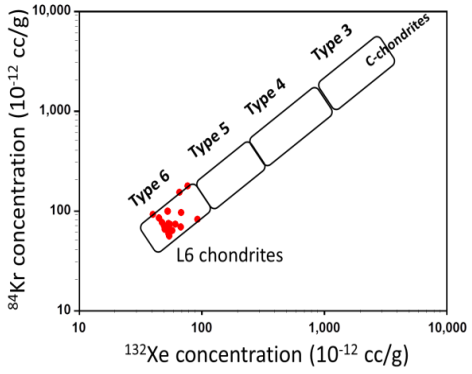

Fig. 1. Plot of ^{84}Kr versus ^{132}Xe concentrations. The petrologic type based on the concentrations agrees with that from mineralogical study.

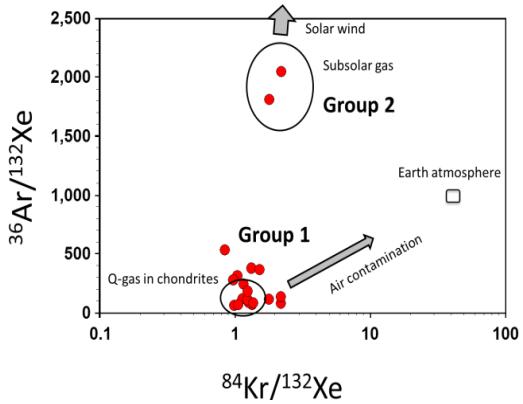

Fig. 2. Plot of $^{36}Ar/^{132}Xe$ versus $^{84}Kr/^{132}Xe$ ratios clearly shows two groups.

DEVELOPMENT OF A NEW SHIPBORNE AUREOLEMETER TO MEASURE THE DIRECT- AND CIRCUM-SOLAR RADIATION

Hiroshi Kobayashi

Hiroshi Kobayashi[1], Yusuke Nomura[1], and Masataka Shiobara[2]*

[1]University of Yamanashi, Japan
[2]National Institute of Polar Research / The Graduate University for Advanced Studies, Japan

kobachu@yamanashi.ac.jp

ABSTRACT

A new shipborne aureolemeter was developed to improve the sun-tracking performance for accurate measurements of not only direct but circumsolar radiation, even on a vessel weltering. Sun position is determined by a real-time image processing system with a CCD camera. A round shape is extracted from the captured image. The centroid position of the round shape is used as the sun position. The accuracy of the sun position determination is better than 0.01°. The radiometer can track the sun under a feedback control with the derived sun position. For a sky radiance distribution measurement, the control target position on the CCD camera image is shifted a pixel corresponding to a measuring scattering angle. In the case of a scattering angle larger than 7°, the radiometer's tracking is conducted under feedforward control on the basis of the angle of roll and pitch monitored with a gyroscope. To decide the solid angle of the radiometer, the radiance around the sun was measured in the angle range between the sun and sensor directions from -1.5° to +1.5° with 0.1° resolution. The instrument constants were determined by the Langley plot method. Test observation is being conducted on the R/V Shirase in JARE (Japan Antarctic Research Expedition) cruise. The volume-size distribution as well as aerosol optical thickness is derived from the test observation measurements. The new shipborne aureolemeter demonstrates that it can measure both direct-solar radiation and distribution of scattered solar radiation on rolling vessel.

PALEO RECONSTRUCTIONS IN THE RUSSIAN ARCTIC COASTAL ZONE AND ISLANDS

Aleksander Makarov

Aleksander Makarov [1,2]

[1]*Arctic and Antarctic research institute, Russia*
[2]*Institute of Erath Science, St.Petersburg state university, Russia*

makarov@aari.ru

ABSTRACT

The results of longitude research carried out in the coastal zone and islands of the Russian Arctic during the past decades allowed for paleogeographic reconstructions of environmental development in the late Neo-Pleistocene and Holocene, as well as for creation of variability curve of the sea level fluctuation during Holocene.
Research activities identified the specific type of sediments, which was formed in the sea, lake and river estuary coastal zones and evidences the sea level in the past. The sediments are basically a mass of sand layered by substantial amount of allochthonous organic matter of low decomposition degree. It is those layers that evidence the forming of stagnant conditions resulted from damming of receiving water body (sea, lake, river) against the raise of the water level. Such sediments are well represented on the coastal like and islands of the Russian Eastern Arctic.
The examinations of sediments in question made available the specific ice complex development scenario in the late Neo-Pleistocene, and allowed identify the phases of the Laptev Sea level high stand during Holocene. It exceeded the current sea level by 5-7 meters 1.2-1.5, 3-4 and over 8 thousand years ago.

MARINE HEAT FLOW MEASUREMENTS IN THE SUBSEA PERMAFROST DEGRADATION AREA OF THE EASTERN MACKENZIE TROUGH, CANADIAN BEAUFORT SEA

Young-Gyun Kim

Young-Gyun Kim[1], Michael Riedel[3], Humfrey Melling[4], Seung-Goo Kang[1], Sookwan Kim[1,2], Jong Kuk Hong[1,2], Scott Dallimore[5], Charles Paull[6], Young Keun Jin[1]*

[1]Korea Polar Research Institute, Korea
[2]University of Science and Technology-Korea, Korea
[3]Helmholtz Centre for Ocean Research Kiel, GEOMAR, Germany
[4]Institute of Ocean Sciences, Fisheries and Oceans, Canada
[5]Geological Survey of Canada, Canada
[6]Monterey Bay Aquarium Research Institute, USA

ygkim@kopri.re.kr

ABSTRACT

Permafrost degradation and associated gas hydrate dissociation occur in the Mackenzie Trough, Canadian Beaufort Sea, because of long-term warming and sea level rise since the Last Glacial Maximum. Marine heat flow was determined along the eastern slope of the trough, using a 5 m Ewing-type heat probe during two Korean Icebreaker R/V Araon expeditions in 2013 and 2014, in order to understand the shallow subsurface thermal structure unraveled to date. Seven stations were chosen along a transect crossing the subsea permafrost limit, at water depths of 50-330 m, where the thermal effects of high Holocene sedimentation rates and large interannual variation in bottom water temperature may influence results. After correcting for these effects, heat flow values are estimated as 105.7 to 139.2 mW/m^2 (average: 122.6 mW/m^2). This range is higher than the regional heat flow distribution derived from deep boreholes below the permafrost base on the Eastern Shelf. This suggests that the local, shallow thermal structure cannot be fully explained by borehole-derived heat flow data, due to a restricted spatial distribution. Observations indicate that ground ice in the trough is susceptible to melting. On the other hand, on the slope as deep as 1540 m water depth heat flow of 90.0 mW/m^2 is reported for the first time. Discrepancies with heat flow estimated from recently found bottom simulating reflectors are not yet fully understood.

CHARACTERISTIC ATMOSPHERE AND OCEAN INTERACTIONS IN THE COASTAL AND MARINE ENVIRONMENT INFERRED FROM INFRASOUND DATA AT TERANOVA BAY, WEST ANTARCTICA

Masaki Kanao

Masaki Kanao[1], Yongcheol Park[2], Takahiko Murayama[3], Won Sang Lee[2], Masa-Yuki Yamamoto[4], Hyun Jae Yoo2, Yoshiaki Ishihara[5], Jin Seok Kim[2], Takuma Oi[6], and Jin Ho on Jung[7]*

[1]National Institute of Polar Research, Japan
[2]Korea Polar Research Institute, Republic of Korea
[3]Japan Weather Association, Japan
[4]Kochi University of Technology, Japan
[5]Japan Aerospace Exploration Agency, Japan
[6]Toho Mercantile Co., Ltd, Japan
[7]Kang Wang National University, Republic of Korea

kanao@nipr.acc.jp

ABSTRACT

Characteristic features of infrasound waves observed in the Antarctic reveal physical interaction involving surface environments around the continent and Southern Ocean. An infrasound array (100 m spacing) by using three sensors (Chaparral Physics Model 25, with a detectable frequency range of 0.1-200 Hz), together with a broadband barometer (Digiquartz Nano-Resolution Model 6000-16B Barometer, with a detectable frequency range of 0-22 Hz) were installed at Jang Bogo Staion, Tera Nova Bay, West Antarctica in December 2015 by the Korea Arctic and Antarctic Research Program (KAARP). The initial data recorded by the broadband barometer include several signals originated surrounding surface environment, in addition to the local wind noises such as katabatic signals. Clear signals from background oceanic origin (the "microbaroms") are continuously recorded at the austral summer on mid-December with predominant frequency around 5 s. Variations of their frequency context and strength appeared in Power Spectral Density are affected by evolution of the sea-ice surrounding the Tera Nova Bay. In contrast, several infrasound monitoring stations have been conducting around the Lützow-Holm Bay (LHB), East Antarctica by Japanese Antarctic Research Expedition (JARE) since 2008. Two infrasound arrays with different diameter triangles have been deployed at both inside the Syowa Station (100 m spacing) and on the continental ice sheet (1000 m spacing). Besides the arrays, isolated single stations are deployed at three outcrops. These arrays in LHB clearly identified the predominant propagating directions in NWN and their frequency content variations of "microbaroms" from Southern Indian Ocean. In this presentation, characteristic features recorded by the initial data observed at Jang Bogo Staiton is presented, as compared with that obtained

at the LHB. Microbaroms measurement is a useful tool for characterizing ocean wave climate, complementing other oceanographic, cryospheric and geophysical data in the Antarctic. Detail and continuous observations of infrasound waves in Antarctica is a new proxy for monitoring a environmental changes such as global warming affecting on polar regions.

P-WAVE VELOCITY STRUCTURE BENEATH GREENLAND USING LOCAL, REGIONAL, AND TELESEISMIC EVENTS

Yongcheol Park

Yongcheol Park[1], Won Sang Lee[1], Hyun Jae Yo1[2] and Choon-Ki Lee[1]*

[1]Korea Polar Research Institute, Korea

ypark@kopri.re.kr

ABSTRACT

A three-dimensional P-wave velocity model was inverted with local, regional, and teleseismic events observed on the GLISN network and GSN stations near study area from 2009 to 2015. The relative travel times from teleseismic events were computed with respect to the IASP91 global reference model using the multi-channel cross correlation method (MCCC) by VanDecar and Crosson (1990). Local and regional first P wave arrivals were extracted ISC earthquake catalog. Our model space was parameterized laterally with 1°×1° from 55°N to 85°N in latitude and from 20°W to 80°W in lon- gitude. This high latitude model space causes spatial distortion in the model parameters on the spherical coordinate for the teleseismic body wave tomography. To minimize a distortion in the model parameters the spherical coordinate system was rotated as the referent stations SUMG and SCO, located on the middle of Greenland, to equator, and all stations and seismic events were converted to this new coordinate system. All ray paths were computed by a three dimensional ray tracing algorithm developed with pseudobending technique and Snell's law (Zhao et al, 1992), and travel times were corrected by ice and crustal thicknesses for each observed station as well. Our inverted model shows a broad low velocity anomaly (~-1.5%) in the mid-eastern parts of Greenland, which is connected to the low velocity anomaly beneath Iceland. Another low velocity anomaly was observed below 300km in the middle of Greenland where the Icelandic mantle plume was located in ~60Ma.

POSTER SESSION

Modeling the Physical Processes of Arctic Climate System

IMPACT OF RADIOSONDE DATA OVER THE ARCTIC ICE ON FORECASTING WINTER EXTREME WEATHER OVER MID LATITUDE

Kazutoshi Sato

**Kazutoshi Sato[1], Jun Inoue[1,2,3], Akira Yamazaki[2], Joo-Hong Kim[4], Marion Maturilli[5], Klaus Dethloff[5], and Stephen R Hudson[6]*

[1]National Institute of Polar Research
[2]Japan Agency for Marine-Earth Science and Technology
[3]SOKENDAI, Graduate University for Advanced Studies
[4]Korea Polar Research Institute
[5]Alfred Wegener Institut
[6]Norwegian Polar Institute

sato.kazutoshi@nipr.ac.jp

ABSTRACT

In February 2015, the Arctic air outbreak caused extreme cold events and heavy snowfall over the mid latitude, in particular over the North America and over Japan. During the winter, special radiosonde observations were made on the Norwegian RV Lance around the north of Svalbard under the N-ICE2015 project. In addition, the numbers of radiosonde launch are increase by four per day at some Arctic observing station during this winter. We investigated the impact of the radiosonde data on forecasting of a cold extreme event over the eastern North America and Japan using the AFES-LETKF experimental ensemble reanalysis version2 (ALERA2) data set. ALERA2 was used as the reference reanalysis (CTL) while the observing-system experiment (OSE) assimilated the same observational data set, except for the radiosonde data obtained by the RV Lance and Arctic stations. Using these two reanalysis data as initial values, ensemble forecasting experiments were conducted. Comparing these ensemble forecasts, there were large differences in the position and depth of a predicted atmospheric circulation in upper levels. The CTL forecast well predicted the southward intrusion of the polar vortex which pushed a cold air over the eastern North America from the Canadian Archipelago. The development of cyclone, which brings cold airflow and heavy snow to Japan, is reproduced due to strong baroclinic instability. In the OSE forecast, in contrast, the trough associated with southward intrusion of the polar vortex was weak, which prevented a cold outbreak from Arctic to eastern North America. The extended ridge at upper level is weaker than that of CTL, suggesting that the development of cyclone is prevented over Japan. This result suggested that the radiosonde observations over the central Arctic would improve the skill of weather forecasts over the mid latitude during winter.

A CONTINUOUS OBSERVATION OF TUNDRA WARMING EFFECTS ON CO_2 EFFLUX AT A HIGH ARCTIC TUNDRA IN SVALBARD

Hanna Lee

Hanna Lee[1], David Risk[2], Ingibjörg Svala Jónsdóttir[3]

[1]Uni Research Climate/Bjerknes Centre for Climate Research, Bergen, Norway
[2]Department of Earth Sciences, St. Francis Xavier University, Antigonish, Nova Scotia, Canada
[3]Arctic Biology, The University Centre in Svalbard, Longyearbyen, Norway

hanna.lee@uni.no

ABSTRACT

Earth System Model projections suggest an amplified effects of warming in the Arctic region. One of the terrestrial feedback effects of accelerated warming in the Arctic comes from the role Arctic ecosystems play in global carbon (C) cycling as changes in vegetation combined with microbial processes regulating C release from soils will alter ecosystem C balance measured as CO2 fluxes.
In situ simulations of warming scenarios in tundra ecosystem have been conducted using passive warming Open Top Chambers (OTCs) as part of the International Tundra Experiments (ITEX) and has become a standard field manipulation method. There has been several ongoing ITEX projects in Svalbard that span over 10 years of observations and experiments in the context of tundra warming using OTCs in the high Arctic tundra ecosystem. Numerous publications emerged from the ITEX projects in Svalbard since its establishment, most of which focuses on the relationship between vegetation response to warming and fewer studies focused on quantification of changing ecosystem C balance as a consequence of warming as it is highly time consuming for the measurements, not to mention capturing long winter months that characterizes the Arctic ecosystem to understanding the full annual C budget. However, combined observations on ecosystem C balance with vegetation dynamics in the context of warming will provide process level understandings on how the terrestrial Arctic ecosystem will respond to warming and alter the feedback cycles to future climate change scenarios.
New membrane-based Forced Diffusion (FD) soil efflux techniques offer promise for longer-term temporal observations. Datalogger-based power management logic decreases the total system power consumption. Because the system monitors both soil concentration and fluxes, it offers several advantages over normal monitoring: infer depths of production, and the vertical profile data provides information physical processes such as snowpack CO2 removal by wind. Most importantly, the systems are proven in Canadian and Antarctic winter environments.
In 2015, the FD chambers were installed at a tundra warming experimental site in Longyearbyen to understand and quantify ecosystem C balance with summer and winter warming in Arctic tundra ecosystem by continuous observations of ecosystem CO2 fluxes.

From July to mid-October, the rate of CO2 fluxes from soil respiration ranged 0.001-0.3 µmol m-2 s-1 in Control and 0.04-0.6 µmol m-2 s-1 in Warming treatments. This was on average 3.3 times greater at the Warming treatment than the Control and the separation in the flux rate between Control and Warming was very distinct with the passive warming of approximately 2°C in the summer and 1-3°C in the winter with snowpack accumulation with the OTC. Our results show that passive warming from OTC significantly increased CO2 fluxes, suggesting that warming stimulated belowground processes enough to release approximately 3 times more CO2 during mid-summer to autumn season in a high Arctic tundra ecosystem in Svalbard.

EXAMINING RECOVERY ICE STREAM SUBGLACIAL LAKES USING A 2D HYDROLOGY MODEL

Christine Dow

*C. F. Dow[*1,2], M. Werder[3], S. Nowicki[2], R.T. Walker[2], G. Babonis[4], B. Csatho[4], M. Morlighem[5]*

[1]Department of Geography and Environmental Management, University of Waterloo, Waterloo, ON, Canada
[2]NASA Goddard Space Flight Center
[3]Laboratory of Hydraulics, Hydrology and Glaciology (VAW), ETH Zurich, Zurich, Switzerland
[4]University at Buffalo, State University of New York
[5]Department of Earth System Science, University of California, Irvine

christine.dow@uwaterloo.ca

ABSTRACT

We investigate the growth and drainage of Antarctic subglacial lakes and their impact on ice stream dynamics. Our methods involve applying GlaDS, a 2D subglacial hydrology model, to assess subglacial drainage development in Recovery Ice Stream in the East Antarctic. We first apply GlaDS to a synthetic system with one overdeepened region. The model outputs suggest that the highly constricted environment of the ice stream combined with funneling of relatively high rates of subglacial water flow from the large catchment create slow-moving high-pressure waves. The waves cause temporally-varying water flow rates through the hydrological system that drives lake growth. Over time, flux from the growing lake causes downstream channel growth that triggers lake drainage. Following lake drainage, channels again shut down. Due to the channels, high water pressures associated with lake drainage are apparent 50 km downstream of the lake rather than immediately in the vicinity of the overdeepening.

JAPANESE CONTRIBUTION TO THE POLAR PREDICTION PROJECT (PPP)

Jun Inoue

Jun Inoue[1,2], Kazutoshi Sato[1], and Akira Yamazaki[2]*

[1]National Institute of Polar Research, Tachikawa, Japan
[2]Japan Agency for Marine-Earth Science and Technology, Yokohama, Japan

inoue.jun@nipr.ac.jp

ABSTRACT

To evaluate the impact of additional observation on the predictability of weather and sea-ice patterns, Japan has contributed to establishing an experimental Arctic observing network as part of an international collaboration (the Arctic Research Collaboration for Radiosonde Observing System Experiment: ARCROSE). It was shown that the incorporation of additional Arctic observations improves the initial analysis and enhances the skill of weather and sea-ice forecasts. Based on these achievements, Japan will extend this activity during the Year of Polar Prediction (YOPP) under the Japanese flagship project, called ArCS (Arctic Challenge for Sustainability). Using RV Mirai and data assimilation technique under international collaborations, the impact of additional Arctic observations on predicting extreme evens in local (e.g. along Northern Sea Route) and remote regions (e.g. mid-latitude severe winters) will be assessed, contributing to optimizing a sustainable Arctic observing network on a cost-benefit basis.

POSTER SESSION

Climate Change and Arctic Terrestrial Ecosystems

VEGETATION MAPPING ON THE MIDTRE LOVÉNBREEN, SVALBARD USING REMOTE SENSED IMAGES

Se-eun Kim

Se-eun Kim[1], Ji Young Jung[1], Yoo Kyung Lee[1]*

[1]Korea Polar Research Institute, Incheon, Korea

senny10@kopri.re.kr

ABSTRACT

With changes in the ecosystem caused by the on-going climate change, biodiversity in the respective regions of the ecosystem have also been subject to change. In particular, as organisms in the Arctic region have shown extra sensitivity to the effects of climate change, they must be continually monitored as indicators of climate change. However, there is a limit to monitoring organisms as field work in the Arctic region. For this reason, satellite data was developed to allow research the regions inaccessible to field work. The objective of this study is to construct the vegetation map of the Midtre Lovénbreen, in Svalbard, Norway and long-term variation of vegetation using remote sensing images. The area of study is the glacier foreland of Midtre Lovén (79°N, 12°W) and cover an area of about 10 km2. 2007 Formosat-2 satellite image and 2013 Pleaides 1A were used in this study. Both of these satellite images are high-resolution and as both carry NIR band, are well-suited to make observations of vegetation states. While moss and lichen are dominant in the Arctic region, observation and analysis using satellite imaging is difficult due to their small and sparse distribution. To improve limits in spatial resolution, several methods were used: first, Minimum Noise Fraction (MNF) was used to minimize the dimensionality and noise; second, the Pixel Purity Index (PPI) was used to collect the endmember; last, Spectral Mixture Analysis (SMA) was used to confirm the abundance of vegetation. These results will be confirmed by comparing the field data from July 2014 and vegetation map (Moreau, 2005).

MOLECULAR CHARACTERIZATION OF SOIL ORGANIC MATTER ALONG A SOIL CHRONOSEQUENCE IN MIDTRE LOVÉNBREEN FORELAND IN SVALBARD

Sungjin Nam, Su-Jeong Jung, Se-Eun Kim, Yoo Kyung Lee and Ji Young Jung*

Korea Polar Research Institute, Incheon Korea

**10pack@kopri.re.kr*

ABSTRACT

Glacier forelands give an opportunity to study the successional processes in the terrestrial ecosystem along the chronosequence at a time, since the ice covers of glacier have receded over the past century. The newly exposed soil gives chances for plants and microorganisms to be established, and these organisms contribute to build up the soil organic matter (SOM) pool in this region. To investigate molecular compositions of SOM along a soil chronosequence, we took the surface soil samples at 0–5 cm depth in the glacier foreland of Midtre Lovénbreen, Svalbard in 2014. Seven sampling sites inside the moraine represented soil ages as 3, 8, 36, 57, 65, 70, and 77 years (sites 1 – 7, respectively). Two sites outside the moraine (sites 8, 9) were also selected as a reference. Before soil sampling, vegetation composition and coverage were surveyed. Since SOM is a mixture of materials showing various turnover time, and the content of SOM was very low in the glacier foreland, density-size based SOM fractionation was used. Firstly, sodium polytungstate solution (1.55 g cm-3) was used to separate soil into the free light fraction (FLF) which floats on the solution and the heavy fraction (HF) which sinks. Secondly, the HF was further separated as the sand-size fraction and silt and clay-size fraction based on size. Molecular composition of FLF which mostly consisting of recently added organic matter was analyzed by pyrolysis-Gas Chromatography/Mass Spectrometry (py-GC/MS) and TMAH(tetramethyl-ammonium hydroxide)-py-GC/MS at two pyrolysis temperatures (350 and 600 °C). The sand-sized and silt and clay sized fractions were treated with hydrofluoric acid to increase carbon concentration by removing mineral particles and analyzed by py-GC/MS at two temperatures (350 and 600 °C). We are currently analyzing molecular characteristics of SOM from these samples. The results of this study could provide better understanding of molecular composition of SOM, successional processes, and the relationships between SOM composition and vegetation in a newly exposed glacier foreland.

ESTIMATION OF SOIL ORGANIC CARBON STOCK IN THE GLACIER FORELAND OF MIDTRE LOVÉNBREEN, IN THE HIGH ARCTIC

Ji Young Jung[1], Dominique Laffly[2], Lennart Nilsen[3], Se-Eun Kim[1], Myrtille Moreau[4], Yoo Kyung Lee[1]*

[1]Korea Polar Research Institute, Korea
[2]Université de Toulouse, Toulouse, France
[3]University of Tromsø, Tromsø, Norway
[4]GEOREX, Pau, France

yklee@kopri.re.kr

ABSTRACT

Global warming leads to rapid melting of glaciers in the high Arctic, exposing new soil surfaces. Soil organic carbon (SOC) accumulation in the proglacial environment has initiated along soil chronosequence after microorganisms and plants have settled down. The quantity and rate of SOC accumulation are also affected by several environmental factors which need to be identified and more throughout studied, however, these influences have not yet been investigated considerably. Hence, we are aiming to estimate the SOC stock in the glacier foreland of the Midtre Lovénbreen, Spitsbergen, Norway (79°N, 12°W) by considering the deglaciated years and several environmental factors such as microtopography, runoff activity, etc. A total of 36 sampling points were selected to collect soil for 0-30 cm depth, and vegetation was surveyed from 93 points. The SOC stock was estimated from the quantity of SOC and bulk density calculated from soil texture. A Multiple Correspondence Factorial Analysis (MCFA) was conducted to investigate the relationship between vegetation and SOC content. The results of MCFA were hierarchically classified with Ward criteria to cluster the sampling points. Since each class is defined by the frequencies of the modalities of variables, Bayesian conditional probabilities for each pixel were calculated by using environmental variables acquired from remote sensing imagery and DEM. The highest probability class was assigned to produce of a map of SOC and to estimate SOC stock in the glacier moraine. This study would contribute to understand the initial soil development in the high Arctic ecosystem with a consideration of environmental parameters as well as soil age.

SPATIAL VARIABILITY OF CANOPY STRUCTURE AND FUNCTION IN THE MOIST ACIDIC TUNDRA

Jane Lee, Youngryel Ryu, Jongmin Kim, Yoo Kyung Lee

Korea Polar Research Institute, Seoul National University

ABSTRACT

Understanding canopy architecture and function is important to link the effects of climate change on carbon, water, and energy exchanges between subarctic vegetation and the atmosphere. Interpreting vegetation spatial variability with satellite products alone is a challenge, due to the patchiness of vegetation in the Arctic ecosystems with transient cloud cover during the summer season that obstructs retrieval of land surface images. To compare and correlate spatial variation of vegetation with satellite data, we collected leaf area index (LAI) and hyperspectral reflectance data in Council, Alaska. To better understand canopy structure and functional variables, we further examined subarctic leaf traits by measuring C:N ratio, leaf mass area (LMA), chlorophyll content, and hyperspectral leaf optical properties. We obtained WorldView-2 Satellite data, which has 8 multispectral bands with 2 m resolution, centered on our study site. There is remarkable variation in spectral reflectance and LAI across three 100-m transects. We discuss how to upscale the information from in-situ observed canopy properties into a landscape scale in tandem with the high-resolution satellite image.

PROKARYOTIC DIVERSITY AND COMMUNITY STRUCTURE IN ARCTIC TUNDRA SOIL, ALASKA

Hye Min Kim

Hye Min Kim[1], Ji Young Jumg[2], Jongsik Chun[1] and Yoo Kyung Lee[2]*

[1]School of Biological Sciences, Seoul National University, Seoul, Korea
[2]Korea Polar Research Institute, Incheon, Korea

hmking@snu.ac.kr

ABSTRACT

The thawing permafrost due to increasing temperatures deepens the active layer, and this phenomenon affects soil microbial communities. It is therefore important to know how the soil microbial communities alter along the environmental variables including various soil depths to understand the potential microbial responses to climate change. However, the vertical distribution of microbial communities has been poorly understood in the Arctic tundra. We investigated the soil prokaryotic community structure and its relationships with various soil properties comparing 3 cores (Core2, Core 3, and Core 5) based on ground-penetrating radar (GPR) survey. Each core sample showed different structure of dominant bacterial groups; Actinobacteria (16.7%), Acidobacteria (11.9%), AD3 (11.6%), and Chloroflexi (10%) in Core 2, AD3 (17.6%), Actinobacteria (13.3%), Chloroflexi (13.2%), and Acidobacteria (10%) in Core 3, and Chloroflexi (31.4%), AD3 (14.5%), and Acidobacteria (12%) in Core 5. Generally, the relative abundance of Actinobacteria, Acidobacteria, Chloroflexi, and AD3 were generally dominant in all soil cores. In Archea community, Methanobacteria (Euryarchaeota) was highly dominant in upper soil layers and Methanomicrobia (Euryarchaeota) increased toward to deeper soil layers in Core 2 and 3. However, Core 5 showed unique distribution of archeal community as showing Methanobacteria abruptly increased in middle layer (around 30 cm depth) and decreased to the soil depth. To identify the vertical distribution of prokaryotic community, statistical correlations with soil parameters are analyzing.

TEMPORAL REGULATION OF PHOTOSYNTHESIS AND NITROGEN FIXATION IN NOVEL SOIL BACTERIA

Woo-Suk Chang

Department of Biology, University of Texas-Arlington, Arlington, TX 76019 U.S.A

ABSTRACT

Recently, a novel soil bacterium, Bradyrhizobium sp. ORS278, was characterized for having a Nod-factor independent approach to form root nodules through a symbiotic interaction with leguminous plants. Symbiotic nitrogen fixation between bacteria and legumes is an important mutualism, the bacterium breaks atmospheric nitrogen down into components the plant can use, and the plant provides photosynthetic products to the bacteria. The mechanism of this mutualism was once characterized by the initial secretion of the signaling molecule (i.e., Nod factor) by the bacterium. However, ORS278 lacks the nod genes responsible for producing Nod factor. In addition, the new strain has photosynthetic capabilities and can form green stem nodules on certain plants from the Aeschynomene genus. A large-scale transposon mutagenesis of this bacterium uncovered multiple mutants which were deficient in nitrogen fixation and/or nodulation. We selected two particular nitrogen fixation deficient mutants. BRADO3946, a putative sensor histidine kinase, is thought to be a global regulator, and BRADO4470, encodes a homologue of LabA, a protein that functions in feedback control of circadian rhythm in cyanobacteria. It is suggested that these two genes are responsible for managing the formation of the photosynthetic apparatus as well as temporally regulating metabolic activities such as nitrogen fixation. These findings could reveal insight into the bacterial process of Nod-factor independent symbiosis but further study is needed to conclude as to whether these genes play a role in the symbiotic interaction.

A COMPARATIVE STUDY OF ENDOLITHIC MICROBIAL COMMUNITES BETWEEN DIFFERENT TYPES OF ROCKS IN THE NORWEGIAN HIGH ARCTIC

Yong-Hoe Choe

*Yong-Hoe Choe, Mincheol Kim, Jusun Woo ,Mijung Lee and Yookyung Lee**

Korea Polar Research Institute, Korea

yhchoe@kopri.re.kr

ABSTRACT

Introduction: In extreme environments, such as the Arctic, endolithic communities are most of the ex-tant life. The endolithic environment is thought to buffer microbial communities from intense solar radiation, temperature fluctuations, wind, and desiccation in environments where such environmental factors inhibit epilithic growth. Therefore, the endolithic environment is a critical habitat to explore in exobiological research.

The abundance of endolithic life in the high Arctic, combined with the potential for biosignature preserva-tion, suggests that rocks associated with endolithic ecosystems may be the best hope for finding fossil evidence of past life on the Martian surface.

The goal of this study is to assess the activity and community composition of the endolithic community inhabiting rocks in the Norwegian high Arctic. To achieve this goal, we combined techniques of DNA sequencing, microscopy and spectroscopy. This work provides an overview of the polar microbial communi-ty and a new recognition of how environmental stresses such as prevailing polar desert conditions may affect the biogeochemical dynamics of high Arctic endolithic microorganisms.

Materials and methods: Endolithic samples were collected in August 2014 at various sites in Spitsbergen on Svalbard, Norway. Samples were collected with hardened steel chisels that were flame sterilized in the field with 100% ethanol and a butane torch. Duplicate rock samples at each site were collected into sterile, plastic tubes and bags, and transported to the laboratory in icebox keeping under ~4°C.

For scanning electron microscopy (SEM), rock pieces were sputter-coated with gold and examined with scanning electron microscope at 20 kV.

Homogenized rock samples were separated into subsamples and DNA was extracted as duplicates. DNA extractions were carried out on 3 g using a Fast DNA® SPIN Kit (MP Biomedicals).

Sequences generated from pyrosequencing of bac-terial 16S rRNA gene amplicons were processed using the mothur pipeline. Statistical analyses were per-formed using the vegan R package.

Results: SEM images allow one to describe morphotypes and to estimate roughly the dimensions of the structures, but it is not possible to obtain infor-mation on the spatial organization of the organisms within the endolithic band. The images obtained illus-trated bacterial colonization in the rocks.

They showed a wide distribution of single coccoid cells of about 5 μm in diameter attached to surfaces,

Small globules forming aggregates covered grains of rock, and fine filamentous structures of 0.3 to 0.5 mm in width, lead to a network in the crevices of the rock.
Traces of interactions between living organisms and inorganic surfaces, such as biocorrosion or calcite formation, were not observed.
Discussion and Implications: Phylogenetic and statistical comparison of endolithic communities from this study with those from previous studies in similar environments support the hypothesis that patterns of microbial diversity are governed by similar principles observed in macro-ecological systems. The majority of the endolithic bacterial sequences were most closely matched to those of isolates or clones derived from cold/dry deserts (i.e., Antarctica, Atacama, and cold alpine environments). This indicates that endolithic bacteria in this region have little site variations and are under similar degrees of environmental constraints of the cold and dry Arctic. Results also provide insight into geobiolo-gical processes that shape the biosphere and help us understand in the cold and dry envionments possibly elsewhere in the Solar System.
References: [1] Starke V. et al. (2013) Environ-mental Microbiology Reports, 5, 648–659. [2] Smith H. D. et al. (2014) International Journal of Astrobiology, 13 (3), 271–277. [3] Horath T. et al. (2005) Microb Ecol. 51(3), 353-64. [4] Cary S. et al. (2010) Nature Reviews. Volume 8. [5] Ziolkowski L. A. et al. (2013) Biogeosciences, 10, 7661–7675

THE DIAGNOSTIC CHARACTERISTICS ARE HIGHLY HOMOPLASIOUS USED IN *Cladonia gracilis* AND *Cladonia cornuta*

Jae Eun So

Jae Eun So[1,2], Ji Hee Kim[1], Soon Gyu Hong[1,2]*

[1]Korea Polar Research Institute, Incheon, Korea
[2]University of Science & Technology, Korea

cladonia@kopri.re.kr

ABSTRACT

With changes in the ecosystem caused by the on-going climate change, biodiversity in the respective regions of the ecosystem have also been subject to change. In particular, as organisms in the Arctic region have shown extra sensitivity to the effects of climate change, they must be continually monitored as indicators of climate change. However, there is a limit to monitoring organisms as field work in the Arctic region. For this reason, satellite data was developed to allow research the regions inaccessible to field work. The objective of this study is to construct the vegetation map of the Midtre Lovénbreen, in Svalbard, Norway and long-term variation of vegetation using remote sensing images. The area of study is the glacier foreland of Midtre Lovén (79°N, 12°W) and cover an area of about 10 km2. 2007 Formosat-2 satellite image and 2013 Pleaides 1A were used in this study. Both of these satellite images are high-resolution and as both carry NIR band, are well-suited to make observations of vegetation states. While moss and lichen are dominant in the Arctic region, observation and analysis using satellite imaging is difficult due to their small and sparse distribution. To improve limits in spatial resolution, several methods were used: first, Minimum Noise Fraction (MNF) was used to minimize the dimensionality and noise; second, the Pixel Purity Index (PPI) was used to collect the endmember; last, Spectral Mixture Analysis (SMA) was used to confirm the abundance of vegetation. These results will be confirmed by comparing the field data from July 2014 and vegetation map (Moreau, 2005).

UNEXPECTED EFFECT OF QUALITY FILTERING: BIAS OF TAXON ABUNDANCE IN 16S RRNA MICROBIAL COMMUNITY ANALYSIS

Kyuin Hwang

Kyuin Hwang[1,3], Kyung Mo Kim[2,3] and Soon Gyu Hong[1,3]*

[1]Korea Polar Research Institute, Incheon, Korea
[2]Korea Research Institute of Bioscience and Biotechnology, Jeongeup, Korea
[3]University of Science and Technology, Daejeon, Korea

rbdls77@kopri.re.kr

ABSTRACT

Next generation sequencing technologies that cost-effectively produce huge amount of 16S ribosomal RNA sequence data confer more powerful ways to unveil microbial diversity of certain environmental samples. Despite the usefulness, analyzing sequence data still suffers from sequencing errors, which can distort intact microbial diversity. It is thus important to eliminate the errors by discarding low-quality reads and trimming out low quality regions of reads. In general, sequencing errors occur selectively, depending on sequence context of template molecules. And, more errors lead to low quality of reads. Consequently, the amount of reads removed by quality filtering depends on their taxa that determine their own sequence contexts. In turn, abundance of taxa that was represented by the number of reads can change arbitrarily. To explore effect of quality filtering on estimating abundance of microbial taxa, we selected a mock community sample data consisting of three variable regions of 16S sequences of 21 microbial clones. By comparing the proportion of abandoned reads between microbial clones after applying various quality filtering, we estimated how much relative abundance of individual taxa can change in the environmental samples. Regardless of quality filtering methods and sequencing regions, our analysis showed that the proportion of abandoned reads significantly differ between microbial clones with little effect on reducing sequencing errors. Consequently, our data reveals that reducing sequencing errors by employing quality filtering steps unexpectedly increases the bias of taxon abundance in analyzing sequence data of microbial community.

POSTER SESSION

Sea Ice Networks for Observation and Prediction

MEASURING ARCTIC SEA ICE MOTION USING HIGH-SPATIAL-RESOLUTION OPTICAL SATELLITE IMAGE

Chang-Uk Hyun, Hyun-cheol Kim, Sung-Ho Kang*

Korea Polar Research Institute, Incheon, Korea

cuhyun@kopri.re.kr, kimhc@kopri.re.kr, shkang@kopri.re.kr

ABSTRACT

Sea ice motion from low-resolution satellite sensors with feature tracking methods, e.g. maximum cross-correlation, has been widely used to monitor changes in sea ice covers. This study presents measuring arctic sea ice motion using high-resolution optical satellite images acquired on August 2014. The high-resolution optical images were obtained from Korea Multi-Purpose Satellite-2 and Korea Multi-Purpose Satellite-3 with the spatial resolutions of 1 m panchromatic (PAN) band and 4 m multi-spectral (MS) bands and 0.7 m PAN band and 4 m MS bands, respectively.

THE VARIABILITY OF SURFACE CHLOROPHYLL-A ASSOCIATED WITH SEA ICE EXTENT IN THE WESTERN ARCTIC OCEAN

Eunho Ko

Eunho Ko[1,2], Jisoo Park[1,2], Jinyoun Jung2 ,Eunjin Yang2 and Sung-ho Kang 2*

[1]University of Science and Technology, Korea
[2]Korea Polar Research Institute, Korea

ehko@kopri.re.kr

ABSTRACT

Over the last several decades, Arctic sea ice extent has dramatically decreased, particularly in the Pacific sector of the Arctic Ocean. The reduction of sea ice is due to increasing air temperatures, inflowing relative warm water in the Arctic Ocean. Associated with the loss in sea ice has been an increase in the amount of light penetrating the upper ocean. Accordingly, it could accelerate the reduction of sea ice extent in spring and summer in the Arctic Ocean. The change of sea ice extent could affect Acrtic marine ecosystem, particularly in lower trophic level organisms. Net primary production of phytoplankton has been a 30% increase since 1998 because of increasing open water area and the length of the phytoplankton growing season (Arrigo and Djiken, 2015). However, the relationship between the variability of sea ice extent and the variation of phytoplankton biomass has not fully observed in the Arctic Ocean. First, to understand the variability of phytolplankton biomass related to sea ice change, we analysed the remote sensing of phytoplankton biomass and sea ice data. Here we used 17 years merged ocean color data by Garver-Siegel-Maritorena model (Maritorena and Sigel, 2005). The western Arctic Ocean was divided into six regions for further analysis accoridng to the previous study (Hill et al., 2013). As the reduction of sea ice extent in all study regions, the open water duration was gradually increased. However, the sum of chlorophyll-a concentration, in summer, showed a different trend by region. It was relatively higher (increased) as open water duration was increased in most regions. On the other contrary, that was relatively lower (decreased) as open water duration was increased in Beaufort Sea. The correlation between two parameters shows a significant relationship. It implies that the variability of phytoplankton biomass in western Arctic must be affected by regionally different meahanisms. Possible implications/explanations of this result will be discussed.

AN INTRODUCTION TO KOPRI'S COLLABORATIVE ACTIVITIES FOR SEA ICE OBSERVATIONS IN THE ARCTIC

Kyoung-Ho Cho[1], Joo-Hong Kim[1], Phil Hwang[2], Koji Shimada[3], Eunjin Yang[1] and Sung-Ho Kang[1]*

[1]Korea Polar Research Institute, Korea
[2]Scottish Association for Marine Science, UK
[3]Tokyo University of Marine Science & Technology, Japan

kcho@kopri.re.kr

ABSTRACT

The Pacific Arctic Sector has experienced a massive decline in sea ice extent during recent decade. In order to unveil the primary factors controlling the sea ice loss, Korea Polar Research Institute (KOPRI) has conducted the ice-ocean observations on the Arctic sea ice since 2011. Most of KOPRI's activities for the observations include the international collaboration with the Scottish Association for Marine Science (SAMS), the Tokyo University of Marine Science and Technology (TUMSAT), the British Antarctic Survey (BAS), the Ocean University of China (OUC), and so on. One of the activies is the deployment of various ice-tethered buoys to measure ice bottom melting, heat exchange between the atmosphere-snow-ice-ocean interfaces, and the three dimensional deformation of the ice. These measurements help us to identify and understand the key physical processes between and within atmosphere-ice-ocean in the Arctic Ocean. Another activity is the melt pond study that reveals the evolution of two different types of melting ponds. In this study, thus, we introduce the overall activities for sea ice observations conducted from 2011 to 2015 and present what kinds of equipments used and some preliminary results.

ICE-BASED MEASUREMENT PLATFORMS IN THE ARCTIC OCEAN: A CONTRIBUTION BY THE FRAM INFRASTRUCTURE PROGRAM

Mario Hoppmann

M. Hoppmann, M. Nicolaus, B. Rabe, F. Wenzhöfer, C. Katlein, D. Scholz

Alfred-Wegener-Institut Helmholtz-Zentrum für Polar- und Meeresforschung

Mario.Hoppmann@awi.de

ABSTRACT

The Arctic Ocean has been in the focus of many studies during recent years, investigating the state, the causes and the implications of the observed rapid transition towards a thinner and younger sea-ice cover. However, consistent observational datasets of sea ice, ocean and atmosphere are still sparse due to the limited accessibility and harsh environmental conditions. One important tool to fill this gap has become more and more feasible during recent years: autonomous, ice-tethered measurement platforms (buoys). These drifting instruments independently transmit their data via satellites, and enable observations over larger areas and over longer time periods than manned expeditions, even throughout the winter.

OBSERVATION OF VERTICAL HEAT FLUX FROM PACIFIC SUMMER WATER TO SURFACE USING ICE-TETHERED MOORINGS

Eun Yae Son

Eun Yae Son[1], Ho Kyung Ha[1], Hyoung Sul La[2], Jae Hun Park[1] and Sylvia T. Cole[3]*

[1]Department of Ocean Sciences, Inha University, Incheon, Korea
[2]Korea Polar Research Institute, Incheon, Korea
[3]Woods Hole Oceanography Institution, Woods Hole, Massachusettes, USA

**hahk@inha.ac.kr*

ABSTRACT

The Pacific Summer Water (PSW) coming through the Bering Strait is one of the major heat sources in the western Arctic area. The PSW can be a heat source to sea ice and monitoring of the heat flux from the PSW could give a hint for sea ice loss in the western Arctic. Short- and long-term moorings were deployed to measure the upward heat flux delivered from the PSW. The short-term (~3.5 day) mooring was conducted to observe the sea ice-water boundary interaction in the summer of 2014 at the Canada Basin, Arctic. It consisted of an acoustic Doppler current profiler (ADCP) and 4 MicroCats to measure the profiles of velocity, temperature, salinity and pressure. The long-term (~9 months) ice-tethered profiler with velocity (ITP-V) mooring was deployed in summer of 2014 to collect the data of temperature, salinity and velocity in the Canada Basin.

The ADCP data exhibited a strong change of velocity at 15 m depth during short-term mooring. Below 15 m depth, the semidiurnal internal wave appeared, however, semidiurnal wave was weak in the layer between the sea ice and 15 m depth. The vertical velocity variation near the surface was generated by the stratification from the sea ice melt. At about 40 m depth, the stratification induced by PSW influenced the velocity from the ITP-V. The periodic components of velocity were extracted through a wavelet transform. During summer to early autumn, when the sea ice concentration was relatively low, the semidiurnal internal wave could propagate down to the PSW from near surface. Especially, in September, the semidiurnal wave appeared down to a deeper¬¬¬ (>150 m) layer. Even in winter when the sea surface was fully covered with sea ice, the semidiurnal internal wave was observed in the PSW layer. The relationship between heat flux and the semidiurnal internal wave will be discussed during the presentation.

POSTER SESSION

Science, Law and Arctic Future / Social and Human Science Research on the Arctic and East Asian Contribution

THE FUTURE OF THE ARCTIC: CONSEQUENCES OF MELTING

Néstor CAMPOS

Complutense University of Madrid (UCM), Madrid, Spain

nestorca@ucm.es

ABSTRACT

THE CURRENT SITUATION AND TASK OF THE DOMESTIC HUMAN AND SOCIAL SCIENCE RESEARCHES ON THE ARCTIC REGION

Jong-Man Han

Pai Chai University

jmhan@pcu.ac.kr

ABSTRACT

POSTER SESSION

Arctic, Antarctic and Other Related

ESTIMATON OF SUBMARINE PERMAFROST IN THE CANADIAN SHELF OF BEAUFORT SEA, ARCTIC

Seung-Goo Kang

Seung-Goo Kang[1], Jong Kuk Hong[1], Young Keun Jin[1], Sookwan Kim[1], Young-Gyun Kim[1], Yeon Jin Choi[1], Scott Dallimore[2] and Michael Riedel[3]*

[1]Korea Polar Research Institute, Incheon, Korea
[2]Geological Survey of Canada-Pacific, Sydney, B.C., Canada
[3]GEOMAR Helmholtz Centre for Ocean Research Kiel, Kiel, Germany

ksg9322@kopri.re.kr

ABSTRACT

Ice-bonded permafrost or ice-bearing sediments are widely distributed under the Beaufort Sea shelf, which have formed during periods of lower sea level when portions of the shelf less than ~100m water depth were an emergent coastal plain exposed to very cold surface. During Expedition ARA05C (from Aug 26 to Sep 19, 2014) on the Korean icebreaker RV ARAON, the multi-channel seismic (MCS) data were acquired on the outer shelf and slope of the Canadian Beaufort Sea to investigate distribution and internal geological structures of the offshore ice-bonded permafrost and gas hydrates, totaling 998 km L-km with 19,962 shots. The MCS data were recorded using a 1500 m long solid-type streamer with 120 channels. Shot and group spacing were 50 m and 12.5 m, respectively. Most survey lines were designed perpendicular and parallel to the strike of the shelf break.

The seismic P-wave velocity is an important geophysical parameter for identifying the distribution of ice-bonded permafrost with high velocity in this area. Recently, full waveform inversion (FWI) is commonly used to delineate detailed seismic velocity information. FWI is a data fitting procedure based on wave field modeling and numerical analysis to extract quantitative geophysical parameters such as P-, S-wave velocities and density from seismic data. In this study, we suggest two-dimensional P-wave velocity models of our survey area using the FWI algorithm to delineate the distribution of submarine permafrost and top and bottom boundaries of ice-bonded permafrost in the Canadian shelf of Beaufort Sea.

STUDIES OF ARCTIC *Chlamydomonas* sp. KNM0029C FOR BIODIESEL PRODUCTION

Eun Jae Kim

Eun Jae Kim[1], Woongsic Jung[1], Sanghee Kim[1], Han-Gu Choi[1], Se Jong Han[1,2]*

[1]Division of Life Sciences, Korea Polar Research Institute, KIOST, Incheon 406-840, Korea
[2]Department of Polar Sciences, University of Science and Technology, Incheon 406-840, Korea

**Corresponding author's Tel: +82-32-760-5521, E-mail: hansj@kopri.re.kr*

ABSTRACT

Biodiesel has attracted interest because this fuel not only can replace the conventional diesel as petroleum fuel but has a low effect to environmental issue. Biodiesel produced by polar microalgae could be used in cold countries, because it has advantages that clogging can be prevented in the fuel supply due to high content of polyunsaturated fatty acids which lower the melting point of biodiesel. In this study, we visualized intracellular lipid formations of Arctic KNM0029C, and analyzed contents of fatty acids by using GC. In addition, to enhance the cell mass and lipid production of KNM0029C, we optimized medium component of Tris-acetate-phosphate (TAP). In conclusion, main fatty acids contents were C18:1, C18:2, C18:3, and C20:2 at 4°C and its maximum lipid production reached 178.6mg L-1 which was 2.3-fold higher than that of C. reinhardtii CC-125 as mesophilic strain. When KNM0029C was cultured in optimized TAP medium, total cell numbers and lipid production were increased to ~35% and ~10%, respectively. The results of the present study could potentially contribute toward large-scale lipid production at low temperatures.

CHARACTERISTICS OF DISSOLVED ORGANIC CARBON IN THE WESTERN AND THE EASTERN ARCTIC OCEAN

Jinyoung Jung

Jinyoung Jung[1], Sun-Yong Ha[1], Jun-Oh Min[1], Eun Jin Yang[1], Kyung-Hoon Shin[2] and Sung-Ho Kang[1]*

[1]Korea Polar Research Institute, Incheon 21990 Korea
[2]Hanyang University, Ansan 15588 Korea

jinyoungjung@kopri.re.kr

ABSTRACT

Dissolved organic carbon (DOC) is an important component for understanding the regional carbon budget and the global carbon cycle. As the amount of river discharge continues to increase, along with increasing DOC export due to climatic warming and permafrost thawing, the remineralization of terrigenous organic matter in the Arctic Ocean can reduce the Arctic Ocean's ability to absorb atmospheric carbon dioxide (CO2). Furthermore, sea ice loss by warming and advection of warm water can result in increasing primary production due to open water area and longer sea ice-free days. Thus a complete understanding of the terrigenous and marine-origin DOC dynamics is required. To investigate behavior of DOC in the Arctic Ocean, seawater sampling was carried out over in the the Beaufort Sea, Chukchi Sea and the East Siberian Sea, including Distributed Biological Observation (DBO) 3, using a CTD/rosette sampler holding 24-10 L Niskin bottles during Korea research ice breaker R/V Araon cruises (ARA04C, September 4–October 2, 2013; ARA05B, July 31, 2014–August 25, 2014; ARA06B, August 1– 22, 2015). In the bottom of the Chukchi shelf, ammonium (NH4) concentration, which is released during remineralization of particulate or dissolved organic matters, was high, and it showed quite similar distribition to minimum values of dissolved oxygen (DO), suggesting that significant remineralization occurred in this region. In addition, N**, which is a useful tracer to investigate nitrogen deficit or excess with respect to phosphorus, showed minimum values, and the distribution of N** was similar to that of DO minimum value, indicating that significant denitrification occurred within the shelf sediments because NO3 is used for organic matter oxidation instead of oxygen under low DO condition. N** value tented to decrease with decreasing DOC concentration since labile DOC can be used as electron donors under denitrification processes. In 2015, a significant relatioship between DOC and N** was observed compared to that in 2014, suggesting that DOC observed in 2015 is more labile, and that denitrification could be an important process for removal of labile DOC in the Chukchi shelf. High DOC concentrations were observed in surface water of the Bering Strait and the Beaufort Sea, suggesting strong influence of riverine water. The vertical distributions of DOC observed in the Bering Strait and Chukchi Sea were similar to that in the Beaufort Sea. However, in the East Siberian Sea, most DOC concentration in deeper layer was lower than those observed in the Chukchi and Beaufort Seas,

suggesting that the DOC in the East Siberian Sea experienced a different removal mechanism and/or was influenced by the Atlantic water.

ENHANCED DIAPYCNAL MIXING DUE TO NEAR-INERTIAL INTERNAL WAVES PROPAGATING THROUGH AN ANTICYCLONIC EDDY IN THE ICE-FREE CHUKCHI PLATEAU

Yusuke Kawaguchi

Yusuke Kawaguchi[1], Shigeto Nishino[1], Jun Inoue[2] and Hiroki Takeda[1]*

[1]Japan Agency for Marine-Earth Science and Techonology, Yokosuka, Japan
[2]National Institute of Polar Research, Tokyo, Japan

yusuke.kawaguchi@jamstec.go.jp

ABSTRACT

The Arctic Ocean is known to be quiescent in terms of turbulent kinetic energy (TKE) associated with internal waves. To investigate the current state of TKE in the seasonally ice-free Chukchi Plateau, Arctic Ocean, we performed a three-week, fixed-point observation (FPO) using repeated microstructure, hydrographic, and current measurements in September 2014. During the FPO program, the microstructure observation detected noticeable peaks of TKE dissipation rate ε during the transect of an anticyclonic eddy across the FPO station. Particularly, ε had a significant elevation in the lower halocline layer, reaching the order of 10−8 W kg−1. The ADCP current displayed energetic near-inertial internal waves (NIWs) propagating via the stratification at the top and bottom of anticyclone. According to spectral analyses of horizontal velocity, the waves had almost downward energy propagation, and its current amplitude reached ~10 cm s−1. These are even more energetic than traditional reports for the ice-covered Arctic and nearly comparable to the canonical values in the mid-latitude seas. The WKB scaling, incorporating vertical variations of relative vorticity, suggests that increased wave energy near the two pycnoclines was associated with diminishing group velocity at the corresponding depths. The fine-scale parameterization using observed near-inertial velocity and buoyancy frequency successfully reproduced the characteristics of observed ε, suggesting that the near-inertial kinetic energy was most effectively dissipated into turbulence at the bottom side of eddy core because of its weaker stratification relative to the top side.

PRELIMINARY REPORT OF LATE PALEOZOIC ONCOIDS FROM THE BRØGGERHALVØYA, NW SVALBARD

Jae-Ryong Oh

*Jae-Ryong Oh[1, 2, *], Jusun Woo[1, 2]*

[1]Polar Sciences, University of Science and Technology, Daejeon, Korea
[2]Division of Polar Earth-System Sciences, Korea Polar Research Institute, Incheon Korea

ggilli@kopri.re.kr

ABSTRACT

Numerous oncoids in the lower part of Wordiekammen Formation are investigated from the two different localities (Strypbekken and Stupbekken) of Brøggerhalvøya, NW Svalbard. The oncoid-bearing beds are characterized by presence of rounded to ellipsoidal meso-oncoids (2-20 mm) and macroids (>20 mm). Oncoids from Strypbekken are dominated by meso-oncoids with lesser amount of macroids (up to 50 mm). On the other hand, from Stupbekken, rather larger-sized oncoids (up to 70 mm) are prevalent. Nuclei of the oncoids are mostly bioclast and some are hard to identify. Cortices are composed of diverse biota. Compactly- or loosely-spaced, non-branching tubular organisms (encrusting foraminifera?) are abundant within the cortex. These tubes are marked by their distinct dark micritic wall and display range in diameter (roughly 20-100 μm). Well-preserved microbes, which are also significant constituents of the oncoids, are appeared as cluster of radiating filamentous tubes. They commonly co-occur with peloidal-micrite with indistinct or absence of filaments (poorly-preserved microbes?). Colonial branching tubes (donezellid algae?) and irregular-shaped encrusting laminar organisms (red algae?) are also abundant in the oncoids from Stupbekken. Based on preliminary microscopic observation, dimensions of oncoid appear to have relation to the biotic composition. Smaller oncoids are mostly formed by foraminifera (foraminiferal oncoids) and larger oncoids are mostly built by consortium of microbe, foraminifera, and alga (composite oncoids; microbial-foraminiferal, foraminiferal-algal, and microbial-foraminiferal-algal oncoids). Although the biotic composition and the associated facies of oncoids are valuable paleoenvironmental proxies, oncoids and oncoidal facies from the late Paleozoic sedimentary successions of Svalbard have been overlooked. Further detailed study of these oncoids and their surrounding facies will enable us to access more precise interpretation and reconstruction of depositional environments of the region.

EVIDENCE FOR THE LATE CENOZIC ANTARCTIC ICE SHEET EVOLUTION AND BOTTOM CURRENT DYNAMICS IN THE CENTRAL BASIN, ROSS SEA (ANTARCTICA)

Sookwan Kim

Sookwan Kim[1,2], Laura De Santis[3], Jong Kuk Hong[1,2], Diego Cottlerle[3], Lorenzo Petronio[3], Ester Colizza[3], Andrea Bergamasco[5], Young-Gyun Kim[1], Seung-Goo Kang[1], Hyounjun Kim[1], Suhwan Kim[1], Nigel Wardell[3], Riccardo Geletti[3], Robert McKay[6], Young Keun Jin[1] and Sung-Ho Kang[1]*

[1]Korea Polar Research Institute, Incheon, Korea
[2]University of Science and Technology-Korea, Daejeon, Korea
[3]Instituto Nazionale di Oceanografia e di Geofisica Sperimentale-OGS, Trieste, Italy
[4]University of Trieste, Trieste, Italy
[5]Institute of Marine Sciences-National Research Council (ISMAR-CNR), Venice, Italy
[6]Victoria University of Wellington, Wellington, New Zealand

skwan@kopri.re.kr

ABSTRACT

Sedimentary records in polar continental margins could provide clues for understanding paleo-depositional environments, related to ice-sheet evolution and bottom-water current dynamics, during times of past climate and global sea-level changes. Previous seismostratigraphic studies of the Ross Sea embayment in the Antarctica illustrated its general stratigraphic framework and glacial sedimentary features over the continental shelf, since the onset of Antarctic glaciation at the Eocene-Oligocene boundary (ca. 34.0 Ma). In contrast, there are a fewer studies for the outer continental margin, where continuous sedimentary deposits generally preserve the record of past climate cycles with minimum hiatus.

ONTOGENY OF THE FURONGIAN (LATE CAMBRIAN) TRILOBITE PROCERATOPYGE CF. P. LATA WHITEHOUSE 1939 FROM NORTHERN VICTORIA LAND, ANTARCTICA, AND THE EVOLUTIONS OF METAMORPHOSIS IN TRILOBITES

Ji-Hoon Kihm

Ji-Hoon Kihm[1, 2], Tae-Yoon S. Park[1, 2], Jusun Woo[1, 2], Young-Hwan G. Kim[1, 2] and Jong-Ik Lee[1, 2]*

[1]University of Science and Technology, Daejeon, Korea
[2]Korea Polar Research Institute, Incheon, Korea

jhkihm@kopri.re.kr

ABSTRACT

Among the cases of trilobite metamorphosis, the most well-known case is the transition from a planktonic globular protaspis to a benthic flat meraspis. The protaspides which underwent metamorphosis into the subsequent meraspid phase is termed as the commutavi protaspides. It has been known that there are multiple origins of commutavi protaspides; within the superfamilies Remopleuridioidea, Trinucleoidea, and within the Order Asaphida. Recent studies have revealed that the protaspides of the Cambrian representatives of the Remopleuridioidea and the Trinucleoidea had flat morphology for benthic lifestyle. However, the protaspid morphology of Cambrian representatives of the Order Asaphida remains unknown. This research documents the ontogeny of the Furongian (late Cambrian) asaphoidean ceratopygid trilobite, Proceratopyge cf. P. lata Whitehouse, 1939, from northern Victoria Land, Antarctica. Two stages for protaspid phase, four developmental stages for the post-protaspid cranidia, and ten stages for the post-protaspid pygidia have been identified. Among other ontogenetic aspects, the protaspid morphology of this trilobite is similar to the general Cambrian ptychoparioid protaspides which directly developed into similarly-looking benthic meraspid morphology. The input of new information for character coding for protaspid morphology enabled a cladistic analysis for Asaphida, which produced a single most parsimonious tree. According to the most parsimonious tree, the presence of the globular commutavi protaspis turns out to be a synapomorphy of Asaphidae + Cyclopygoidea, not a synapomorphy of the Order Asaphida. Because the all the commutavi protaspides occurred not until the Early Ordovician, so far, it can be inferred that there were convergent evolutions of indirect-developing commutavi protaspides near the Cambrian/Ordovician transition. Metamorphosis-entailing planktonic larvae evolved in many different metazoan lineages at this period, due to the escalating ecological pressure of the Ordovician Biodiversification Event. Evolution of planktonic larvae was an escape strategy from the benthic predators. The convergent evolution of the indirect development of the Ordovician representatives of the three trilobite lineages could also be a result of adaptation to the Ordovician Biodiversification Event.

Keywords: metamorphosis, Cambrian, Ordovician, trilobite, protaspis

STRUCTURAL BASIS FOR THE LIGAND-BINDING SPECIFICITY OF FATTY ACID-BINDING PROTEINS (pFABP4 and pFABP5) IN THE GENTOO PENGUIN

Changwoo Lee

Chang Woo Lee[1,2], Jung Eun Kim[1], Hyun Park[1,2], Il-Chan Kim[1], and Jun Hyuck Lee[1,2]*

[1]Division of Polar Life Sciences, Korea Polar Research Institute, Incheon 406-840, Republic of Korea
[2]Department of Polar Sciences, University of Science and Technology, Incheon 406-840, Republic of Korea

justay@kopri.re.kr

ABSTRACT

The fatty acid-binding proteins (FABPs) are involved in transporting hydrophobic fatty acids between various aqueous compartments of the cell by direct binding of ligands inside their β-barrel cavities. Here, we report the crystal structures of ligand-unbound pFABP4, linoleate-bound pFABP4 and palmitate-bound pFABP5 from the gentoo penguin (Pygoscelis papua) at 2.1, 2.2, and 2.3 Å resolutions, respectively. The pFABP4 and pFABP5 proteins comprise a canonical β-barrel structure with two short α-helices forming a cap region and fatty acid ligand binds in the hydrophobic cavity inside the β-barrel structure. The two linoleate-bound pFABP4 and palmitate-bound pFABP5 structures shows a different ligand-binding mode and a unique ligand-binding pocket caused by several sequence differences (A76/L78, T30/M32, underlining used to indicate pFABP4 residues). Structural comparison also shows a significantly different conformation change in the β3-β4 loop region (residues 57-62) of pFABP5 as well as flipped Phe60 residue (the corresponding residue in pFABP4 is Phe58). Moreover, a ligand-binding study using fluorophore displacement assays indicated that pFABP4 has a relatively strong affinity to linoleate compared with pFABP5. In contrast, pFABP5 clearly exhibits higher affinity for the palmitate compared with pFABP4. Conclusively, our high-resolution structures and ligand-binding study provide useful insights into the ligand-binding preferences of pFABPs based on key protein-ligand interactions.

CYCLIC DEPOSIT OF THE CHANNELIZED DEBRIS FLOWS IN THE SPURS FORMATION, THE MARINER GROUP (CAMBRIAN), NORTHERN VICTORIA LAND, ANTARCTICA

Young-Hwan G. Kim

Young-Hwan G. Kim[1,2], Jusun Woo[1], Tae-Yoon S. Park[1], Moon Young Choe[1]

[1]Division of Polar Earth-System Sciences, Korea Polar Research Institute, Incheon 406-840, Korea
[2]Polar Science, School of Science, Korea University of Sciences and Technology (UST), Daejeon 305-333, Korea

dave8379@kopri.re.kr

ABSTRACT

The Cambrian Spurs Formation is exposed on the east side of a valley made by the Mariner Glacier (Eureka Spurs 3) in the central-eastern part of northern Victoria Land, Antarctica. This section shows 1099 m (including gaps covered by snow) of the succession which consists of fissile mudstone, thin bedded sandstone, and channel-fill conglomerate. The channel-fill deposit occurs in 130 m above the lowest exposure and is ca. 190 m in width and ca. 20 m in thickness. Six sections (CU1 to CU6 from east to west), spaced about 10 to 45 m, were measured and used to construct a two-dimensional correlation panel.

A detailed facies analysis of the channel-fill deposit suggests four main lithofacies: 1) breccia (cohesionless debris flow), 2) diamictite (cohesive debris flow), 3) thin-bedded sandstone (low-density turbidity currents), and 4) mudstone (low-density turbidity currents). The architectural elements consist of hollow fill element (HF) and Sheet-like element (SL). The HF is a sedimentary body with concave-up erosional base and flat upper surface and consists mostly of cycles of breccia and diamictite beds with minor thin-bedded sandstone. This element is interpreted as the deposits filling the scoured hollows. The SL has wide convex-up geometry and consists solely of very thick bed of diamictite and is interpreted as submarine channel lobe. The channel-fill deposit is formed by succession of 3 depositional stages: 1) the channel-wide erosion and hollow-fill deposition, 2) the non-channelized deposition, and 3) the small scale channel erosion and fill deposition.

In the HF, the cyclic succession of breccia and diamictite occurs 9 times and ranges from 0.55 m to 3.3 m in thickness, with average of 1.8 m. The erosive lower boundary of cycles incises into the underlying mudstone and the diamictite of the preceding cycle, whereas the diamictites are confined to the dimension of the underlying breccia with sharp boundary. The initial phase of each cyclic succession is controlled by repeated allogenic processes such as tectonic activity, eustatic sea-level changes, climate changes, and sediment flux changes. In contrast, abrupt vertical transition from breccia to diamictite in each cycle is interpreted to result from an autogenic process, channel wall collapse causing muddy cohesive debris flow (diamictite).